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Drivers and inhibitors of adoption of led lighting by households in India – a structural equation modelling approach

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Abstract: The research aims at finding out the factors that drive and the factors that inhibit the adoption of LED lighting by households in India. A theoretical model of drivers and inhibitors is developed for the empirical study, based on theory of planned behaviour. Apart from the three basic constructs of theory of planned behaviour, some more variables are included in the model. A structured questionnaire was administered to the households in six largest metro cities of India. The sample size of the study is 555. For data analysis, partial least square-structural equation modelling (PLS-SEM) technique is applied. The study also makes importance-performance matrix analysis to further strengthen the findings. Aesthetics, attitude, perceived behavioural control, and subjective norms proved to be the most influencing factors of purchase intention of LED, in that order and showed a positive association with purchase intention of LED. Only personal moral norms showed an insignificant impact. Inertia turned out to be the inhibitor of purchase intention with a negative relationship, as per our assumption. The study also revealed that, perceived cost which was assumed to be an inhibitor is not an inhibitor.

Keywords: structural equation modelling; SEM; attitude; aesthetics; inertia; LED; lighting; India.

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1 Introduction

Lighting is undergoing a rapid transformation as light emitting diode (LED) has become the most important source of light and LED lighting market is growing (Zissis and Bertoldi, 2018). International Energy Agency (2020) in its report mentions that LED is currently shaping the market dynamics. Many countries are phasing out conventional bulbs and LEDs are marching to the top of the market (Zissis and Bertoldi, 2018).

India's tryst with energy conservation and energy efficiency began, when it passed Energy Conservation Act in 2001. Bureau of Energy Efficiency (BEE) was formed in 2002. India is also making efforts to adopt energy efficient lighting. India aims to reduce the share of national energy consumption of lighting from 18% to 13% (Zissis and Bertoldi, 2018). An important development is the launching of Unnat Jyoti Affordable LEDs for All (UJALA) program by Government of India in 2014. Energy Efficiency Services Ltd (EESL) which is an energy service company (ESCO), of Government of India is mainly responsible for the implementation of the program, under which LED bulbs and tube lights are distributed to the households at subsidised rates. For promoting LED manufacturing facilities the central government has reduced the import duties on LED components. BEE has empanelled more than 30 ESCOs in the domain of lighting (Jituri and Sarin, 2015).

Residential sector is the second largest consumer of electricity after industry, which consumed about 6,000 Twh of electricity in 2018 (IEA, 2020). The reasons for rise in residential electricity consumption, has been a subject of research. For instance, Ek and Soderholm, (2010) and Tan et al. (2017) attribute the rise in energy consumption to living standards and household incomes which have improved. Gaspar and Autunes (2011) attribute the rise in electricity consumption in residential sector to rise in usage of electrical appliances.

In the total residential electricity consumption in India, the share of lighting is about 18% to 27% (Chunekar et al., 2017). Parikh and Parikh (2016) in their study mention that, because of economic growth in India, the middle class is able to buy household appliances in large numbers. Their findings reveal that the stock of appliances will rise by many times in 2030 when compared to 2009. Survey conducted by Council on Energy Environment and Water (CEEW) (2020) found that, LED lighting has made significant inroads because of UJALA program, but low awareness and cost concerns of LED lights continue to be the barriers for adoption of LED lighting. So, increasing electricity consumption as a result of rise in ownership of appliances and lack of awareness of energy efficient measures is a cause of concern.

The study aims at finding out the factors that drive and factors that inhibit the adoption of LED lighting by households in India. Survey of literature has shown that many studies on energy efficiency among households have focussed on intention to buy

energy efficient appliances in general, by the households (Ali et al., 2019; Tan et al., 2017; Waris and Hameed, 2020). Some studies have focussed on drivers and inhibitors of adopting renewable energy by households (Zahari and Esa, 2018). Yet some more studies have focussed on drivers of energy saving behaviour (Broek et al., 2019; Li et al., 2020). However, studies focussing on a particular energy efficient appliance or a device are few (Abreu et al., 2019; Apipuchayakul and Vassanadumrongdee, 2020; Kumar et al., 2020). Ali et al. (2019), while outlining the limitations of their study mention that, research done in future should focus on finding out consumer intentions towards specific products, because the factors that influence the purchase intention may differ with change in product types. Therefore the study fills the gap by focussing on drivers and inhibitors of purchase intention of LED. The contribution of this research is that, unlike the previous studies of purchase intention of LED (Apipuchayakul and Vassanadumrongdee, 2020), which considered only the three basic constructs of TPB, this study extends TPB by including aesthetics and personal moral norms as other factors that are expected to be the drivers of purchase intention of LED. Moreover this study not only includes the drivers but also inhibitors of purchase intention of LED, by including inertia and perceived cost as factors that are expected to inhibit the purchase intention of LED.

Following is the structure of the remaining part of the paper: Section 2 reviews the literature of the theoretical framework and develops hypothesis, Section 3 outlines the research methodology. Section 4 provides the analysis of results. Section 5 consists of discussion, policy implications, limitations and future research directions. Section 6 is the conclusion.

2 Theoretical framework and hypothesis development

2.1 Theory of planned behaviour and its extension

Theory of planned behaviour (TPB) was posited by Ajzen (1991). The theory posits that, three factors drive the behavioural intentions of a person. They are attitude, subjective norms and perceived behavioural control. Khan and Vaidyanathan (2018), while studying the potential antecedents of pro environmental consumer behaviours of Indian consumers who are young and educated, mention that, to understand the behavioural intentions of consumers, TPB is a very predictive theory. Ravis et al. (2009) in their study, opine that, among all the psychological models and theories that help us in understanding electricity consumption behaviour of households, TPB is very influential. This could be the reason why TPB has been considered in research on purchase intention of energy efficient appliances by households (Ali et al., 2019; Tan et al., 2017), in research on adoption of renewable energy by households (Zahari and Esa, 2018), in research on adoption of rooftop PV (Abreu et al., 2019).

Klößner (2013), mentions that, in studies that focused on household energy behaviour, 39% of the studies applied TPB when compared to norm activation model (NAM) that was applied in 15% of the studies and value-belief-norm theory (Stern, 2000) that was applied in 13% of the studies. This underscores the significance of TPB when compared to other theories. The universal application of TPB can be known from the fact that it has been applied to research on varied behaviours. Apart from the pro environmental behaviour and energy efficiency behaviour, its application can be found in diverse areas of research such as, blood donation, binge drinking and cyberbullying. This

list is only illustrative. Relatively, other cognitive theories have limited applications. For instance, NAM is developed more so for altruistic or pro environmental behaviour. Therefore this research on LED adoption has considered TPB.

Further, scholars have used other models and theories along with TPB. Such a model is called as extended theory of planned behaviour. The model which has been very often used in conjunction with TPB is, norm activation model (NAM) developed by Schwartz (1977), which considers personal norms of an individual to predict his behavioural intentions. Kaffashi and Shamsudin (2019), Wang et al. (2018) and Mensah and Bein (2019), have used both TPB and NAM models. There are many other studies that have modified the TPB model to increase its explanatory power. For instance, Waris and Hameed (2020) in their study, consider two more constructs, knowledge of eco labels and green trust, along with the constructs of TPB. Hameed et al. (2019) in their study, consider three constructs namely, intrinsic religious orientation, green trust and environmental concern along with constructs of TPB.

Researchers have also studied factors that could inhibit the adoption intentions of households to purchase a particular commodity. Ali et al. (2019) in their study on purchase intentions of energy saving household products by consumers, consider two inhibitors, insecurity and discomfort. Zahari and Esa (2018) in their study, consider perceived risk, perceived expense and perceived no need as inhibitors to study adoption of renewable energy by households.

This study considers attitude, perceived behavioural control, subjective norms of TPB model, personal moral norms of NAM model and includes a new construct of aesthetics which has not been explored much in the studies on energy efficient behaviour of households. The study considers two inhibitors, namely, perceived cost and inertia. Each of the constructs has been explained in the following section.

2.2 Model and the hypothesis development

2.2.1 Attitude

TPB maintains that it is the attitude (ATT) of the consumer that is one of the important factors that determine purchase intentions. Ajzen (1991), considered this as a very important part of TPB. Jabeen et al. (2019) in their study on consumers' intention to adopt renewable power technologies view attitude as viewpoints of purchasers towards renewable power technologies, which are either optimistic or undesirable. Wang et al. (2011) in their study define attitude in the context of electricity saving behaviour as, "the degree of people awareness of performing electricity saving behaviour, which largely depends on the evaluation of preference for the electricity savings and the information the individual holds towards such behaviour". More positive the attitude much stronger is the purchase intention. Research has proved a positive association between attitude and intention to purchase energy efficient appliances (Ali et al., 2019; Gadenne et al., 2011; Hua and Wang, 2019; Waris and Hameed, 2020). Therefore the hypothesis:

H1 Attitude and purchase intention of LED lighting have a positive association.

2.2.2 Subjective norms

The second important construct in TPB is subjective norms (SJN). Ajzen (1991) defines subjective norms as, social pressure of performing or not performing a behaviour. SJN

refers to perceptions that we absorb from surroundings that force us to act or not to act (Abrahamse and Steg, 2009). This fact has been explored by researchers in studies on energy efficiency behaviour. Mau et al. (2008) in their paper on new vehicle technologies, talk about 'neighbour effect', that is, consumers' preferences change as new technology gains market share, that is, more and more people adopt new technology. Research done by Allcott (2011), evaluates a program run by a company called OPOWER. Under this program, OPOWER sent letters to residential electricity consumers in which they compared the electricity used by them with electricity used by their neighbours. The results showed that the average program reduced energy consumption by 20%. Schultz et al. (2007) in their research in which they conducted a field experiment, found that normative messages regarding neighbours usage of electricity produced desirable energy savings by households. Jabeen et al. (2019) in their study find SJN to have positively influenced, consumers' intention to adopt renewable energy. Their finding is similar to that study by Ha and Janda (2012), who found a positive association between SJN and intentions of consumers to adopt energy efficient appliances. Similarly Waris and Ahmed (2020) in their research find that SJN highly influenced consumer purchase intention of energy efficient home appliances. Therefore we hypothesise that:

H2 Subjective Norms and the intention to purchase LED lighting have positive association.

2.2.3 Perceived behavioural control

Perceived behavioural control (PBC) means, perception of people regarding ease or difficulty of performing the behaviour of interest (Ajzen, 1991). Drawing an analogy, Ajzen compares two persons who have equally strong intention to learn ski. He says that, although both want to learn ski, the person who doubts his ability to learn ski will not be able to learn it when compared to the person who is confident that he will. Taking the same analogy in the domain of energy efficient behaviour of households, PBC can be defined as, one's beliefs regarding how easy or difficult it is to adopt an energy efficient behaviour. Intention of residents to save electricity will be stronger if they believe they have knowledge and skills to save electricity (Li et al., 2020). Many other studies have shown a positive association between PBC and intention to purchase energy efficient appliances or the intention to use renewable technologies or indulging in energy saving behaviour (Jabeen et al., 2019; Oikonomou et al., 2009; Tan et al., 2017). Albayrak et al. (2013) in their study on green purchase behaviour find PBC to positively influence the green purchase behaviour. Hence, the hypothesis:

H3 Perceived behavioural control and the intention to purchase LED lighting have a positive association.

2.2.4 Personal moral norms

Ajzen and Fishbein (1977) define moral norms as, the perceived moral responsibility to execute or not to execute a particular behaviour. Chan and Bishop (2013) in their study, on moral basis for recycling define moral norms as, responsibility of an individual to behave morally. Moral norms, which is an important factor in Schwartz's norm activation model (1977), has been widely used as a construct, in research on adoption energy

efficient appliances, energy saving behaviour, adoption of renewable generation technologies by households (Jabeen et al., 2019). Tan et al. (2017) in their study, mention that moral norms have a significant influence on buying energy saving related products. Hence the hypothesis:

H4 Personal moral norms and purchase intention of LED lighting have a positive association.

2.2.5 *Aesthetics*

Noble and Kumar (2010), in their study mention that, aesthetics as a factor has often motivated consumer choice. They mention, ‘aesthetic compatibility’ meaning, consumers evaluate a product based on how best it looks in their home and pick up the product if they feel it looks good in their home. Aesthetics as a factor that determines energy efficient behaviour has been explored by few studies. Kumar et al. (2020) in their study on adoption of solar water heater include aesthetics as one of the constructs. They mention that aesthetics of solar product is an important factor for their adoption. Sovacool (2009), in his study mentions that people do not like to purchase solar products because they have large and unappealing designs. Since this study relates to lighting we feel aesthetics should be one of the constructs to examine whether it has a significant driver of adoption of LED lighting. Lighting is about aesthetics also, as much as it is about energy efficiency. Probably that is reason why some studies have talked about aesthetics of light in their study. For instance, Bladh and Krantz (2008) in their study on household use of electric light, discuss about the relationship between culture and preference for light. They mention that, Norwegian households prefer cosiness in the light whereas, Japanese households prefer proper vision. Therefore we hypothesise:

H5 Aesthetics and purchase intention of LED lighting have a positive association.

2.2.6 *Perceived cost*

Literature on adoption of energy efficient appliances is suffused with studies that have focussed on how the upfront cost of energy efficient appliances, proved to be an impediment in their adoption (Hausman, 1979; Houston, 1983; Newell and Siikamaki, 2015). These studies have discussed ‘Discount Rates’, which refer to an indicator of a consumer’s valuation of future benefits from current investment (Chunekar and Rathi, 2012). That is, consumers while purchasing an energy efficient appliance compare the initial cost of it, with future energy savings. Consumer would pay for energy efficient appliances only when he finds that the present value of future benefits is more than the incremental cost. Therefore we hypothesise:

H6 The perceived cost has a negative influence on purchase intention of LED lighting.

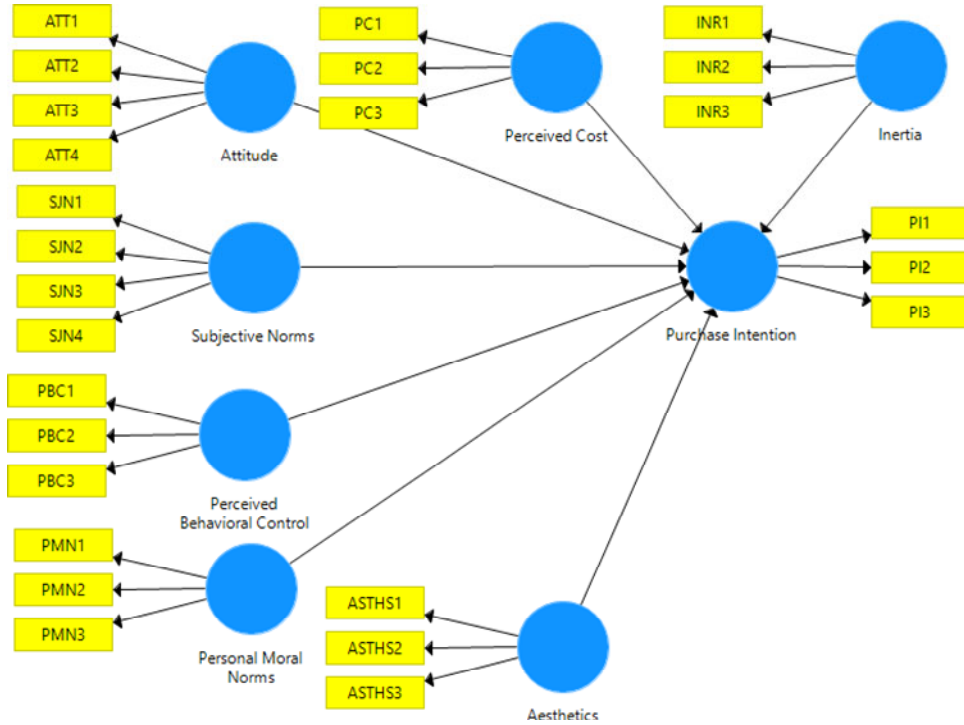
2.2.7 *Inertia*

There are studies that have focused on inertia or procrastination as an inhibitor of adoption of energy efficient appliances. Ek and Soderholm (2010) mention that, in the household decision related to electricity use, there is a presence of inertia which is very strong. Catteneo (2019) in her study talks about ‘status quo’ bias that is, sticking to

default settings, which she feels affects energy efficient choices. There is inertia in decision making process because decisions are postponed. So, the hypothesis:

H7 Inertia has a negative influence on purchase intention of LED lighting.

Figure 1 Conceptual framework (see online version for colours)



3 Research methodology

3.1 Sample and data collection

For data collection, a self-administered questionnaire was developed. First section of the questionnaire is demographic profile of the respondents and the second section consists of the constructs. The questionnaire was sent to 838 respondents residing in the six largest metro cities of India, namely, Delhi, Mumbai, Kolkata, Chennai, Hyderabad and Bengaluru. Responses were received from 555 of them. So the response rate is 66.5%. The sampling method that was used was a combination of convenience sampling and snowballing. Before the questionnaire was finalised, a pilot study was undertaken on 30 participants. After the pilot study, the questionnaire was revised based on the feedback of participants. A five-point Likert scale was used from strongly disagree = 1 to strongly agree = 5. The profile of the respondents is given in Table 1.

Table 1 Demographic details of the participants

<i>Variables</i>	<i>Frequency</i>	<i>Percentage</i>
<i>Age</i>		
Below 20 years	5	1
21–30 years	156	28
31–40 years	152	27
41–50 years	97	17
Above 50 years	145	26
<i>Education</i>		
Matriculation	13	2
Graduate	214	39
Post graduate	265	48
Doctorate	63	11
<i>Annual family income</i>		
Below 3,00,000 Rs.	70	13
3,00,001–5,00,000 Rs.	82	15
5,00,001–10,00,000 Rs.	174	31
Above 10,00,000 Rs.	229	41
<i>Gender</i>		
Male	387	70
Female	168	30
<i>Profession</i>		
Homemaker	27	5
Professional	187	33
Self-employed	75	14
Service	238	43
Others	28	5

3.2 Measures

The measures taken in the study are from research done previously and were suitably amended for the needs of this study. In case of attitude, the measures were taken from Li et al. (2020) and Tan et al. (2017). In case of subjective norms they were taken from Jabeen et al. (2019), Li et al. (2020) and Tan et al. (2017). In case of perceived behavioural control from Jabeen et al. (2019), Li et al. (2020) and Tan et al. (2017). In case of personal moral norms from Jabeen et al. (2019), Li et al. (2020) and Tan et al. (2017). In case of purchase intention, they were taken from Apipuchayakul and Vassanadumrongdee (2020) and Jabeen et al. (2019). In case of inertia, aesthetics and perceived cost, the measures were developed by the researchers from literature review.

Table 2 Constructs and measurement items

<i>Constructs</i>	<i>Item codes</i>	<i>Items</i>
Aesthetics	ASTHS1	LED lighting looks very good
	ASTHS2	The illumination from LED lighting is very pleasant
	ASTHS3	LED lighting gives me a feeling of comfort and cosiness
Attitude	ATT1	Saving electricity is a good idea
	ATT2	I have a favourable attitude towards energy efficient lighting
	ATT3	It is important to me whether lighting used in my house is energy efficient or not
	ATT4	Using LED lighting in my house would save electricity
Inertia	INR1	I do not want to change the present lighting forms that I have, such as CFL
	INR2	Purchasing LED lighting is not a priority for me right now
	INR3	I don't think energy efficiency of lighting is a major issue
Perceived behavioural control	PBC1	It is easy to use LED lighting in my house if I want to
	PBC2	Using LED lighting is entirely within my control
	PBC3	I have the resources and knowledge to use LED lighting
Perceived cost	PC1	I don't want to buy LED lighting because of its high cost
	PC2	I will buy LED lighting only if the electricity savings from it is more than the investment made in it.
	PC3	High cost of LED doesn't matter to me as they are energy efficient
Personal Moral norms	PMN1	It is my moral obligation to save electricity
	PMN2	Using energy inefficient lighting would go against my principles of saving electricity
	PMN3	I will feel bad, if I do not use LED lighting in my house
Purchase intention	PI1	I have intentions to buy LED lighting in future
	PI2	If lighting is required for my house I will always buy LED lighting
	PI3	I would give my strongest recommendations to others to use LED lighting in their house
Subjective norms	SJN1	My friends and neighbours around me encourage me to save electricity
	SJN2	If my friends, relatives and neighbours suggest me to purchase LED lighting, I will purchase
	SJN3	Publicity and appeals by government for energy conservation will motivate me to purchase LED lighting
	SJN4	People whose opinion I value would prefer that I purchase LED

3.3 Structural equation modelling

Structural equation modelling (SEM) with PLS software, is considered for the result analysis. In recent years SEM is being used in diverse fields, which includes tourism (Huang et al., 2009; Song and Li, 2012; Valle and Assaker, 2015), strategic management

(Hair et al., 2012), international business (Richter et al., 2015), energy efficiency (Hua and Wang, 2019; Wang et al., 2017). Literature mentions many advantages of using PLS SEM. When a theoretical framework is to be tested from a perspective of prediction, when the structural model is complex, and when the objective of the study is to understand theoretical extensions of established theories, PLS SEM is suitable (Hair et al., 2019). Another advantage that is very often mentioned of PLS SEM is that assumption of normality is not required (Nitzl, 2016; Valle and Assaker, 2015). Probably that is the reason why it has been called as 'silver bullet' (Hair et al., 2011). PLS SEM analysis is divided into two parts. The first part is, assessment of outer model, which is also called as measurement model, in which validity and reliability of the model is examined. The second part is assessment of inner model or structural model, in which hypothesis is tested and the predictive power of the model is assessed.

4 Analysis of results

4.1 Model fit results

Standardised root mean square (SRMR) test confirms whether the data that is compiled is a good fit for model estimation or not. If the value of SRMR is 0, it signifies a perfect fit. Hu and Bentler (1998) suggest a cut off of 0.08, that is, value above 0.08 is considered a bad fit. The SRMR for this study is, 0.077, which suggests a good fit (see Table 3).

Table 3 Results of measurement model (item loadings, internal consistency reliability and convergent validity)

<i>Constructs</i>	<i>Item codes</i>	<i>Outer loadings</i>	<i>Cronbach's alpha</i>	<i>Composite reliability</i>	<i>Average variance extracted (AVE)</i>
Aesthetics	ASTHS1	0.886	0.875	0.923	0.800
	ASTHS2	0.905			
	ASTHS3	0.891			
Attitude	ATT1	0.666	0.729	0.828	0.548
	ATT2	0.793			
	ATT3	0.695			
	ATT4	0.798			
Inertia	INR1	0.838	0.767	0.862	0.676
	INR2	0.885			
	INR3	0.737			
Perceived behavioural control	PBC1	0.869	0.821	0.893	0.735
	PBC2	0.870			
	PBC3	0.831			
Perceived cost	PC1	0.776	0.620	0.762	0.534
	PC2	0.445			
	PC3	0.895			
Personal moral norms	PMN1	0.755	0.622	0.794	0.564
	PMN2	0.655			
	PMN3	0.833			

Table 3 Results of measurement model (item loadings, internal consistency reliability and convergent validity) (continued)

<i>Constructs</i>	<i>Item codes</i>	<i>Outer loadings</i>	<i>Cronbach's alpha</i>	<i>Composite reliability</i>	<i>Average variance extracted (AVE)</i>
Purchase intention	PI1	0.777	0.825	0.895	0.741
	PI2	0.899			
	PI3	0.900			
Subjective norms	SJN1	0.623	0.796	0.866	0.621
	SJN2	0.845			
	SJN3	0.806			
	SJN4	0.856			

4.2 Assessing the measurement model

As a first step, indicator loadings are examined. The values of indicator loadings should be above 0.708, which shows that, more than 50% of indicator's variance is explained by the construct (Hair et al., 2019). The indicator loadings below 0.7 need to be removed. However literature shows that even loadings between 0.4 and 0.7 can be retained and should be considered for removing only if composite reliability (CR) can be increased, (Hair et al., 2017). Tabachnick and Fidell (2007) recommend loadings above 0.55 as good. Even in studies on energy efficiency, researchers obtained values below 0.7 for some of the outer loadings (Ali et al., 2019). In this study, only five outer loadings are below 0.7. The remaining loadings are much above the threshold limit of 0.708, which indicates, that construct explains 50% variation in the indicator. It means that, items are reliable (see Table 3).

In the second step, internal consistency reliability and convergent validity are examined. The internal consistency reliability is measured by Cronbach's alpha and also by composite reliability (CR). If the values of these indicators are between 0.7 and 0.9, then it means good reliability (Hair et al., 2019). Cronbach's alpha of all the constructs except of two is above 0.7. Cronbach's alpha of two constructs is above 0.6. When it comes to comparison between Cronbach's alpha and CR, the latter is considered as a superior measure of reliability than the former (Hair et al., 2017; Tan et al., 2017; Waris and Hameed, 2020). CR above 0.7 is considered good. In this study, the CR of all the constructs is more than 0.7, indicating high reliability (Hair et al., 2019). The values of Cronbach alpha and CR are given in Table 3.

After testing the reliability, the next step is testing the validity. Convergent validity and discriminant validity are two types of validity that are tested. Convergent validity is measured by average variance extracted (AVE), which shows the extent to which the construct converges to explain the variance in dependent variable. An AVE of 0.5 and above is considered good, since it explains 50% of the variance. The AVE of all the constructs in this study are above 0.5, indicating, high convergent validity (see Table 3).

Discriminant validity tests whether the constructs are distinct from each other or not. It examines the correlations between the measures of overlapping constructs (Tan et al., 2017). In simple words it means, whether the respondents of the survey were able to clearly distinguish between one construct and the other. There are two measures of discriminant validity: Fornell-Lacker criteria and heterotrait-monotrait ratio (HTMT).

HTMT ratio is considered superior to Fornell-Lacker criteria, as some researchers (Henseler et al., 2015) found that Fornell-Lacker criteria does not give good results if the difference between indicator loadings are too small. Henseler et al. (2015) suggest that, when the constructs are different, a threshold value of 0.85 is good. For examining the discriminant validity, the diagonal elements of the HTMT table needs to be seen. If those values are within the threshold limits of 0.85, then there is no discriminant validity problem (see Table 4). All the values are within the limit of 0.85, which means the problem of discriminant validity is not there.

Table 4 Discriminant validity analysis – HTMT ratio

<i>Construct</i>	<i>Aesthetics</i>	<i>Attitude</i>	<i>Inertia</i>	<i>Perceived behavioural control</i>	<i>Perceived cost</i>	<i>Personal moral norms</i>	<i>Purchase intention</i>	<i>Subjective norms</i>
Aesthetics								
Attitude	0.508							
Inertia	0.201	0.414						
Perceived behavioural control	0.539	0.699	0.330					
Perceived Cost	0.384	0.319	0.609	0.535				
Personal moral norms	0.587	0.809	0.466	0.728	0.491			
Purchase intention	0.693	0.702	0.472	0.714	0.575	0.734		
Subjective norms	0.561	0.66	0.345	0.667	0.491	0.739	0.709	

4.3 Assessment of structural model

After the assessment of measurement model, structural model is assessed. The assessment of structural model involves finding out the R^2 which explains the extent to which the variance in dependent variable is explained by the independent variables, f^2 which measures the effect size of each of the independent variables, Stone Geisser's Q^2 , which measures the predictive relevance of the model. Another important step in the process of assessment of structural model is, finding out the significance of path coefficients, that is, hypothesis testing. Variance inflation factor (VIF) is also calculated, to see if there are any collinearity issues among the independent variables. The threshold limit of VIF is 3, which signifies that there is no multicollinearity among the independent variables. .

Table 5 shows the results of structural model, which consists of hypothesis testing. Table 5 also shows the value of R^2 and values of f^2 . R^2 value is, 0.609, which means, the independent variables explain 60.9% of variation in the dependent variable, which is substantial as per Hair et al. (2019). The values of f^2 of all the independent variables are less than 0.15, which means the effect sizes are small (Cohen, 1988).

Table 5 Structural model results

Hypotheses	Path	Path coefficient	R ²	f ² effect size	T statistics	P values	Model fit – SRMR
H1	Attitude → Purchase intention	0.165		0.037	4.061	0.000	
H2	Subjective norms → Purchase intention	0.142		0.027	3.332	0.001	
H3	Perceived behavioural control → Purchase intention	0.143		0.027	3.377	0.001	
H4	Personal moral norms → Purchase intention	0.075		0.008	1.857	0.063	
H5	Aesthetics → Purchase intention	0.279		0.135	7.704	0.000	
H6	Perceived cost → Purchase intention	0.168		0.047	4.381	0.000	
H7	Inertia → Purchase intention	-0.122		0.030	4.06	0.000	
Dependent variable in the model	Purchase intention		0.609				
Model fit			SRMR				0.077

Hypothesis testing is done by analysing the path coefficients. This has been done by a process of bootstrapping with 5,000 resamples. Based on the analysis of path coefficients, it is found that among the drivers of LED adoption, except personal moral norms all other antecedents proved to be significant determinants of purchase intention of LED. Among the inhibitors, perceived cost did not have the negative relationship, which was against our assumption, whereas inertia, which was assumed to be another inhibitor, was found to have negative relationship.

As depicted in Table 5, attitude (H1, $\beta = 0.165$, $t = 4.061$, $p < 0.000$) has a positive association with purchase intention. Subjective norms showed a positive association with purchase intention (H2, $\beta = 0.142$, $t = 3.332$, $p < 0.001$) Perceived behavioural control also revealed a significant positive association (H3, $\beta = 0.143$, $t = 3.337$, $p < 0.001$). The association between personal moral norms and purchase intention was found to be insignificant (H4, $\beta = 0.075$, $t = 1.857$, $p < 0.063$). Aesthetic sense was found to have highest positive significant relationship in this study (H5, $\beta = 0.279$, $t = 7.704$, $p < 0.000$).

Among the antecedents, that were assumed to be inhibitors, perceived cost was not found to be an inhibitor, as there was no negative association between perceived cost and intention to purchase LED lighting (H6, $\beta = 0.168$, $t = 4.381$, $p < 0.000$). Inertia which was assumed to be another inhibitor, was found to have negative relationship, as assumed (H7, $\beta = -0.122$, $t = 3.332$, $p < 0.000$).

The value of Q² is shown in Table 6. The Q², which is obtained by a process called blindfolding, is 0.434, which signifies high predictive power of the model. According to Hair et al. (2019), the values of Q² higher than 0 are meaningful and those above 0.25 and

0.50 have medium and high predictive accuracy respectively (Hair et al., 2019). So this model is much above the medium predictive accuracy.

Table 6 Blindfolding test for predictive relevance (Q^2)

<i>Construct</i>	<i>SSO</i>	<i>SSE</i>	$Q^2 (=1 - SSE/SSO)$
Aesthetics	1,665	1,665	
Attitude	2,220	2,220	
Inertia	1,665	1,665	
Perceived behavioural control	1,665	1,665	
Perceived cost	1,665	1,665	
Personal moral norms	1,665	1,665	
Purchase intention	1,665	941.776	0.434
Subjective norms	2,220	2,220	

4.4 Importance performance map analysis

The importance-performance map analysis (IPMA), which is one of the neglected methods, helps researchers in enhancing their PLS SEM analysis by giving some additional insights (Ringle and Sarstedt, 2016). In studies on energy efficiency also, very few have focussed on IPMA like Zahari and Esa (2018). In simple terms, IPMA makes a comparison between importance (total effect) of the predecessor constructs (independent variables) and their performance which is indicated by their average variable scores (Fornell et al., 1996). IPMA helps in prioritising the constructs to improve a target construct (Ringle and Sarstedt, 2016). The objective of IPMA is to focus on those predecessor constructs that are high on importance but relatively low on performance, which require the attention of policy makers and managers. More the construct is to the right, more important it is. More the construct is at the lower end, less is its performance. According to priority, the lower right area (high importance-low performance) in IPMA should be given maximum attention by managers and policy makers, and then the higher right, lower left and finally higher left. Figure 2 depicts the IPMA of the constructs on the whole. Figure 3 depicts the IPMA of individual indicators of the predecessor constructs. This will further help in understanding the importance-performance of each of the indicators, and gives more insights.

Figure 2 shows aesthetics is more important than attitude, but relatively low in performance when compared to attitude. Even when compared to perceived behavioural control, aesthetics is relatively less in performance, even though in terms of importance it is much higher when compared to perceived behavioural control. Therefore the policy makers and the manufactures of LED need to further give their attention to aesthetics of LED, so that it further improves the purchase intention of LED.

According to Figure 3, all three indicators of aesthetics are high in importance when compared to all the indicators of all other constructs. However in terms of performance all three indicators of aesthetics are lower than the indicators of attitude. This further gives insights to the stakeholders to pay more attention to the aesthetics of LED. Among the three indicators of aesthetics ASTHS3 (LED gives me a feeling of comfort and cosiness) is lower in performance, indicating that this part of LED aesthetics should be given more attention. Among the four indicators of attitude, ATT4 (using LED lighting in

my house would save electricity) is low in performance but high in importance, thus indicating, more attention should be given to this aspect.

Figure 2 Importance performance map analysis (construct)

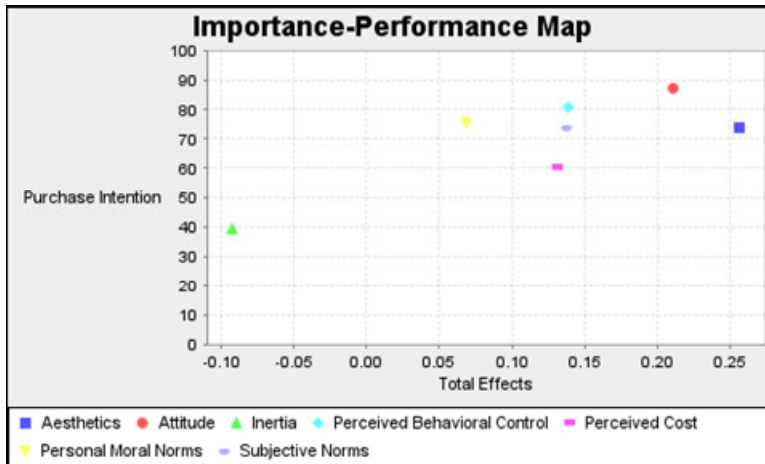
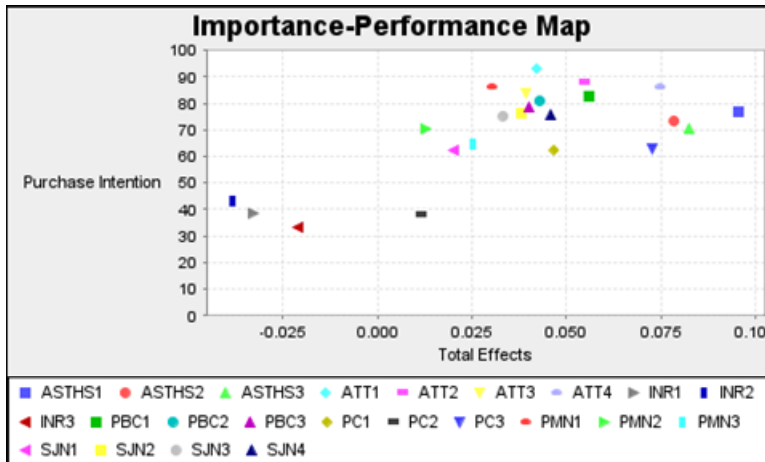


Figure 3 Importance performance map analysis (indicators) (see online version for colours)



5 Discussions, policy implications, limitations and future research directions

5.1 Discussions and policy implications

At a time when research (Akadiri et al., 2019) has found positive relationship between economic growth and energy consumption, this study is timely. The hypothesis results show that, out of the five antecedents that were assumed to be the drivers of purchase intention of LED lighting, all except personal moral norms proved to be significant

predictors of purchase intention of LED. Among all the drivers aesthetics showed highest positive significance. This finding is, contrary to the study by, by Kumar et al. (2020) who found an insignificant relationship between aesthetics and purchase intention towards solar water heater. This shows that, people in India seem to give importance to the aesthetics of lighting and that, they have aesthetic sense. It appears that the illumination of LED, the way LED lighting looks and the comfort that it gives matters a lot to Indians. This may be because, lighting illuminates the interior and as such the comfort and cosiness it gives matters a lot. This finding is important for policy makers and manufacturers of LED lighting. Government in India needs to encourage the manufactures of LED lighting to make LED lighting products which look very stylish and give comfort in terms of illumination. Electric Lamp and Component Manufacturers' Association of India (ELCOMA) which plays a pivotal role in manufacturing of LED lighting, needs to pay due attention to the aesthetics and keep innovating to improve luminance, colour combinations which add to the aesthetics of LED lighting. It needs to be mentioned that, the 'LED lighting chapter', which is a semi-autonomous body of ELCOMA, consists of all the stakeholders such as, LED manufacturers, R&D organisations, engineers, architects, designers (Ministry of Power, 2010). This will certainly enhance the standards of LED lighting and its aesthetics. The IPMA analysis, shown in Figures 2 and 3, brings out the fact there is a room for improving the aesthetics of LED, so that the purchase intention can be further improved. Comfort and cosiness requires more attention by the manufactures of LED. ELCOMA, BEE and Bureau of Indian Standards (BIS), which is a national standard body of India, should jointly make efforts in improving this aspect of LED.

After aesthetics, attitude showed positive significant relationship in the study. Other studies such as that of Apipuchayakul and Vassanadumrongdee (2020), Halder et al. (2016) and Hua and Wang (2019), also showed similar findings. This means, people in India have a positive attitude towards purchasing energy efficient lighting like LED because they believe that it is important to be energy efficient in lighting and saving electricity is a good idea and that, LED would save electricity. It appears that they are of the opinion that reduction in electricity consumption is very important. For the policy makers, this is an important insight. They should tweak this positive attitude among the people. India is taking up manufacture of LED on a big scale as a part of its 'Make in India' campaign. A positive attitude of people towards energy efficient lighting, would further give a boost to production of LED. Even IPMA results confirm the significance of attitude as an important variable determining the purchase intention of LED. IPMA results further show that ATT4 requires more attention because although relatively high in importance when compared to other indicators of attitude, it is relatively less in performance. So the promotional campaigns of LED should emphasis on the fact that, using LED would save electricity.

Perceived behavioural control was found to be another antecedent having a positive significant relationship with purchase intention of LED. This finding is similar to the findings of Alam et al. (2014), Ali et al. (2019) and Parikh and Parikh (2016). It means when people feel that it is easy to buy and install LED in their residences and if they feel buying LED is within their control they will certainly buy it. To this end the policy makers again have to make efforts for easy availability of LED and the manufacturers need to pay due attention to the design of LED lighting in such a way that they are easy to install. In this regard it needs to be mentioned that Government of India through the

UJALA program, is distributing LED through distribution kiosks, so that they are readily available to the people. This may further boost the sale of LED.

After aesthetics, attitude and perceived behavioural control, the study found subjective norms to have significant positive relationship. Subjective Norms showed a positive, significant association with intention to purchase. This finding is unlike some studies (Apipuchayakul and Vassanadumrongdee, 2020; Tan et al., 2017), that found non-significant relationship between the two. However there are some studies that found a significant positive association between the two (Hai, 2019; Waris and Ahmed, 2020). This shows that Indians value the opinion of their peers, friends, relatives and neighbours. Indian society is very much assimilated and that is why feedback from people around is given lots of importance. Therefore a positive word of mouth about LED lighting would result in its adoption by many. The significant positive relationship of SJN with purchase intention further confirms that, persuasive appeals by government also influence the purchase intention. Policy makers need to give wide publicity of advantages of LED lighting through media. If possible road shows and campaigns need to be held. The UJALA program of the government needs to be given wide publicity through advertisements. For this purpose government needs to resort to celebrity endorsement as it did it in case of another flagship program called Swatch Bharat Mission. Manufactures of various LED brands also need to constantly advertise the inherent benefits of using LED working in tandem with the government. Government should take the help of those households who have already installed LED in their house for spreading the information regarding positive benefits of using LED.

Personal moral norms, is the only antecedent that showed insignificant relationship with purchase intention. Jabeen et al. (2019) also found an insignificant relationship between moral norms and adoption of renewable power generation technology. However, Li et al. (2020) found a positive relationship between personal moral norms and habitual saving intention of electricity. It means although Indians are positively inclined to purchase LED, they do not consider buying energy efficient lighting form moral obligation point of view. This finding is very significant for the policy makers. It is necessary that they need to publicise that it is a moral obligation to save electricity. People need to be constantly told about the adverse impact of inefficient energy consumption. The attitude of the consumer is influenced towards environmentally friendly products such as LED, if they feel it is their moral duty to preserve the environment (Moghavvemi et al., 2020). Therefore emphasis on moral norms is essential. Lessons on energy efficiency should be a part of curriculum in schools, which will inculcate moral norms at an early stage in life.

Findings show that perceived cost which was assumed to be the inhibitor is not an inhibitor at all. This is probably because people do not see purchasing LED lighting as a big burden on the budget. Lighting is not seen as a luxury good like AC and Refrigerators. It appears that people would not mind paying a little more on LED if it is saving electricity. Probably they are also aware that, in the long run, electricity savings from using LED will more than compensate for the high initial cost that they pay. This is a significant finding which would help manufacturers of LED to strategise their pricing technique in a better manner. The study suggests that a reduction in price of the LED may boost the sales even more.

Inertia, which was another antecedent, that was assumed to be the inhibitor showed a negative sign, revealing that Indians seem to procrastinate when it comes to buying LED

lighting. They do not see it as a priority. Even though they have a positive attitude towards energy efficient lighting, in case they have already purchased another lighting form they are not much interested in changing it. Hesselink and Chappin (2019), their study call this attitude as, 'persisting with sunk costs'. That means, people show an inclination to stick to status quo, because they want to avoid hidden costs that go with a switch. Policy makers and manufacturers can solve this problem by nudging the people to shed their inertia. This again can be done through messages and slogans that highlight the importance of shedding the inertia of continuing with energy inefficient lighting. After Richard Thaler got Nobel Prize for his 'nudging' theory, nudging as a behavioural intervention tool is getting increasing attention. This can very well be used in the domain of energy efficiency.

5.2 Limitations and future research directions

This research focuses only on the purchase intention of LED. Further research is required, to study whether this purchase intention has been translated into purchase behaviour or not. A study on actual purchase behaviour will give better insights. Another limitation of this study is that, it focuses only on six largest metropolitan cities of India. The study can be extended to other cities in India and also to rural India. In fact research has shown that rural India is still not very inclined to adopt energy efficient lighting (Chunekar et al., 2018). So pan India study comparing the six metros with other cities and with rural India would be a fertile area of research. A study considering demographic variables as moderators is also necessary. Moreover, this study considers few antecedents. There can be a study with some more variables such as environmental knowledge, past purchase experience and perceived risk. Previous studies (Mills and Schleih, 2008) have shown that, household characteristics such as, floor space, household member characteristics, can also be the determinants of adoption of energy efficiency lighting. This study can be extended by considering such factors. A comparative analysis of lighting with other household electricity appliances, taking the same antecedents, can also be an interesting area of study. Such a comparative analysis will give insights into the fact whether households view energy efficiency in lighting differently from that of other appliances. A comparative analysis using the same framework can be done between India and other countries. In spite of the limitations, this research has given some insights into the drivers and inhibitors of purchase intention of LED in lighting in six largest metros of India. This study can very well become a base for other studies focussing on energy efficient lighting not only in India, but also elsewhere in the world.

6 Conclusions

The study focused on drivers and inhibitors of LED lighting in India. The number of respondents of the study was 555 residing in the six largest metropolitan cities of India. The method of sampling that was used was convenience sampling and snowballing. Structural equation modelling with PLS software was considered for result analysis. All the results were found to be robust as far as reliability and validity was concerned. The study also passed the model fit test. Hypothesis testing showed that, out of five antecedents that were assumed to be drivers, only personal moral norms showed an insignificant association with the purchase intention of LED. All other antecedents,

attitudes, subjective norms, perceived behavioural control, aesthetics, showed a significant positive association with purchase intention. Aesthetics showed the highest positive significant relationship with purchase intention, followed by attitude, perceived behavioural control and subjective norms. Among the antecedents that were assumed to be inhibitors perceived cost did not prove to be an inhibitor, whereas inertia proved to be an inhibitor. Certain limitations of the study were identified, which can be future research directions. India is making concerted efforts to achieve energy efficiency and energy conservation. This study would give insights to the Indian Government at the centre, which is assiduously trying to promote the adoption of LED lighting, through its UJALA program in a big way. There is a need for synergy between government and manufactures of LED to promote adoption of LED among residential electricity consumers in a big way by highlighting the benefits of purchasing energy efficient lighting such as LED.

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