

INNOVATIVE HOUSING ADOPTION MODEL FOR HOUSEHOLDS

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Abstract

Rogers' Innovative-Decision Theory was used to develop a framework and model to study acceptance of innovative housing. The dependent variables for the model were level of knowledge, innovativeness, willingness, and attitude toward housing innovations. The independent variables included the basic demographic and social variables that influence the housing acquisition process. Sex, age, and education were important in the adoption process. The housing market conditions of "soil condition" and "land availability" were significant factors in the knowledge aspect of the housing innovations.

Introduction

Adaptation to change is an intriguing phenomenon in today's information world. The response of the individual to change is of major importance to researchers seeking to understand how people adapt to change in a positive manner. Changing environmental situations pose interesting problems as individuals deal with their micro-environments. An evaluation of the way people respond to adaptation can be studied using the energy crisis of the mid-1970s as stimulus for decisions about housing environments.

Rogers' Innovative-Decision process (1983) provides a method for the study of consumer response to the adoption of energy efficient housing structures. Rogers defined the innovation-decision process as "the process through which an individual passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision" (Rogers, 1983, p. 20). Rogers presents five stages and suggests these rest on conditions related to the impact of the process on previous practice, pressing needs, problems, innovativeness, and the norms of the social system. Characteristics of the decision-making unit affect the knowledge stage and perceived characteristics of the innovation act to persuade the individual.

The primary objective of this research was to analyze the factors which influenced the choice of energy-efficient, innovative housing and to rank the relative weight of their contributions. Housing that is innovative can be characterized by the variables of technique, structure, and design. In this study, these variables are related to energy-saving features. Specifically, solar and earth-sheltered housing are used as examples of innovative, energy-efficient housing

Literature Review

In defining the variables to predict adaptive behavior related to energy-efficient, innovative housing, previous studies have concentrated on aspects of acceptance and conservation. Johnson-Carroll, Brandt, and Olson (1987) found that the public believed in the energy crisis and a shortage of fossil fuels. Yet, this belief did not necessarily lead to energy-conservation behaviors. Niemeyer and Morris (1986) found a similar inconsistency between beliefs and behaviors. They identified constraining factors that impeded linkage between behavior and attitude.

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Resource constraints were identified as a major barrier to adaptive behavior. The expense of an energy-saving feature was perceived as an economic constraint. Other constraints related to demographic variables such as age, education, and household size (Niemeyer and Morris, 1986). In addition, Darley and Beniger (1981) discovered an image problem. Frequently, conservation features were perceived as a step backwards or a constraint on today's lifestyle. This perception produced resistance to adoption of energy conservation in residences. Design techniques such as retrofitting have often been referred to as innovative in the literature because they are not perceived as a constraint to lifestyle. The same is true for passive- and active-solar, earth-sheltered, or envelope housing types.

Research has indicated that consumer behavior and attitude are positively related when a convincing case is presented regarding the need for energy conservation (Bartz and Cook, 1987; Beamish, Sweaney, Tremblay, and Bugg, 1987; Chatelaine and Petersen, 1985). To residents of these innovative housing types energy conservation and related money-saving aspects are most important (Bartz and Cook, 1987; Brandt, Wilson, Inoue, Hogue, and Herron, 1987). Although energy efficiency is a positive feature of these housing types, that alone has not been sufficient to make innovations widely acceptable.

Other research has focused on the barriers and incentives related to energy-efficient housing (Combs and Tremblay, 1981; Dagwell, 1983; McCray and Weber, 1981; McKown, Gustafson, and Hobbs, 1982; Stewart, McKown, and Newman, 1981; McCray, Baird, Weber, and Day, 1984). It is apparent from these studies that several factors serve as disincentives. Factors previously identified in this diffusion process as barriers include: initial costs, design and appearance, and lack of reliable information (Combs, 1985; Combs and Tremblay, 1982; Conway, 1987; McCray, Weber, and Claypool, 1987).

Differences that arise between the housing consumer and housing intermediaries provide additional obstacles to the adoption of innovative housing. Combs (1985) found that the housing types most psychologically acceptable to consumers pose structural and construction-related problems for builders.

Solar homes are perceived as an acceptable housing form, yet inadequate or incomplete information may pose a construction problem for the builder. Such shortcomings may be critical to the energy-efficiency and function of the building (Chatelain and Petersen, 1985). Other constraints related to the builder are economic, social, and political.

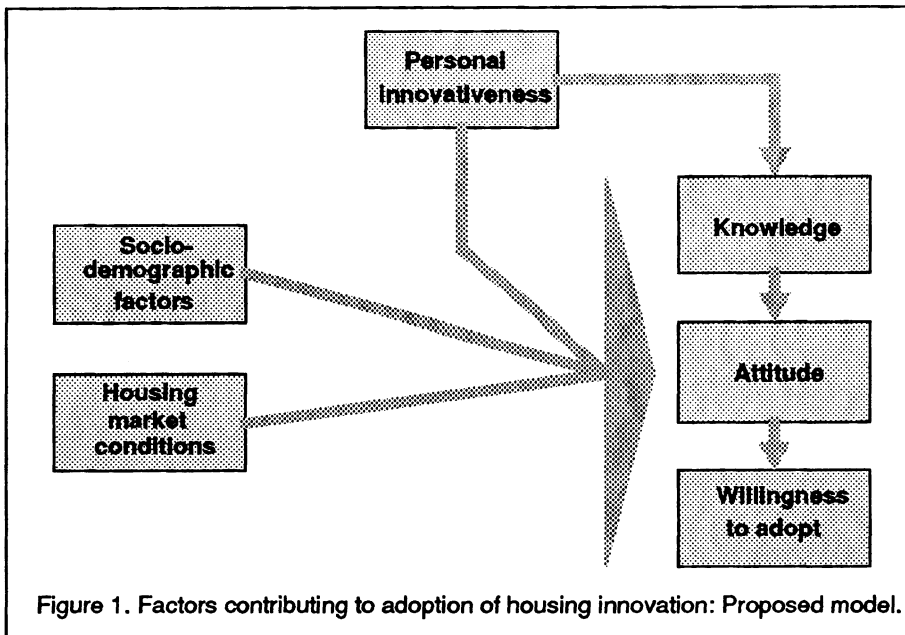
Economic risks include construction costs, resale values, and financing costs (Bartz and Cook, 1987; Combs and Tremblay, 1981; Conway, 1987). Reducing costs through design, technology, and building codes may pose political risks when the economic stability of a particular sector of the building industry is forced to change. Likewise, zoning patterns are threatened by unconventional housing. This creates social risks for builders and consumers alike (McCray and Weber, 1981).

The general public prefers solar homes that are more traditional in appearance than earth-sheltered homes (Beamish, et al., 1987). Consumers also perceive earth-sheltered housing as dark and damp. They equate them to basements and other below-grade spaces (Bartz and Cook, 1987; Stewart et al., 1981). However, residents of earth-sheltered housing exhibit higher levels of satisfaction concerning safety, privacy, exterior design, views, lighting, acoustics, and comfort (Bartz and Cook, 1987).

Theoretical Model

A model for this study was developed from Rogers' (1983) Innovation-Decision Theory. The model provides the basis for understanding the interactions and relationships that affect the adoption process. See Figure 1.

The independent variables for the model are household sociodemographic characteristics and the community's housing market conditions. There are four dependent variables: 1) innovativeness, 2) knowledge, 3) attitude, and 4) willingness to adopt housing innovation.



The model postulates that a willingness to adopt housing innovations is related to an attitude about innovation. This willingness is also related to an individual's knowledge of the innovation. Knowledge of an innovation is related positively to personal innovativeness and housing market conditions. Sociodemographic characteristics may also influence personal innovativeness.

Research Design

Data Collection Procedures

Data for this analysis were provided by the Southern Regional Housing Research Committee. Questionnaires were mailed to households in one rural community in each of six states: Alabama, Arkansas, Georgia, Oklahoma, Tennessee, and Virginia. The communities were selected on degree of diversity based on the results of a "Housing Practices Survey." The Housing Practices Survey was to identify the diversity of housing practices within a community and was completed by mailing a questionnaire to selected housing-related agencies in each state (Beamish and Weber, 1989).

From this information study communities were selected within each state for each level of diversity. An instrument was developed to gain a better understanding of barriers, incentives, and innovativeness as it related to affordability in housing. Data collection procedures for the questionnaires for each of the pilot communities (N=4) followed the Total Design Method (Dillman, 1978).

Sample

This study analyzed the data obtained from 287 respondents. This represents a 35 percent response rate. The results are summarized in Tables 1 and 2. Eighty-five percent of the respondents were home owners. Almost the same number lived in single-family, detached housing. The mean residence value for the sample was \$99,931. The median was \$50,000. Respondents included approximately an equal number of males and females. Their mean age was 52 years. Over 70 percent had completed high school; one in five held a bachelor's or advanced degree. About 10 percent were in professional or technical occupations; the same percentage held managerial or administrative positions.

Table 1. Descriptive information of sample.

Characteristic	f	Percent
Gender		
Male	148	56.1
Female	116	43.9
House type		
Single detached	233	83.8
Single attached	2	0.7
2-4 units	10	3.6
5+ units	8	2.9
Mobile home	18	6.5
Other	7	2.5
Tenure		
Own	235	84.5
Rent	43	15.5
Education		
11 or less	67	25.9
12 years	90	34.8
13-15 years	48	18.5
16 years	42	16.2
17-plus	12	4.6
Occupation		
Professional/technical	28	10.7
Manager/administrator	28	10.7
Sales worker	6	2.3
Clerical worker	5	1.9
Crafts worker	7	2.7
Machine operator	12	4.6
Laborer	7	2.7
Farmer/farm mgmt	12	4.6
Service worker	15	5.7
Private homemaker	2	0.8
Government/military	9	3.4
Retired	79	30.3
Student	3	1.1
Homemaker	27	10.3
Disabled	6	2.3
Other	15	5.7
Household income		
To \$9,999	62	23.5
\$10,000-\$19,999	55	20.8
\$20,000-\$29,999	68	25.8
\$30,000-\$39,999	32	12.1
\$40,000-\$49,999	23	8.7
\$50,000 or above	24	9.1
Would consider living in a solar house		
Yes	120	41.8
Maybe	133	46.3
No	34	11.8
Would consider earth-sheltered housing		
Yes	91	31.7
Maybe	139	48.4
No	34	11.8

Table 2. Descriptive statistical information of sample.

	N	Mean	STD	Minimum	Maximum
Age	266	51.8	17.1	18	88
Education	259	12.3	3.2	2	25
House value	210	99,931.9	147,489.8	1,500	800,000
Year built	270	1957.7	21.3	1870	1986
Innovativeness	286	83.7	16.5	32	225
Solar H knowledge	268	8.0	3.2	0	15
ESH knowledge	265	7.3	3.3	0	15
Solar H attitude	283	35.5	5.4	3	48
ESH attitude	284	35.4	5.8	3	49
Solar H willingness	287	3.5	1.6	0	5
ESH willingness	287	3.0	1.8	0	5

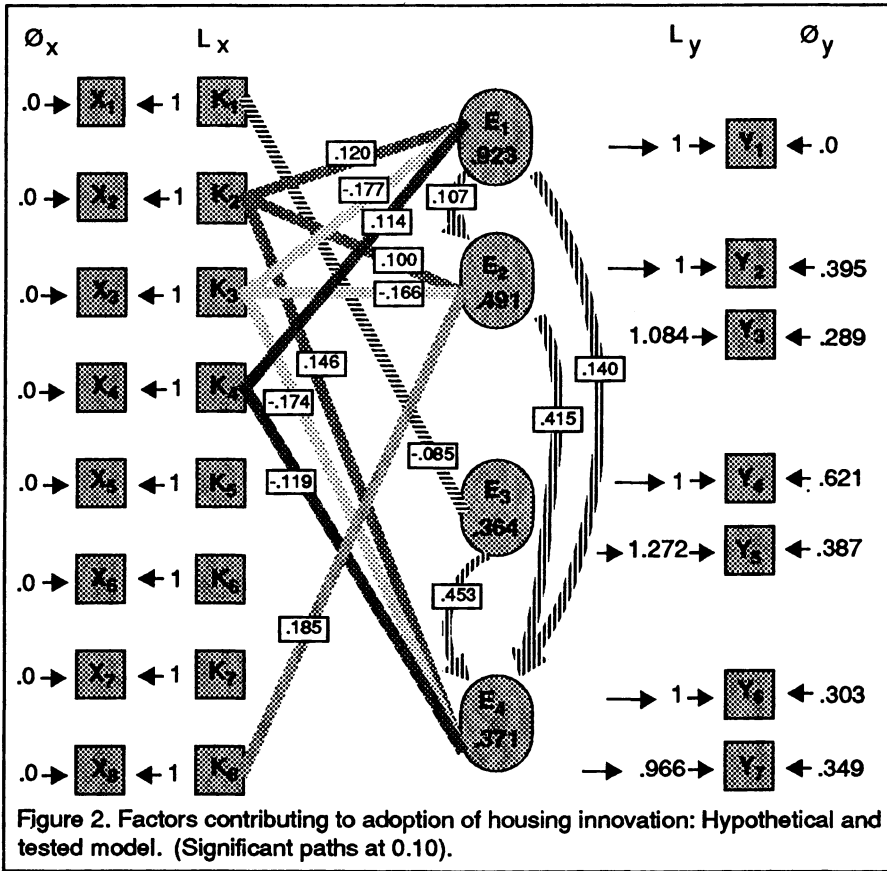


Figure 2. Factors contributing to adoption of housing innovation: Hypothetical and tested model. (Significant paths at 0.10).

Dependent Variables

Measurement of the variables included a series of questions for each variable subset. Innovativeness was measured by a series of questions adapted from Midgley and Dowling (1977). Using a five-point scale, responses ranged from "strongly agree" to "strongly disagree." Knowledge was assessed from the respondent's knowledge of the innovative housing types. This included three levels of interaction with the housing type. Willingness to adopt indicated the respondents' consideration of options. Acceptance of the innovative housing type was the attitude variable.

Reliability of the dependent variable indices indicated an inter-item consistency of standardized alphas ranging from 0.59 to 0.90. This would indicate an acceptable level of reliability for the instrument.

Independent Variables

The independent variables included factors relevant to the adoption and acceptance process. The sociodemographic factors included the basic demographic and social variables which influence the housing acquisition process. Housing market conditions were used to describe a builder's grasp of barrier-incentive dynamics.

Housing market measures were subjected to a factor analysis. This is shown in Table 3. Four factors resulted from this analysis and were included in the model as housing market conditions. These factors were called 1) planning-development, 2) regulation, 3) financing, and 4) land. The components of each factor are shown in Table 3.

Table 3. Four dimensions of housing market conditions: Factors loadings (N=287).

Housing market conditions	Planning/ developing	Regulation	Financing	Land aspect
Skilled labor availability	.734	.083	.239	.130
Builder/developer availability	.702	.039	.212	.107
Builder acceptance	.684	.209	.278	-.072
Water and sewer availability	.643	.137	.103	.233
Wide range of bldg products	.577	-.013	.435	.137
Improvement of housing quality	.499	.484	.061	.014
Local enforcement of zoning	.029	.801	.188	.022
Local enforcement of bldg code	.262	.787	.036	-.062
Building code	.057	.734	.071	.195
Approval process of bldg permit	.260	.732	-.101	.107
Zoning regulation	-.261	.526	.125	.215
Financing availability	.079	.040	.808	.171
Market information	.212	.082	.693	.043
Lender attitude	.166	.095	.656	.044
Consumer knowledge	.331	.085	.570	-.164
Affordable housing concern	.406	.008	.453	.172
Soil condition	.221	.097	.012	.763
Land availability	.102	.180	.146	.739
Eigen value	3.114	2.985	2.564	1.425

Note: Bracketed items loaded to form the components for the four dimensions.

Hypothetical Model

The general model tested in this study was defined by the following three equations and depicted in Figure 2.

$$\text{Structural Equation Model: } E = BE + GK + e$$

$$\text{Measurement Model for Y: } Y = L_y E + \varnothing_y$$

$$Y: X = L_x K + \varnothing_x$$

in which the dependent variables are:

- E₁ - Innovativeness
- E₂ - Knowledge of innovation
- E₃ - Attitude toward innovation
- E₄ - Willingness to adopt innovation
- Y₂ - Knowledge of solar house
- Y₃ - Knowledge of earth-sheltered house
- Y₄ - Attitude toward solar house
- Y₅ - Attitude toward earth-sheltered house
- Y₆ - Willingness to adopt solar house
- Y₇ - Willingness to adopt earth-sheltered house

and the independent variables are:

- K₁ - Tenure of respondent
- K₂ - Sex of respondent
- K₃ - Age of respondent
- K₄ - Education of respondent
- K₅ - Regulation aspect of housing-market condition
- K₆ - Planning aspect of housing-market condition
- K₇ - Financing aspect of housing-market condition
- K₈ - Land aspect of housing-market condition

Analysis of the Linear Structural Relationships (LISREL) developed by Joreskog and Sorbom (1986) was used to connect a quantitative estimate to causal effects within the model and for the overall model fit.

Parameter estimates (L_y) of the measurement model of Y in this study are also shown in Figure 2. For example, knowledge of innovation (E_2) was measured with knowledge of solar home (Y_2) and knowledge of earth-sheltered home (Y_3). Parameter estimates (L_x) for measurement model for X were 1 and measurement errors (\varnothing_x) were zero because each independent variable (K_i) was measured with one observed variable (X_i).

The direct and indirect effects among variables are shown in Figure 2. For example, the direct effect of tenure status (K_1) on knowledge level (E_2) is explained by g_{21} ; the indirect effect of tenure on knowledge is $g_{11}b_{21}$. The sum of the direct and indirect effect, the total effect of tenure on knowledge, is $g_{21}+g_{11}b_{21}$.

Findings and Discussion

The respondents' levels of acceptance of solar housing or earth-sheltered housing was high. Almost 90 percent expressed a positive attitude about adopting a solar house (yes 41.8 percent, maybe 46.3 percent). Eight of ten responded positively to earth-sheltered housing (yes 31.7 percent, maybe 48.4 percent). These are shown in Tables 1 and 2.

The results of testing the hypothetical model are illustrated in Tables 4 and 5. The direct effects are presented in Table 5. The computed total effects are shown in Table 6. A 10 percent level of significance was selected as a criterion for acceptance. This was done because the study is exploratory and trends may be important to help define further research.

Table 4. Factors contributing to adoption of housing innovation: Total effect of latent independent variables on latent dependent variables (N=224).

	Tenure	Sex	Age	Educ- ation	Regu- lation	Plan- ning	Finan- cial	Land	Innova- t'ness	Know- ledge	Atti- tude
Innova- tiveness	-.013	.120	-.177	.114	.00	.00	.00	.00	.00	.00	.00
Knowledge	.015	.113	-.185	.080	-.028	-.012	-.028	.185	.107	.00	.00
Attitude	-.084	-.010	-.045	.008	.045	.011	-.054	.006	-.042	.007	.00
Willingness	-.028	.206	-.296	-.066	.060	-.016	-.032	.060	.166	.412	.453

Willingness to Adopt Housing Innovations

Respondents with greater innovativeness ($p < .05$) and knowledge ($p < .001$) were more willing to adopt innovative housing than others. These results show the importance of information systems in the diffusion process. The more exposure to information about the innovative housing, the higher the level of acceptance. Respondents with more positive attitudes toward the innovative housing were also more willing to adopt innovative housing types ($p < .001$).

A respondent's sex, age, and education had significant effects on willingness to adopt innovative housing. Males, younger respondents, and less-educated respondents were more willing to adopt innovations.

Attitude toward Innovation This was a significant factor in the willingness to adopt innovations but was not affected by respondents' innovativeness or knowledge level. However, tenure tended to have an effect on attitude toward housing innovation ($p < .10$). Renters had more positive attitudes than owners and would consider innovative housing as an alternative when they purchase a house.

Knowledge of Innovation This was a significant factor in the willingness to adopt innovations. It was affected by the respondent's innovativeness level ($p < .10$). People with a higher innovativeness score sought more information about new ideas and therefore had more knowledge of them.

Other variables with a significant impact on knowledge were the respondent's age and the "land aspect" of housing market conditions ($p < .10$). Younger respondents had more knowledge about innovative housing. The land aspect of the housing market condition, which included soil condition and land availability within a community, was a significant incentive-barrier factor. There was a difference between the sexes in knowledge level about housing innovations ($p < .10$). Males tended to have more knowledge than females.

Respondent's Innovativeness This was a significant, positive factor in willingness to adopt innovation. It was also related to age, sex, and education. Younger respondents reported themselves as more innovative than their older counterparts ($p < .01$). Generally, males were more innovative than females ($p < .10$). The better educated respondents also had higher innovativeness scores ($p < .10$).

Overall Fit of Model

The measure of fit indicate that the model fits the data well despite some measurement error in the latent dependent variables. The overall chi-square goodness-of-fit measure for the model was 48.71 with 45 degrees of freedom ($p = .326$). The null hypothesis fitting the model to the data failed to be rejected. The goodness-of-fit index was 0.971 with an adjusted goodness-of-fit index of 0.923. The root mean-square residual was 0.026.

Summary and Conclusion

This study tested a model of diffusion in innovative housing. The willingness to adopt housing innovations was the final interest stage. The model was based on Rogers' Innovation-Diffusion Theory. The model of consumer perceptions of housing innovation was subjected to a LISREL analysis using maximum likelihood methods for estimating the strength of the causal relationship within the model.

Table 5. Factors contributing to adoption of housing innovation: Parameter estimates for structural equation model (N=224).

	Tenure ^a	Sex ^b	Age	Edu- cation	Regu- lation	Plan- ning	Finan- cial	Land	Innov- at'ness	Know- ledge	Atti- tude	R ²
	g	g	g	g	g	g	g	g	g	b	b	
Innovativeness	-.013	.120 ¹	-.177 ³	.114 ¹	-.028	-.012	-.028	.185 ³	.00	.00	.00	.077
Knowledge	.016	.100 ¹	-.166 ³	.068	.045	.011	-.054	.007	.107 ¹	.00	.00	.188
Attitude	-.085 ¹	-.004	-.053	.013	.052	-.016	.004	-.020	-.040	-.007	.00	.040
Willingness	.006	.146 ³	-.174 ³	-.119					.140 ²	.415 ⁴	.453 ⁴	.465

Note: ¹ = p <.10; ² = p <.05; ³ = p <.01; ⁴ = p <.001.

^a--owner=1, renter=0; ^b--male=1, female=0.

A respondent's sex, age, and education were found to be significant factors in the decision to choose innovative housing. When the acceptance of energy-innovative housing is interpreted as one of energy-conservation behaviors, the results are consistent with findings by Johnson-Carroll et al. (1987). In that study males were more likely to plan energy-efficiency improvements than females. It also indicated that older respondents were less likely to improve the energy efficiency of their dwellings. However, the profile of passive-solar residents in Brandt et al. (1987) described them as middle-aged home owners. Similarly, Brandt et al. (1987) indicated that males in Oregon identified themselves as being more familiar than females with the passive solar features of their houses. The better educated respondents were more likely to be concerned about energy problems. Nevertheless, actual energy-conservation and the compared energy efficiency were negatively related (Johnson-Carroll et al., 1987).

The findings of our study indicate that personal innovativeness, knowledge of innovative housing, and attitude toward innovative housing are significant in the decision process. These results emphasize that consumer education through a common communication system is important for the diffusion of innovative housing.

The model tested in this study needs further evaluation. Housing market conditions, except for the land factor, did not present significant effects in the decision process. The sample for this study included only households. Future research with data from housing intermediaries might yield different results. Further studies of urban samples might indicate the results of this study are unique to the rural households. Research which studies the effects of "willingness to adopt" on "real and practical selection" of innovative housing may show differences between the perceptual and the real decision.

Conservation of energy within the household will continue to be a major concern. The current political situation in the Middle East is again forcing the consumer to face rising energy costs. A housing structure which uses renewable sources of energy will allow its inhabitants to more fully realize their lifestyles.

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