

Building Code Officials Intent to Adopt and Perceptions of the International Green Construction Code

Aaron D. Sauer, Ph.D.
University of Central Missouri
Warrensburg, Missouri

David McCandless, Ed.D.
University of Central Missouri
Warrensburg, Missouri

Curtis W. Bradford, M.S., CPC
University of Central Missouri
Warrensburg, Missouri

The transition from traditional practices to sustainable design and construction will require action on many fronts. Change must occur in social, economic, and political-legislative spheres. In the design and construction field, a prominent aspect of the political-legislative landscape is building code enforcement. While sustainability is a prominent issue, it is frequently practiced on an elective basis. However, the International Green Construction Code (IGCC), developed by the International Code Council (ICC), will impose mandatory green construction standards in jurisdictions that choose to adopt the code. Building on the existing theories and literature, the problem of the study was to investigate how building code officials' perceptions of twelve key attributes, sub-dimensions of relative advantage, compatibility, complexity and observability, influence their intent to adopt the IGCC. A random sample of building code officials from Illinois, Kansas, Missouri and Nebraska participated in the study. The data revealed that code officials' perceptions of the initial costs for building owners and long term benefits for building owners were the lone significant predictors of intent to adopt. Based on the findings of this study, proponents of sustainable construction practices will be better prepared to promote the application of sustainable building regulations at the local level.

Key Words: sustainable design and construction, International Green Construction Code; sustainable building codes

Introduction

Sustainable practice is a prominent issue in the design and construction industries. In recent years the introduction of sustainable technologies, including both products and processes, has greatly changed the way many projects are developed and constructed. Although there is speculation that the trend towards "green" buildings is a passing fad (Downs, 1972) a diverse array of contemporary concerns including global climate change, corporate accountability, depletion of non-renewable energy reserves, rising energy costs, energy security, environmental deterioration, and environmental health (Fraj-Andrés & Martínez-Salinas, 2007; Kibert, 2008) provide fertile ground for the continued growth of sustainable design and construction practices in the foreseeable future.

The transition from traditional practices to sustainable design and construction will require action on many fronts. As with other ecological issues, change must occur in social, economic, and political-legislative spheres (Fraj-Andrés & Martínez-Salinas, 2007). In the design and construction field, a prominent aspect of the political-legislative landscape is building code enforcement. In the U.S., building code adoption and enforcement is a process that is carried out at the local level with code officials, elected officials, designers, construction professionals, and the general public as primary constituents.

While sustainability is a prominent issue in the construction industry, it is frequently practiced on an elective basis at the discretion of the building owner with the assistance of the designer and contractor. This is especially true in cities not governed by statewide efficiency and environmental performance standards. However, the International Green Construction Code (IGCC) which was developed by the International Code Council (ICC) will impose mandatory green construction standards in jurisdictions that choose to adopt the code. Based on the widespread acceptance of the ICC model codes and the favorable climate for green construction, it is reasonable to assume that IGCC could have a significant impact on the construction industry within the next ten years.

In March of 2012 the ICC launched the IGCC which establishes minimum standards for environmental performance for new commercial construction and renovation projects. The new code is designed to overlay existing ICC model codes and includes provisions for the application of a wide range of green technologies and sustainable practices. While the IGCC shares many characteristics with existing building rating systems such as the Leadership in Energy and Environmental Design (LEED) standard developed by the U.S. Green Building Council (USGBC), it is unique in its intent to be used as a mandatory building code, not on an elective basis.

As an innovative code offering, the IGCC faces many barriers to adoption. Although the ICC family of model codes has achieved widespread adoption in the U.S., it is unknown to what extent the IGCC will be embraced by local jurisdictions. The adoption of green technologies has been the focus of increased study in recent years. These studies expand on a wealth of research dedicated to the diffusion of technological innovations. Building on the existing theories and previous research by the primary investigator, the problem of the study was to investigate how building code officials' perceptions of twelve key attributes influence their intent to adopt the IGCC.

Review of Literature

Existing diffusion theory has shown that individual perceptions of innovation attributes can be used to predict the rate of adoption (Rogers, 2003). Individual perceptions of innovation attributes have also been used to predict adoption behaviors and intent to adopt (Bolton, 1980; Labay & Kinnear, 1981; Ostlund, 1974; Ozaki, 2011; Strutton & Lumpkin, 1994). By exploring code officials' perceptions of the IGCC, one can reveal potential barriers to the adoption of the code standard. Based on the findings of this study, proponents of sustainable construction practices will be better prepared to address issues related to strategy formulation and policy development (Rogers). Ultimately this will serve to accelerate the adoption of the IGCC by assisting change agents in promoting the application of sustainable building regulations at the local level.

The significance of research aimed at understanding the diffusion and adoption of sustainable construction codes is tied to the wide range of critical concerns driving the sustainable construction movement and the proven effectiveness of green codes. As was previously stated, some of the concerns driving the sustainable design and construction movement include the global climate change, depletion of non-renewable energy reserves, rising energy costs, energy security and environmental deterioration. Empirical research has shown that the introduction of energy performance standards in building construction can begin to address these concerns. According to Aroonruengsawat, Auffhammer, and Sanstad (2012), the adoption of statewide energy codes has reduced per capita residential electricity consumption up to 4.98% annually. Ultimately, the need to understand the diffusion of green codes and the factors that influence their adoption can be grounded in research that shows them to be effective in addressing the contemporary concerns facing this generation.

To understand the challenges associated with the diffusion of the IGCC it is first necessary to frame the code as a type of innovation. In this context, an innovation is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p.12). Within that definition, the application of the IGCC can best be described as a practice, the practice of sustainable techniques as required by the code. The diffusion of new innovations is typically a slow process with no guarantee for success. History includes many examples where superior technologies were available long before their widespread adoption. However, some innovations are able to overcome resistance and gain acceptance at an accelerated rate. Curiosity of the factors that influence the adoption process has led to a significant body of research in the field.

Individuals form attitudes towards innovations on many levels. Defining the attributes of innovations that influence the decision to adopt has been the focus of much research. Based on an extensive review of existing innovation adoption literature, Rogers (2003) identified five attributes of innovations that can be used to explain about half of the variance in the rate of adoption. They include relative advantage, compatibility, complexity, trialability and observability.

Relative advantage is the measure to which an innovation is perceived to be better than its alternatives or the idea it supersedes (Rogers, 2003). Studies on relative advantage show that it is one of the strongest predictors of the rate of adoption for a new innovation. It can be considered in terms of a ratio of cost (financial, social, etc.) to the expected benefits of an innovation. Key sub-dimensions of relative advantage include economic profitability, low initial cost, social prestige, and immediacy of reward (Rogers).

Because the IGCC is an idea only regulatory innovation, relative advantage in terms of economic factors is not immediately apparent. Although they are subject to budgetary constraints, economic profitability is not a consideration for most code officials. However, it is reasonable to assume that economics could influence code officials' perceptions of the relative advantage of the IGCC. From a fiduciary perspective, code officials may perceive a long term economic benefit for building owners resulting from improved building performance. In contrast, the perception of higher initial costs for owners may have a negative influence on perceived relative advantage. A final economic consideration could be the initial cost of implementation for the local jurisdiction. The three economic sub-dimensions of relative advantage investigated in this study were code officials' perceptions of initial cost for building owners, implementation costs for the city, and long term cost benefits for building owners.

Because sustainability is a significant contemporary topic, it is reasonable to assume that social prestige could influence code officials' perceptions of the IGCC. Code official's wishing to differentiate themselves from other jurisdictions and promote a pro-sustainability image may have a positive perception of the IGCC. External pressure from the community or from peers in code enforcement may also influence code officials' perceptions of the IGCC based on social factors. These regional attitudes towards sustainability and regulation could have a positive or negative impact on perceived relative advantage. Therefore, code officials' perceptions about how adopting the IGCC could improve or diminish their image or social prestige was identified as a sub-dimension of relative advantage.

Rogers (2003) presents the concept of a preventive innovation which is a new technique that can be adopted to prevent some future consequence. Preventive innovations face slow adoption rates because of the delayed benefit (if any) which speaks to the immediacy of the reward for adoption. Because it is unknown to what extent the adoption of the IGCC will have an impact on concerns such as global warming and energy shortages, and because those problems are so large and difficult to overcome (Downs, 1972), there is less of an immediate reward for those who choose to adopt. Therefore, code officials' perceptions of the immediacy of reward (benefit) from adopting the IGCC was identified as a sub-dimension of relative advantage.

Perceptions of relative advantage may also be influenced by available alternatives to the IGCC. At present, the IGCC is the only sustainable building standard that is designed to overlay the existing ICC family of model codes. However, jurisdictions could choose to develop their own green code or modify certification systems such as the LEED standard. Therefore, the final sub-dimension of relative advantage was code official's perceptions of the IGCC as compared to available alternatives.

Compatibility is defined as "the degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters" (Rogers 2003, p.240). The more compatible an innovation, the more likely it is to be adopted. Consequently, compatibility can be used to predict the scope and rate of adoption of innovations. Two primary sub-dimensions of compatibility are socio-cultural values and beliefs and individual needs for the innovation. Therefore, code officials were asked if they believed that the IGCC was consistent with the values and beliefs of their local community and if their community had a need for a sustainable building code like the IGCC.

According to Rogers (2003, p.257), "The complexity of an innovation as perceived by members of a social system is negatively related to its rate of adoption". The personal computer and cellular telephone are innovations whose adoptions were greatly influenced by their perceived complexity. While the personal computer resembled a typewriter, it functioned much differently, especially when the first machines were introduced. Early adopters were quickly frustrated with computers due to poor technical manuals and weak customer support, contributing to slower adoption rates. Early cellular telephones, however, resembled and operated in the same way as traditional telephones which led to faster rates of adoption (Rogers). Although the IGCC shares many characteristics with existing green standards such as LEED, it is unclear how code officials will perceive its complexity. While the LEED standard is widely used in the U.S., it is primarily a tool for designers and contractors with little or no participation from the code officials. With little previous experience, code officials may perceive the application of the IGCC as highly complex which may lead to slower rates of adoption. Another consideration is the perceived complexity associated with the adoption of any new code standard. Separate from concerns over the IGCC, one would expect some level of apprehension based on the implementation of any completely new or significantly modified existing standard. This apprehension may have an influence on a code official's intent to adopt. The two sub-dimensions of complexity identified through the literature were code officials' perceptions of the complexity of adopting the IGCC and their perceptions of the complexity of adopting any new code standard.

Trialability refers to the degree to which an innovation can be applied and explored on a limited basis. According to Rogers (2003), innovations that can be used for a trial period adopt more rapidly than those that do not lend themselves to trial usage. Based on the scope of the IGCC and because it is an idea only innovation that involves the participation of multiple constituents (building owners, design professionals, construction professionals and code officials), the code is not well positioned for trial applications. It would be impractical for code officials to select a small sample of projects to apply the IGCC on a trial basis. Because the concept of trialability does not fit with the code adoption process, it provides little value as a variable in predicting intent to adopt and was therefore excluded from this study.

Innovations that are difficult to observe and communicate to others diffuse slower than easily observed innovations (Rogers, 2003). Technologies that manifest themselves as a physical object, such as a new construction tool, are highly observable. Potential adaptors can see the new innovation and watch how it performs in practice. Less observable innovations such as new software or systems or management practices are less visual and require more conceptualization on the part of potential adopters. This ultimately leads to slower rates of adoption.

As an idea only innovation, the IGCC is likely to display a low level of observability for potential adopters. However, it was unknown how the perceived observability would influence code officials' intent to adopt. The adoption of any new code would involve similar low levels of observability. In that sense, the IGCC is no different from a new plumbing or life safety code standard. For the purposes of this study observability was divided into two sub-dimensions. The first sub-dimension explored if code officials had observed other jurisdictions that had adopted the IGCC or similar sustainable code standard. The second sub-dimension focused on code officials' perceptions of their ability to observe other jurisdictions that had adopted the IGCC or similar sustainable code.

The available literature documents how relative advantage, compatibility, complexity and observability can be used to predict the diffusion of a new technology like the IGCC. However, it is unknown to what extent each of the sub-dimensions of the four attributes contributes to the ability to predict intent to adopt. The present study provides a thorough analysis to investigate the individual contributions of twelve sub-dimensions of the four initial attributes. This study will report on the individual relationship between each sub-dimension and the dependent variable and produce a best fit regression equation with statistically significant predictors to model intent to adopt.

Method

A descriptive research design was used to guide the study. From the existing literature, a survey instrument created by Moore and Benbasat (1991) was adapted to collect data on code officials' perceptions of relative advantage, compatibility, complexity and observability. A six point Likert scale with answers ranging from strongly agree to strongly disagree was used to measure perceptions of each attribute. Prior to being administered, the survey instrument was examined for reliability by a panel of industry experts representing code officials, architects, professional constructors and academia. Concerns identified by the expert panel were addressed and incorporated into the final survey instrument. A complete copy of the research instrument is included as an Appendix in Sauer, 2013. A listing of survey question related to perceptions of relative advantage, compatibility, complexity and observability is included with this paper as Appendix A.

The population for the study was code officials from Illinois, Kansas, Missouri and Nebraska. A random sample of 200 cities with a population of greater than 5,000 inhabitants was selected to be invited to participate in the online survey. An invitation e-mail informed code officials of the purpose of the study and explained their rights as research participants. The invitation also included a link to the online survey instrument. A total of 59 code officials participated in the study. Once the data collection was closed, the raw data was compiled for analysis with SPSS software. A Type-1 error rate of .05 was used for hypothesis testing.

From the literature review the researchers identified twelve sub-dimensions of relative advantage, compatibility, complexity, and observability. The results of the survey questions for each of the twelve sub-dimensions were compiled for analysis. The researchers first calculated the Pearson correlation coefficient to investigate the relationship between each sub-dimension and intent to adopt the IGCC. Next, a two round forced enter multiple regression procedure was used to construct a model equation with only significant sub-dimensions to predict intent to adopt.

Results

The first step in the data analysis was to examine a correlation matrix from SPSS. Table 1 presents the Pearson correlation coefficients between the dependent variable, code officials' intent to adopt the IGCC and each sub-dimension of relative advantage, compatibility, complexity and observability.

Table 1

Correlation Coefficients

Sub-dimension	Intent to Adopt the IGCC
Intent to Adopt the IGCC	1.00
Relative Advantage Initial Cost, City	.38**
Relative Advantage Initial Cost, Owners	.58**
Relative Advantage, IGCC vs. Alternatives	.30*
Relative Advantage Social Prestige	.56**
Relative Advantage Benefits for Owners	.50**
Relative Advantage Immediacy of Benefits	.24*
Compatibility with Community	.49**
Compatibility, Need for the IGCC	.43**
Complexity, Perceptions of the IGCC	.31*
Complexity With Adopting Any New Code	-.24
Observability, Have Observed Other Adopters	-.14
Observability, Ability to Observe Adoption	-.03

Note: $^*p < .05$, $^{**}p < .01$

From the twelve initial sub-dimensions, only nine have a significant correlation with intent to adopt at the .05 level (One Tailed). Code officials' perceptions of the complexity of adopting a new code does not have a significant relationship with intent to adopt at the IGCC. The two questions that address the sub-dimension of observability are also not significantly related to intent to adopt. It is important to note that these three non-significant sub-dimensions also have a negative correlation with the dependent variable. In the coding phase, the results were formatted to align with the literature review and yield a positive correlation coefficient. Therefore, when considering the general complexity of adopting a new code in relation to a code official's intent to adopt the IGCC a positive value would have indicated that code officials who reported that learning a new code was easy would have shown a higher intent to adopt the IGCC. However, the opposite is true. Code officials who reported observing other communities who had adopted the IGCC or similar sustainable code also indicated lower intent to adopt. A final observation of the three non-significant sub-dimensions is that they all represent a small effect ($\pm$ .1) (Field, 2009), which further negates their value in predicting code officials' intent to adopt the IGCC.

Each of the nine remaining significant sub-dimensions has a positive correlation with intent to adopt which is consistent with the findings of the literature review. Four of the sub-dimensions show a medium effect ($\pm$ .3) (Field, 2009), and five show a large effect ($\pm$ .5) (Field). The largest correlation value dealt with code officials' perceptions of the initial cost of implementing the IGCC. Those who perceived the code would have a minimal initial cost impact for owners showed a higher intent to adopt. The next largest correlation dealt with social prestige and image. Code officials that reported that adopting the IGCC would improve their prestige as a code official and the prestige of their city also reported higher intent to adopt. The sub-dimension addressing the perceived economic and environmental benefits for building owners shows the third largest effect. The remaining two sub-dimensions with a large effect relate to the compatibility of the IGCC with the culture and needs of the code officials' community.

Due to space constraints a full correlation matrix could not be provided. However, while some sub-dimensions do show strong relationships, there are no "substantial correlations (r>.9)" (Field, 2009, p.233), between predictor variables.

The second step in the data analysis was to prepare a multiple regression model to predict intent to adopt based on the twelve available sub-dimensions of relative advantage, compatibility, complexity, and observability. A two round, forced entry procedure was employed to isolate sub-dimensions with little predicting value and to construct a best fit regression equation. The results of the first round including all sub-dimensions are shown in Table 2.

Table 2

First Round Model Coefficients

	B	*SE B*	*β*
Constant	-6.03	3.20	
Relative Advantage Initial Cost, City	-.06	.23	-.04
Relative Advantage Initial Cost, Owners	.93	.34	.51*
Relative Advantage, IGCC vs. Alternatives	.33	.22	.20
Relative Advantage Social Prestige	.07	.22	.06
Relative Advantage Benefits for Owners	.62	.25	.38*
Relative Advantage Immediacy of Benefits	.13	.28	.06
Compatibility with Community	.07	.09	.11
Compatibility, Need for the IGCC	-.12	.29	-.07
Complexity, Perceptions of the IGCC	-.22	.29	-.14
Complexity With Adopting Any New Code	-.01	.23	.00
Observability, Have Observed Other Adopters	-.27	.25	-.14
Observability, Ability to Observe Adoption	-.04	.25	-.02

Note: R^2 = .76 ($p < .001$), *$p < .05$.

The results show that the model is significant and can account for 76% of the variance in predicting intent to adopt the IGCC. When comparing the β (standardized) values of the twelve sub-dimensions, relative advantage in terms of perceptions of initial costs and owner benefits show the greatest overall importance. They are also the only two significant factors (p < .05). Based on these results a final regression model was created including only the two significant independent variables. The results of the final model are shown in Table 3.

Table 3

Second Round Model Coefficients

	B	*SE B*	*β*
Constant	-4.21	1.51	
Relative Advantage Initial Cost, Owners	.98	.19	.54*
Relative Advantage Benefits for Owners	.56	.17	.35*

Note: R^2 = .47 ($p < .001$), *$p < .001$.

The results show that the final model is significant and accounts for 47% of the variance in predicting intent to adopt the IGCC. When comparing the β (standardized) values of the two sub-dimensions, relative advantage in terms of perceptions of initial costs has the greatest ability to predict intent to adopt followed by relative advantage in terms of owner benefits. The final regression equation follows:

Intent to Adopt = -4.21 + (.98 * RA Perceptions of Initial Costs) + (.56 * RA Perceptions of Owner Benefits)

Based on space constraints a thorough summary of the assumptions of the multiple regression is not permitted. However, there were no significant violations that bring into question the results of the analysis. Additionally, a histogram of the standardized residuals from the regression model is shown in Figure 1. From the histogram it appears that the residuals are normally distributed, an assumption that is supported by the results of the Kolmogorov-Smirnov test ($p = .200$).

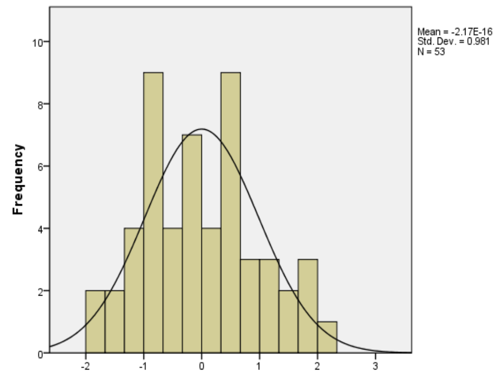

Figure 1: Histogram of Standardized Residuals

Conclusions and Discussion

The Pearson correlation values are consistent with studies of similar technology innovations and show that sub-dimensions related to relative advantage and compatibility have the strongest relationship with intent to adopt. Perceptions of the complexity of adopting the IGCC also had a significant relationship with intent to adopt, but with a low level effect. The correlation values do not show a significant relationship between the sub-dimensions of observability and intent to adopt.

Through the use of the multiple regression procedure it is possible to look beyond the simple one to one correlation relationships and partial out the unique variance accounted for by each sub-dimension. Following the first round of the multiple regression, only two sub-dimensions remained as significant predictors. They include perceptions of the initial costs for building owners and perceptions of the long term economic and environmental benefits for owners. These two sub-dimensions were further refined into a model that accounts for 47% of the variance in code officials' intent to adopt the IGCC. These findings are consistent with previous research that showed relative advantage to be the single significant predictor of intent to adopt (Sauer, 2013). However, this study provides additional value by eliminating four of the six original sub-dimensions of relative advantage, bringing more focus to the key attributes of a code official's intent to adopt the IGCC.

Based on the Pearson correlation values, it is surprising that other sub-dimensions with a large effect, such as perceptions of the compatibility of the IGCC with the local community, do not have a significant role in the final model. However, it is clear that the strong relationship of several sub-dimensions is based on shared variance with other attributes.

It is necessary to consider how the findings of this study can be used by proponents of sustainable building regulations. The correlation values and multiple regression results show that perceptions of minimal initial cost for owners are closely linked with a greater intent to adopt. However, this relationship does not indicate direction of causality. It is unknown if perceptions of minimal initial costs lead to a greater intent to adopt or if greater intent to adopt leads to perceptions of minimal initial costs. The same is true with perceptions of long term benefits for building owners. However, the results do indicate which sub-dimensions have little or no relationship with intent to adopt and as such should be given the appropriate attention in promotion efforts. Furthermore, rather that promoting all sub-dimensions of relative advantage, the results clearly point to two significant factors that should receive the greatest attention.

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Appendix A

Survey Questions for Sub-Dimensions of Key Attributes

<u>Relative Advantage</u>
Adopting the IGCC will benefit building owners through lower energy costs and improved environmental conditions.

Adopting the IGCC will hurt the image of my city.
The initial costs associated with building in accordance to the IGCC will be prohibitive for building owners.
Adopting the IGCC would be more beneficial than alternative sustainable codes such as the LEED Standard and the IECC.
The initial cost associated with adopting the IGCC will be prohibitive for my city.
Adopting the IGCC will have a minimal initial cost for my city.
Adopting the IGCC will have little impact or may diminish my image among my peers in the code enforcement community.
Any benefits associating with adopting the IGCC will be realized far into the future.
Adopting the IGCC will have a minimal impact on the initial cost of construction for building owners.
Alternatives to the IGCC such as the LEED Standard and the IECC are better suited to my city.
Adopting the IGCC will improve the image of my city.
Sustainable building regulations such as the IGCC have a minimal benefit for owners in respect to energy costs and the environment.
Adopting the IGCC will improve my image among my peers in code enforcement community.
Building owners, my city and the world will begin to realize benefits shortly after adopting the IGCC.
I feel pressure from the local community to adopt a comprehensive sustainable building code such as the IGCC.
Members of my community are opposed to comprehensive sustainable building regulations such as the IGCC.

Compatibility

Adopting sustainable codes such as the IGCC is compatible with the culture of my city.
Any type of additional regulation including the IGCC would be resisted by my city.
The IGCC is a solution that is compatible with the current needs of my city.
My city is open to additional regulation in the form of the IGCC or other comprehensive sustainable building codes.
The culture of my city is not consistent with sustainable codes such as the IGCC.
There is little need for the IGCC or similar comprehensive sustainable building codes in my city.

Complexity

I believe that the IGCC will be difficult to use.
Learning new code standards is easy for me.
I expect that following the IGCC will require a lot of extra effort.
As a code official, my role in administering the IGCC is clear and understandable.
Overall, I believe that the IGCC will be easy to use.
Adopting a new code standard is often frustrating for me as a code official.

Observability

I have been able to observe other cities that have adopted the IGCC or similar comprehensive sustainable code standard.
It is difficult to observe how other code officials are using the IGCC.
I have not observed other cities that have adopted the IGCC or similar sustainable code standard.
It is easy for me to observe how other code officials are using the IGCC.