AN ASSESSMENT OF THE INTERNAL CONSISTENCY OF MEASURES OF CONSTRUCTS USED TO REVISE THE INNOVATION DECISION FRAMEWORK

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ABSTRACT
This research emerges from the integration of the diffusion of innovations literature and renewable energy literature. This paper examines the internal consistency of multi-item measures of constructs that have been used to extend the diffusion of innovations model proposed by Rogers (1995) and Kaplan's (1999) new innovation-decision framework. It recognises the importance of proper operationalisation of theoretical constructs. Multi-item scales were used to measure each of the three constructs — *Government Initiatives, Demonstration Sites and Finance.* The item pool for each construct was drawn largely from renewable energy literature. Multi-item scales were used to measure each construct in order to increase internal consistency and to decrease measurement errors. The Internal Consistency Reliability analysis approach adopted in the study allowed for identification of variables which were reliable measures of these constructs.

INTRODUCTION
This research emerges from the integration of the diffusion of innovations literature and renewable energy literature. The objective of this paper is to examine the internal consistency of multi-item measures of constructs that have been used to extend the diffusion of innovations model proposed by Rogers (1995) and Kaplan's (1999) new innovation-decision framework. Kaplan examined the factors that influenced the interest of utility managers in adopting solar-based technology. He proposed that interest is the product of heightened knowledge of the technology. Knowledge is the product of Motivation and Experience. In an attempt to fill the gap between knowledge and Interest, Kaplan included Experience and Familiarity as intervening variables and identified causal relationships that were not examined earlier.

Further investigation of the literature has led to the identification of other variables. The effect of independent variables such as Government Initiatives, and Demonstration Sites on Experience, Knowledge and Interest has not been studied in the context of diffusion of photovoltaic (PV) power supply systems in developing countries. The availability of Finance is another crucial factor in the adoption of PV Systems. Finance was identified as another intervening variable in addition to, Experience, Knowledge and Familiarity. Peter and Dickie's (2005) revised framework establishes the relationships between these variables and the decision to adopt.

The discussion in this paper revolves around issues pertaining to the reliability of measures of Government initiatives, Demonstration Sites and Finance. These constructs were developed largely from renewable energy literature and there are no scales to measure them. This paper is a step in the development of scales to measure these constructs.

LITERATURE REVIEW

Government Initiatives

The government can play a leading role through the formulation of favourable policies, by showing a practical commitment and by enhancing public awareness of the potential of PV in all walks of life. (Muntasser et al. 2000). It should disseminate information pertaining to the environmental and other benefits of PV with a view to educating the industry and public (Cesta & Decker 1978). Government intervention for fostering diffusion of PV systems include provision of: tax incentives soft loans, subsidies, credit services, direct support of the distribution system and liberalized foreign investment procedures (Rubab & Kandpal 1996; Martinot 1998; Muntasser et al. 2000). Government should also publish the results of comparative analysis of solar systems and conventional systems (Cesta & Decker 1978). There is a need to develop system standards for all the main system components. Establishing performance standards for PVs, establishing independent testing centres and government endorsing of solar systems are measures that will serve to boost the confidence level of PV users (Cesta & Decker 1978). Government intervention, therefore, is necessary in a number of ways to promote solar energy

Demonstration sites

Demonstration plants are being set up in developing countries as they serve a number of purposes. However, their numbers are limited and therefore more are needed in different parts of these nations in order to significantly raise the level of awareness of PV systems (Adurodija, Asia & Chendo 1998). Demonstration projects facilitate trials of PVs and provide data for comparison with conventional systems (Nayar 1997, Koner & Dutta, 1998). The publication of these results leads to these projects serving as centres for dissemination of information on PV systems. Further they enhance the delivery and installation infrastructure that is available in the country as they provide technical assistance, technician training and other valuable inputs (Marawanyika 1997). Qualified and trained workers install PV systems. End-users are trained on preventive maintenance. These measures increase the quality of the installation infrastructure (Gope, Aghdasi & Dlamini 1997).

Finance

The capital needs are high when investing in renewable energy technologies (RETs) such as PV systems. Therefore, well-adapted financial schemes and financial support are essential for the adoption of these technologies (Langniss 1996). Financial institutions are not always interested in giving or opening lines of credit for private PV investors (Muntasser et al. 2000). Hence, there is a need for some sort of financing mechanism along the lines of traditional banking channels. In India, the Indian Renewable Energy Development Agency (IREDA) provides credit for renewable energy users, manufacturers and producers at concessional terms initially, which progressively approach commercial market rates as the technology gains wider acceptance (Nayar 1997). The initial costs of PV systems are high and, hence, the acceptance of PV systems will depend on the financial viability of investments in PV systems (Bugaje 1999; Rubab & Kandpal 1996). The high outlay required of these systems is a major barrier for a broader market penetration of this technology (Hass et al. 1999). A comparative cost analysis of PV power generation and DG power generation, undertaken by Koner and Dutta (1998) based on six years of field data revealed that the unit cost of PV electricity is cheaper or comparable with that from DG power at present market price.

RELIABILITY

Multi-item scales should be evaluated for accuracy, reliability and applicability. Measurement accuracy refers to capturing the responses as the respondent intended them to be understood. Errors can result from either systematic error, which affects the observed score in the same way on every measurement, or random error, which varies with every measurement (Malhotra 2007). Multi-item scales consist of a number of rating scale items where the responses are usually summed over the items to determine an overall or total score. The true score model provides a framework for understanding the accuracy of measurement.

According to this model:

$$X_O = X_T + X_S + X_R$$

where

X_O = the observed score or measurement
X_T = the true score of the characteristic
X_S = systematic error
X_R = random error

The total measurement error is the sum of the systematic error, which affects the model in a constant fashion, and the random error, which affects the model randomly. Systematic errors occur due to stable factors which influence the observed score in the same way on every occasion that a measurement is made. However, random error occurs due to transient factors which influence the observed score differently each time (Malhotra 2007).

Scale evaluation involves assessment of Reliability which refers to the extent to which a scale reproduces consistent results if repeated measurements are made. Systematic error does not affect reliability since their influence on the measurement is constant. Random error on the other hand produces inconsistency, and causes lower reliability. Thus, reliability can be understood as the extent to which measures are free from random error. In other words if XR = 0, the measure is perfectly reliable (Zikmund and Babin 2007).

There are different ways of assessing reliability such as test-retest, alternative forms and internal consistency methods. The test-retest reliability administers the same scale at two different times and measures the correlation between the results. The time interval varies between two to four weeks. The correlation coefficient is a measure of the degree of similarity and higher correlations imply greater reliability. Alternative-forms reliability uses two equivalent forms of a scale which are administered to respondents at two different times. The scores for the two tests in which alternative scale forms are used, are correlated to assess reliability (Malhotra 2007).

The internal consistency reliability approach can be applied to assess the reliability of a summated scale where several items are summed to form a total score. Each item can be considered to measure some aspect of the construct and the items should be consistent in what they indicate about the construct. Split-half reliability is a simple measure of internal consistency, where the items on the scale are divided into two halves. High correlations between the results of these halves indicate higher degrees of internal consistency. A potential problem is that the manner in which the scale items are divided could affect the results (Zikmund and Babin 2007).

This is overcome by adopting the Cronbach's alpha as a measure of the internal consistency of the items. The Cronbach's alpha is the average of all possible split-half coefficients resulting from different ways of splitting the scale items. The Cronbach's alpha varies from 0 to 1 and values greater than 0.7 indicate higher degrees of internal consistency. The three commonly used model based measures of reliability include the squared multiple correlations, item-total correlations and reliability as assessed by Cronbach's alpha (Hair et al. 1998).

METHODOLOGY

A combination of extensive literature review and results of the pre-tests led to the development of the final questionnaire, which was used as the survey instrument in this study. Single-item measures are generally deficient both with respect to validity and reliability (Pedhazur & Schmelkin 1991). Hence multi-item scales were resorted to and the development of multi-item scales starts with an understanding of the underlying construct being measured. The item pool was drawn from literature and relates to these three constructs used in Peter-Dickie's (2005) framework.

Scales of Measurement for Government Initiatives

Government initiatives refer to the actions that are required to be taken by the government to promote and foster the adoption of solar-based power supply systems. This construct was assessed by eleven items GI1 to GI11, drawn from Cesta & Decker (1978), DeLaquil (1996) Adurodija et al (1998) and Muntasser (2000). Respondents were asked to rate the importance of the role of government in fostering the commercialization of solar PV systems on a seven point Likert type scale from 1 = Not Important to 7 = Very Important as the anchor points (Cesta & Decker 1978). The variables measuring government initiatives include:

- Creating awareness by providing helpful information (Adurodija et al. 1998).
- Disseminating relevant information (Adurodija et al. 1998).
- Promoting use of solar systems (Cesta & Decker 1978).
- Publishing results of comparative analysis of solar systems with conventional systems (Cesta & Decker 1978).
- Providing tax incentives for users (DeLaquil 1996).
- Providing tax incentives for producers (DeLaquil 1996).
- Providing subsidies for installing PV systems (Cesta & Decker 1978).
- Providing concessional financing for installing PVs (Adurodija et al. 1998).
- Establishing performance standards for PVs (Adurodija, et al. 1998).
- Establishing independent testing centers for PVs (Cesta & Decker 1978).
- Removing subsidies to fossil fuels such as diesel (DeLaquil 1996; Edinger & Kaul 2000).

Scales of Measurement for Demonstration Sites

Demonstration sites/projects of PV systems have an important role to play in creating awareness, disseminating information, facilitating trials, providing comparative data and promote the use of PV Systems. Respondents' assessments for each item were obtained via a

7 point Likert scale from 1 = Strongly Disagree to 7 = Strongly Agree. The variables are DS1 to DS5 and the items include:

- Demonstration projects promote awareness of PVs (Sastry 1997; Adurodija et al. 1998).
- Demonstration projects provide comparative data of PV systems against conventional systems. (Koner & Dutta 1998; Nayar 1997)]
- Demonstration projects serve as centres for dissemination of information on PV systems (Nayar 1997; Adurodija et al. 1998).
- A number of demonstration projects/sites set-up in different parts of India would serve to promote the use of PV systems to a greater degree (Choffray and Lilien 1978; Adurodija et al. 1998).

The proximity of these demonstration projects is another important factor and this is assessed through DS1 where the respondent is asked to rate the importance of the following statement on a 7-point scale of 1 = Not Important to 7 = Very Important - Proximity of demonstration sites where PV systems have been installed (Marawanyika 1997).

Scales of Measurement for Finance

Finance relates to financial support that may be available through the government/funding agencies in the form of concessional loans at attractive credit terms. The other elements of finance are the initial cost of PV based power supply systems and their comparative costs. These are operationalised through five variables, FIN1 to FIN5 in the final questionnaire. A seven point Likert type scale from 1 = Not Important to 7 = Very Important (Labay & Kinnear 1981) was used to assess the responses of respondents. The five items are:

- Availability of Concessional Loans (Sastry 1997; Nayar 1997).
- Availability of finance exclusively for renewable energy projects from lending institutions such as IREDA (Gope et al. 1997; Nayar 1997; Sinha et al. 1998).
- Credit terms of these Financial Institutions (Marawanyika 1997; Nayar 1997; Sinha et al. 1998).
- Initial capital cost of PV systems (Labay and Kinnear 1981; Roy and Gupta 1996; Gope et al. 1997).
- Comparative cost of PV systems vis-à-vis conventional systems (Bugaje 1999; Koner & Dutta 1998; Roy & Gupta 1996).

Data collection:

The Directory of Hotels and Resorts in India was used as the sampling frame as it provided a comprehensive listing of the target population. The hotels were categorized according to their star ratings and adequate care was taken to ensure a representative sample. The sample size of 205 was spread across six Indian cities covering the different regions of the country. The data was collected from the hotels, using a structured questionnaire, by a prestigious market research firm in India. The results of the reliability analysis are discussed in the next section.

RESULTS

Government Initiatives

Government Initiatives was assessed by eleven items (GI1 to GI11). The variable GI11 was dropped because of low inter-item correlation (r = 0.135) and very low squared multiple correlations (r2 = 0.075). Thus ten variables GI1 to GI10 were retained as variables demonstrating internal consistency in this analysis. The Item-Total Correlations for these ten variables were greater than 0.6. The squared multiple correlations were greater than 0.5 for all the variables. The standardised Cronbach's alpha ($\propto$) was 0.938 and hence these ten items were assessed as internally consistent measures of Government Initiatives. Details of the reliability statistics are shown in Table 1.

Table 1 : Statistics for Measures of Government Initiatives

Variable	Mean* ($\bar{x}$).	Item-Total Correlations	Squared Multiple Correlations (r^2)	Cronbach's Alpha** (if Item Deleted)
GI1	6.11	.618	.555	.936
GI2	5.91	.730	.687	.931
GI3	6.02	.796	.683	.929
GI4	5.93	.703	.543	.932
GI5	6.06	.825	.835	.927
GI6	5.86	.766	.747	.930
GI7	6.02	.801	.787	.928
GI8	5.99	.832	.791	.926
GI9	6.00	.755	.650	.930
GI10	5.84	.659	.508	.935

*Number (N) of responses; N = 205; Scale Used: 1 = Not Important to 7 = Very Important
**Standardised Cronbach's alpha $\propto$ = 0.938

Demonstration Sites

Four variables DS2, DS3, DS4 and DS5, were identified as reliable measures of Demonstration Sites,. The variable DS1 was dropped from the analyses because of low inter-item correlation (r = 0..242) and very low squared multiple correlations (r2 = 0.086). Thus four variables DS2 to DS5 were retained as variables demonstrating internal consistency in this analysis. The Item-Total Correlations for these four variables were greater than 0.6. The squared multiple correlation was greater than 0.5 for all the variables. The standardised Cronbach's alpha ($\propto$) was 0.863 and hence these four items were assessed as internally consistent measures of Demonstration Sites. Details of the reliability statistics are shown in table 2.

Table 2 : Statistics for Measures of Demonstration Sites

Variable	Mean ($\bar{x}$).	Item-Total Correlations	Squared Multiple Correlations (r^2)	Cronbach's Alpha** (if Item Deleted)
DS 2	5.67	0.700	0.505	0.829
DS3	5.40	0.729	0.545	0.817
DS4	5.42	0.707	0.521	0.826
DS5	5.62	0.707	0.510	0.826

*Number (N) of responses; N = 205; Scale Used: 1 = Strongly Disagree to 7 = Strongly Agree
**Standardised Cronbach's alpha, $\propto$ = 0.863

Finance

Finance was measured by five variables FIN1 to FIN5. The inter-item correlation of all the items were greater than 0.56 and the squared multiple correlations were higher than the recommended level of 0.5. The standardised Cronbach's alpha ($\propto$) was 0.859 and hence these five items were assessed as internally consistent measures of Finance. Details of the reliability statistics are shown in Table 3.

Table 3 : Statistics for Measures of Finance

Variable	Mean ($\bar{x}$).	Item-Total Correlations	Squared Multiple Correlations (r^2)	Cronbach's Alpha** (if Item Deleted)
FIN1	5.37	0.667	0.600	0.833
FIN2	5.38	0.760	0.688	0.805
FIN3	5.43	0.710	0.553	0.818
FIN4	5.87	0.686	0.608	0.826
FIN5	5.85	0.561	0.500	0.855

*Number (N) of responses; N = 205; Scale Used: 1 = Not Important to 7 = Very Important
**Standardised Cronbach's alpha, $\propto$ = 0.859

The key statisitics from the reliability analysis are summarised in Table 4. An examination of the Cronbach's Alpha ($\propto$) reveal that all of them were greater than 0.85. Thus, the scale reliability was very good and the squared multiple correlations were greater than 0.50. There is therefore sufficient evidence to support that the individual variables identified in the reliability analysis were good measures of the three constructs - Government Initiatives, Demonstration Sites and Finance.

Table 4 : Summary Statistics

Measures	Government Initiatives	Demonstration Sites	Finance
Cronbach's Alpha ($\propto$)	0.938	0.863	0.859
No of items	10	4	5
Squared Multiple Correlations	> 0.5	> 0.5	> 0.5
Item to Total Correlations	> 0.61	> 0.70	> 0.56
Item Means	5.974	5.528	5.579
Item Variances	1.589	1.930	3.030

CONCLUSION

The results of the reliability analysis show that each construct was well defined by the variables that contributed to the multi item scales. Reliability is a necessary, but not a sufficient, condition for validity. The authors have examined various aspects of validity such as construct validity, convergent validity and discriminant validity in another study (See Peter and Dickie's (2005)). An integration of both these studies will facilitate the development of scales to measure Government Initiatives, Demonstration Sites and Finance. The contribution of the study to knowledge development emerges from the operationalisation of constructs that have hitherto not been considered. A set of parsimonious and multi-item scales have been developed to measure Government Initiatives, Demonstration Sites and Finance. This study draws its inferences from empirical testing of data from India, which is a developing country.

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