Influence of Rogers’ theory of innovation of diffusion on customer’s purchase intention – a case study of solar photovoltaic panels

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Abstract. The key objective of utilizing sustainable energy in a developing country like India is to enhance economic growth and development, energy security, access to clean energy and to alleviate environmental problems. Sustainable growth of a nation is possible only through the adoption of renewable energy technologies and by providing access to these technologies to all the citizens. This paper discusses how the product attributes described by Rogers’ theory of innovation of diffusion such as the relative advantage of technology, compatibility, complexity, observability, and trialability influence consumer’s intention to diffuse solar panels. A questionnaire survey consisting of 23 questions has been designed and it was administered to 63 adopters of solar panels in the Thrissur district of Kerala. After the collection of data, reliability test and factor analysis were conducted for determining the reliability and validity of the questionnaire. Multiple regression analysis was conducted to determine the relationship between the purchase intention of customers with five sub-factors under product attributes as specified by Rogers’ theory of innovation diffusion. The results obtained from the analysis showed that compatibility and trialability of a product significantly influence the intention to purchase the solar panels.

Keywords: solar panel, questionnaire survey, product attributes, regression, analysis

1. Introduction
The generation and diffusion of sustainable energy resources such as solar, wind, hydro, and biomass energy is expanding and gaining importance in India[1]. Some of the factors that have contributed to this include rapid industrialization, varying lifestyles among citizens, increased fluctuation in the cost of electricity with varying demand patterns, and depleting reserves of fossil fuels due to continuous usage, etc. To eliminate this problem, policymakers have been searching for renewable energy reserves for the production of electricity. However, solar energy is regarded as the most sustainable power source across the world, which is easy to harness unlike other sources such as wind, hydro, biomass, etc. [2]. India is situated in the northern half of the hemisphere and because of its locational advantage, India receives an average of about 250 to 300 sunny days per year and obtains an average hourly illumination of 200 MW/km²[2]. Approximately 5,000 trillion kWh per year of energy is incident over Indian land area with most areas receiving 4-7 kWh per sq. meter per day. Approximately 5,000 trillion kWh per year of solar energy is incident over the land surface with most places getting 4 to 7 kWh per m² per day [3].
2. Literature Review
The theory of innovation of diffusion was proposed by Rogers in 1958 after completing his doctoral research at Iowa State University, US, in the area of adoption of agricultural innovations. Rogers describes technological innovation as something which is supposed as new by a person and the adoption of innovation depends upon the characteristics of a person.

The theory states that an individual's interest to purchase a new product or service depends upon the way that an individual observes the product in terms of some of the characteristics of innovation such as product relative advantage, compatibility, complexity, or user-friendliness, observability, and trialability. If the individual notices the product to have a higher relative advantage over parallel products in terms of performance, more compatible with a person's interest, less complexity in the usage of the product, more observability, that is the outcomes or benefits provided by the product can be observed, and more trialability that is the extent to which a product or service can be experimented before purchasing it, then that person will have higher interest to adopt the product[4].

The application of Rogers' theory of innovation diffusion has been studied by Simpson and Clifton[5]. A survey was conducted in Western Australia by employing the theory of innovation of diffusion, the study found that the provision of incentives influenced the adoption of solar photovoltaic panels in houses. The majority of the adopters have installed these panels for financial reasons and also about 85% of the respondents indicated that proper education is required to understand the cost parameters and advantages of solar technologies. Islam[6] conducted a study in Ontario city of Canada and by employing the theory of disruptive innovation of diffusion found that the level of awareness about technology and power cost savings significantly influences the rate of adoption, which in turn suggests that proper education level can strengthen the level of awareness of the technology. The study also suggests that proper campaigns should be conducted to describe the investment norms, feed-in tariffs, and environmental features. Lazzarotti [7] by employing this framework conducted a study in micro families in Italy and provided a case study that describes the factors which favour and discourages the intention to adopt solar panels by utilizing past evidence about the particularities of family firms. Feng [8] conducted research to identify the key parameters which influence an individual's intention to adopt green energy technologies. By employing TAM, TRA, and Rogers' theory of innovation diffusion suggests that, to have effective adoption of these technologies, the innovation or technology promoters and appropriate policymakers should consider an individual's attitude, behavioural patterns, and environmental changes.

Franceschinis et.al.[9] conducted a research in Veneto, a region of Italy, by employing the Rogers' theory of diffusion of innovation; found that characteristics of systems influence an individual's preference choices. The study proves that individual perception of characteristics of a system, social factors, and channels for effective communication influences their choices to adopt renewable heating systems. The study also found that consumer’s preferences for the heating systems and their readiness to pay for the system features vary across different segments, which enabled them to plot maps depicting how the customer's readiness to pay for the system varies across different regions. Edward and Bakkabulindi [4] designed a framework by employing IDT and formulated 14 hypotheses which can be used for future analysis. The study suggests that the relative advantage of technology, compatibility, perceived ease of use and observability significantly influence adoption of innovations. Mohammadi et.al.[10] has conducted research by employing Rogers’ theory of innovation diffusion to identify the variables which influence evidence-based practice adoption. The results proved that acceptance was influenced by several factors, such as the innovation level of individuals, attitude of a person, level of knowledge, and perception of attributes. Among these, the attitude level significantly influences EBP adoption. Lee[11] conducted a research study in a hospital in Taiwan by employing Everett Rogers’ theory of innovation diffusion model to examine the perception of nursing staff towards using a computer-controlled patient care plan system. The results obtained from the study indicated that the model can precisely predict the behaviour of nursing staff during the onset of adopting new technologies at the workplace.
Agag and Masry [12] conducted a research study by employing the innovation diffusion theory and technology acceptance model to determine the intention of consumers to take part in the online travel community. The results obtained from structural equation modelling analysis describes that theory of innovation diffusion and theory of acceptance model can provide a suitable model for predicting consumer’s willingness to participate in the program. Barry et.al.[13]researched by employing the theory of innovation diffusion to develop 4D-Building information modelling to reduce the timeframe for completing the projects of the British construction industry. The research found a growing rate of 4D BIM adoption and discovered a time delay between awareness and first use. Bhattacharya[14] developed a model that connects the RFID diffusion issues with the innovation acceptance stages recommended by Rogers’ theory of innovation of diffusion. The results from the study indicated that different stages such as awareness, persuasion, strategy, and execution significantly influence the decision for adoption.

This paper studies how the various factors prescribed by Rogers’ theory of innovation of diffusion such as the relative advantage of technology, compatibility, complexity, observability, and trialability influence customer's intention for the adoption of solar panels in the Thrissur district of Kerala.

3. Research Methodology
The research methodology employed in this study is a questionnaire survey. The questionnaire contains a set of questions with a choice of answers used to acquire data in a statistical study. The questionnaire was prepared based on a five-point Likert scale format ranging from (1- strongly disagree, 2- Disagree, 3- Neutral, 4- Agree, 5- Strongly agree). The questionnaire consists of 23 questions grouped into two sections. The first section deals with 14 questions dealing with parameters under product attributes such as relative advantage, compatibility, complexity, observability, and trialability. The second section consists of 9 questions that measure the dependent variable customer's intention to adopt solar panels. The questionnaire survey was conducted for 63 adopters of solar panels in the Thrissur district of Kerala by employing the method of convenience sampling by taking into account the user's readiness to participate in the survey, their time of convenience, and geographical limits. The responses were collected and analyzed using IBM-SPSS software.

4. Results and Discussions
The reliability analysis was employed to determine the reliability or consistency of the designed questionnaire. The value of Cronbach's alpha is used to determine the reliability of the questionnaire. Usually, values greater than or equal to 0.7 are generally considered to be acceptable[15]. The Cronbach's alpha value obtained for product attributes is 0.888 and the Cronbach's alpha value obtained for the dependent variable customer's intention for adoption is 0.790. From the results, it can be understood that the values are acceptable and hence the questionnaire is reliable and consistent. The results of reliability analysis are summarized in Table.1.

| Table 1. Results of Reliability Analysis |
|------------------------------------------|
| Product Attributes (Roger’s Theory of Innovation of Diffusion) | Number of variables (questions) | Cronbach’s Alpha |
| Relative Advantage | 2 | 0.888 |
| Compatibility | 4 | |
| Complexity | 2 | |
| Observability | 3 | |
| Trialability | 3 | |
| Dependent Variable - Customers Intention for the adoption of solar panels | 9 | 0.790 |
Factor analysis was employed to determine whether the factors are consistent with their factor loadings. Kaiser-Meyer-Olkin (KMO) test was employed to determine the adequacy of the sample taken. It specifies the proportion of variance in the collected sample. Higher values (greater than 0.6) stipulate that the factor analysis might be suitable. Bartlett's Test of Sphericity was employed to examine whether the variables are associated or not. Small values (less than 0.05) predict that the factor analysis might be appropriate with the data. The results of factor analysis are summarized in Table 2. From Table 2, it can be seen that all necessary conditions have been satisfied and hence the factors are consistent with their factor loadings.

### Table 2. The results of factor analysis

| Factor                                | KMO Value | Bartlett’s Test of Sphericity Value |
|---------------------------------------|-----------|------------------------------------|
| Product Attributes                    | 0.781 > 0.6 | 0.000 < 0.05                       |
| Dependent Variable-Customers Intention for adoption | 0.789 > 0.6 | 0.000 < 0.05                       |

Before conducting multiple regression analysis, some of the assumptions regarding linearity, normality, homoscedasticity, and multicollinearity need to be satisfied[16,17]. The linearity of a relationship is examined through residual plots and it represents the linear relationship between the independent and dependent variables. Any curvilinear relationship indicates that necessary actions are needed to rectify the data to enhance accuracy and validity. The residual plots are also used for determining the homoscedasticity of data. It represents that the variance around the regression line should be constant across all the independent variables under study. The Normality tests are employed to determine whether the residuals of the independent variables are normally distributed or not. The normal distribution makes a slanting straight line, and the plotted residuals are compared with the diagonal line. If the distribution is normal, the residual line closely follows the diagonal line. The standard residual plots, Probability-Probability plot, and multicollinearity tests are employed to determine whether the assumptions are satisfied or not.

![Figure 1. Scatter plot of standardized residual versus predicted value](image1)

![Figure 2. Normal P-P plot of regression standardized residual](image2)
The pattern obtained from the scatter plot is depicted in Figure 1, indicates that there is a random spread of residuals without a curvilinear pattern. This predicts homoscedasticity and linearity to a great extent. The Normal P-P plot of regression standardized residual as shown in Figure 2 indicates that only a slight deviation of residuals from the ideal slanting line, which predicts normality to a great extent. A multicollinearity test was employed to determine whether any similarity exists between the dependent and independent variables. Here, the Variance Inflation Factor (VIF) method was conducted to determine multicollinearity in the data since both the dependent and independent variables are considered for analysis of data. If the VIF value lies in the rage (1-10), then there is no presence of multicollinearity in the data.

Table 3. Summary of results of Multicollinearity test

| Model          | Unstandardized Coefficients | Standardized Coefficients | t      | Sig.   | Collinearity Statistics |
|----------------|-----------------------------|---------------------------|--------|--------|-------------------------|
|                | B   | Std. Error | Beta  |        | Tolerance | VIF |
| 1 (Constant)   | 1.863 | 0.322     | 5.782 | 0.000  | 0.573      | 1.744 |
| Relative Advantage | 0.144 | 0.089     | 0.196 | 1.620  | 0.111      | 0.573 |
| Compatibility  | 0.288 | 0.093     | 0.437 | 3.109  | 0.003      | 0.428 |
| Complexity     | 0.047 | 0.070     | 0.084 | 0.672  | 0.504      | 0.546 |
| Observability  | -0.104 | 0.093    | -0.145 | -1.113 | 0.270      | 0.498 |
| Trialability   | 0.181 | 0.089     | 0.262 | 2.042  | 0.046      | 0.511 |

*Dependent variable: Consumers intention to adopt solar panels

The results obtained for multicollinearity tests are described in Table3. From the collinearity statistics, it can be seen that all the values of VIF lie in the range between (1-10). This indicates that there is no multicollinearity in the collected data.

Multiple regression analysis was conducted to determine the relationship between independent variables and the dependent variable. The formulated hypothesis for analysis is given below.

H0: There is no significant relationship between the product attributes specified by Rogers' theory of innovation of diffusion with the purchase intention of customers.

H1: There is a significant relationship between the product attributes specified by Rogers' theory of innovation of diffusion with the purchase intention of customers.

The results obtained from the multiple regression analysis of the formulated hypothesis are depicted in Tables (4a to 4c). From the results obtained from Table 4a, it can be seen that the obtained value of the Durbin-Watson index is 2.026. The value should lie in the range of 1.50 to 2.50 and this indicates that there is no autocorrelation problem in the data (Durbin and Watson, 1951). According to Cohen (1988), R² value in the range of 1.0 % and 5.9 % is regarded as small, between 5.9 and 13.8 % is regarded as medium and more than 13.8 % is large. The coefficient of determination (R ²) is 0.519, which suggests that 51.9 % of performance can be predicted by the independent variable. Table 4b summarizes the results obtained from ANOVA, which gives a value of 0.000 which suggests that it is significant. Table 4c summarizes the coefficient summary of the formulated hypothesis. The significance level for each of the factors except compatibility and trialability is greater than 0.05, which provides strong evidence for accepting the null hypothesis. For the factor compatibility, the p-value is 0.003 < 0.05 and the β value is 0.437. For the factor trialability, the p-value is 0.046 < 0.05 and the β value is 0.262. Here the null hypothesis is rejected. The unstandardized coefficient (B)
Table 4(a). Multiple regression analysis summaries for Hypothesis

| Model | R     | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|-------|-------|----------|-------------------|-----------------------------|---------------|
| 1     | 0.720a| 0.519    | 0.477             | 0.31702                     | 2.026         |

Table 4(b). ANOVA output of Hypothesis

| Model     | Sum of Squares | df | Mean Square | F    | Sig.  |
|-----------|----------------|----|-------------|------|-------|
| Regression| 6.183          | 5  | 1.237       | 12.305 | 0.000b |
| Residual  | 5.728          | 57 | 0.100       |       |       |
| Total     | 11.912         | 62 |             |       |       |

Table 4(c). Coefficient summary of Hypothesis

| Model     | Unstandardized Coefficients | Standardized Coefficients | t     | Sig.  |
|-----------|------------------------------|---------------------------|-------|-------|
|           | B                            | Std. Error                | Beta  |       |
| (Constant)| 1.863                        | 0.322                     | 5.782 | 0.000 |
| Relative Advantage | 0.144                   | 0.089                     | 0.196 | 1.620 | 0.111 |
| Compatibility | 0.288                     | 0.093                     | 0.437 | 3.109 | 0.003 |
| Complexity  | 0.047                       | 0.070                     | 0.084 | 0.672 | 0.504 |
| Observability | -0.104                   | 0.093                     | -0.145| -1.113| 0.270 |
| Trialability| 0.181                       | 0.089                     | 0.262 | 2.042 | 0.046 |

obtained for the factor observability is (-0.104), which means that when the observability increases by one unit, the dependent variable that is consumer's intention for adoption decreases by 0.104 units. The standardized coefficient β value obtained for the factor observability is (-0.145), which is a smaller and negative value indicating that it does not have any influence on the dependent variable. From the result, it can be interpreted that out of 5 variables, the compatibility and trialability of a product significantly influences the intention to purchase the solar panels among customers in the Thrissur district of Kerala.

5. Conclusion
The overall results obtained from the analysis show that compatibility and trialability of a product significantly influence the intention to purchase solar panels in the case of adopters in the Thrissur district of Kerala. So, if a product has got more compatibility which is reliable with an individual's work interest, values, and requirements, it will lead to higher purchase intention among customers. The results also prove that more trialability among customers, i.e. a demonstration of the actual performance of a product or service before purchasing it can also increase the purchase intention among customers. So, companies should manufacture products which are more compatible with the existing values and beliefs of customers and also should conduct public campaigns and awareness programs to enhance the purchase intention among customers.
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