Breaking Down Barriers: An Alternative Method to Measure Program Influence

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Abstract

Energy efficiency interventions occur amid a backdrop of many influences on the market. In the absence of the interventions, it is likely that some improvement in energy efficiency would occur. Interventions are often intended to accelerate the process or smooth the introduction of new efficient technologies. However, separating intervention effects from other external market effects is challenging.

This paper proposes an innovative approach using the Analytic Hierarchy Process (AHP) to assess the influence of efficiency interventions and address validity issues associated with previous methods. AHP was developed to facilitate complex decision making and provides structure to quantify the decision making process.

The Barriers Approach leverages the versatility of AHP to sharpen our ability to estimate the actual impacts of efficiency interventions. This new approach is based on assessing the relative importance of barriers faced by customers and the effectiveness of the program intervention in comparison to external influences in overcoming these barriers. The Barrier Approach quantifies the influence of efficiency interventions in a defensible and reproducible way.

The Barriers Approach was tested on a small sample of participants in a residential audit program. The rigorous review process indicated that this innovative approach shows promise. The approach is versatile and has the potential to be expanded for evaluating a wide range of types of efficiency interventions.

This paper starts with a description the AHP method, followed by an explanation of the Barriers Approach. The pilot study and other possible applications of the method are also covered.

Introduction

Energy efficiency is insufficiently valued in the market, and consequently, government, utilities and other groups have designed interventions to overcome this market failure and raise the level of energy efficiency. However, these interventions occur amid a backdrop of many influences on the market. In the absence of the interventions, it is likely that some improvement in energy efficiency would occur. Interventions are often intended to accelerate the process or smooth the introduction of new efficient technologies.

Demonstrating the actual impact of these interventions is critical to ensure that public and private funds are spent wisely, encourage continued support for these efforts and assess how to modify existing, or develop new, interventions. In considering how to separate the intervention-induced savings from efficiency due to other market influences, three types of validity need to be considered:

1. Construct validity: does the method correctly measure the impacts of the intervention?
2. Internal validity: does the method clearly identify the causal mechanism between the intervention and the increased efficiency?
3. External validity: can the results of the study be generalized to the population?

The reliability of the approach relies on the ability to address potential threats to these types of validity.

In the US, estimating the intervention-induced savings is focused on the counterfactual: what would have happened in the absence of the efficiency intervention? Four major approaches have been used to try to answer this question, as described in the table below. These methods have generated substantial controversy about the validity of the approach and reliability of results.

Table 1. Current Approaches to Estimating Net Savings from Efficiency Interventions in the US

Approach	Description	Advantages	Disadvantages
Self Reports	Interview market actors about what they would have done without the efficiency intervention	Extensively used Survey-based Easy to implement	Counterfactual questions are difficult to answer (construct validity) Respondents may not be able to quantify the savings due to the program (internal validity) Results may be biased due to validity issues
Statistical Modeling	Discrete choice modeling or conjoint analysis	Measures choices to install EE or standard products	Requires very large samples of nonparticipants, studies are expensive (external validity) Only works for the most commonly installed energy efficiency technologies (limited applicability)
Comparison Studies	Compare efficiency activity to another location with no efficiency interventions	Intended to address market shifts by use of a comparison area	Increasing difficulties finding comparison areas with no efficiency initiatives (construct validity) "Contamination" by participation in energy efficiency programs in prior years (internal validity)
Sales Data Analysis	Assess changes in overall sales of efficient products	Directly measures changes in market share	Difficult to obtain complete sales data (external validity) May not separate intervention impacts from other market forces (construct validity) Applies only to specific products (limited applicability)

A key issue with these methods is the difficulty in separating intervention effects from other market effects. While comparison area studies were intended to address this problem, the increasing difficulties in finding a comparison area with similar characteristics and no efficiency interventions raises questions about the feasibility of this approach moving forward.

This paper proposes an alternative approach using the Analytic Hierarchy Process (AHP) to assess the influence of efficiency interventions and address the issues with validity inherent in the previous methods. AHP was developed to facilitate complex decision making by a group of stakeholders. As the AHP is used to assist with decision making, it can also be used to deconstruct a decision made in the past. This method provides the structure to quantify the decision making process.

The Barriers Approach applies the AHP to the decision to make energy efficiency upgrades by identifying the market barriers and the range of influences that assist customers with overcoming the barriers. The relative importance of the market barriers and the influential factors in overcoming the barriers are determined through the use of pairwise comparisons and the outcome of the Barriers Approach is the Pairwise Program Influence Score, which reflects the percent of the impacts (energy savings, demand reduction, greenhouse gas emissions, etc.) that are attributable to the intervention.

The Barriers Approach represents an innovative use of the versatility of AHP to sharpen our ability to estimate the real impacts of energy efficiency interventions over and above naturally occurring efficiency improvements. The main advantages of this approach are 1) external effects outside of the intervention are explicitly incorporated into the analysis, leading to high construct and internal validity; 2) it is based on a strong theoretical foundation and does not require large sample sizes, which improves the external validity. The approach is versatile and has the potential to be expanded for evaluating a wide range of types of efficiency interventions. Figure 1 shows the relationship between the AHP and the Barriers Approach.

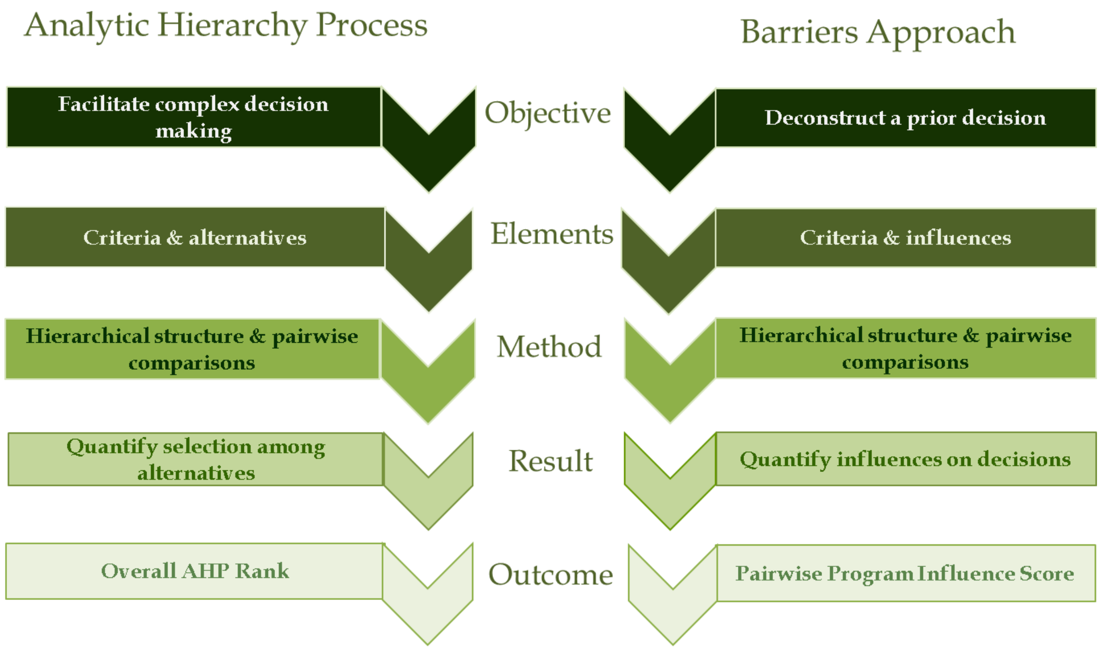

Figure 1. Comparison of the Analytic Hierarchy Process and the Barriers Approach

The remainder of this paper is divided into four main sections: a description and example of the AHP, a description of the Barriers Approach, including a discussion of the initial testing of the method and an example of the calculations, a discussion of potential applications for the Barriers Approach and conclusions.

The Analytic Hierarchy Process

AHP was designed to provide a comprehensive structure for complex decision making. The overall strategy is to define the goal, alternatives and priorities, and then conduct a series of pairwise comparisons to identify the relative importance of each element. A relatively simple mathematical process is used to rank the elements. The outcome is a score for each alternative that quantifies its relative value in comparison to the other alternatives. It allows diverse criteria to be quantified and combined in a consistent way. The framework is as follows:

1. develop a model of the decision making process that defines the goal, the alternatives and the criteria for selecting among them
2. prioritize the selection criteria using pairwise comparisons
3. rank the alternatives through pairwise comparisons within each selection criterion
4. integrate the priorities and the ranking of the alternatives to develop a score for each alternative reflecting the importance of each of the selection criteria and the relative value of the alternative within each selection criterion
5. check for consistency

Pairwise comparisons are the building blocks of AHP and are used at each stage in the model. At the first level, each selection criterion is compared to one other to assess the relative importance. AHP specifies the relationship between two decision making components using a numerical scale, as shown in Table 2. The even numbers can be used for responses that fall between the categories given below (Saaty, 2006). The number of pairwise questions increases with the number of options, with two options requiring one question, and four options requiring six questions.

Table 2. AHP Scale for Pairwise Comparisons

Numerical Scale	Description	Meaning
1	Equal importance	Both factors make the same contribution to the decision.
3	Moderate importance	The favored factor is moderately more important than the weaker factor.
5	Strong importance	The favored factor is strongly more important.
7	Very strong importance	The favored factor is very strongly more important.
9	Extreme importance	The favored factor is extremely more important.

These results are entered into a matrix and matrix algebra is used to calculate the eigenvector and the normalized score, with all of the scores for a specific priority adding to 1.0. The numerical ratings are entered into the lower right part of the matrix as follows:

1. If the rating is greater than 1 (indicating that the factor is the stronger of the two), the number is directly entered into the matrix.
2. If the rating is 1 (indicating that the factor is the weaker or that the two factors are equivalent), the reciprocal of the rating is entered.

In the corresponding upper left box, the reciprocal of the value entered into the lower right box is entered (Saaty, 2006). This process is unique to AHP. Different scaling mechanisms may be applied, as appropriate (Franek, 2014).

AHP also has a method to calculate the consistency ratio when three or more factors are compared. The consistency ratio compares the maximum of the eigenvalues for the matrix to the average eigenvalues of randomly generated reciprocal matrices.[1] Saaty recommends allowing a consistency ratio of 10% or less to account for variations in human judgment. (Saaty, 2006)

AHP Example

A simple illustration of this method is choosing a car. The purchasers are considering three electric vehicles and are planning to make the decision based on cost, reliability and distance per charge and overall fuel efficiency. The characteristics of the cars are described in the table below.

Table 3: Electric Car Characteristics

Criteria	Car A	Car B	Car C
Cost	30,000	45,000	70,000
Reliability	3-year warranty	8-year warranty	8-year warranty
Distance per charge	25 miles	50 miles	235 miles

The analysis has two stages: 1) determine the relative importance of the selection criteria and 2) determine the performance of each car according to the selection criteria. An integrated score for each car is constructed that accounts for the relative importance of each criterion and the performance of the car in comparison to the other alternatives.

[1] The method for calculating eigenvalues and the eigenvector can be found in textbooks on linear algebra (such as Anton, 1981), the AHP texts (such as Saaty, 2006) and numerous university Web sites.

The purchasers ranked the criteria in importance from most to least important: 1) cost, 2) distance per charge and 3) reliability. Pairwise questions are constructed to compare them two at a time, resulting in three questions. The results of these comparisons are shown in Table 4.

Table 4. Pairwise Responses for Selection Criteria for AHP Electric Car Example

Row	Criteria 1	Pairwise Rank 1	Criteria 2	Pairwise Rank 2	Response
1	Cost	5	Reliability	1	Cost is strongly more important than distance per change
2	Cost	3	Distance	1	Cost is moderately more important than reliability
3	Reliability	1	Distance	5	Distance per charge is strongly more important than reliability

The results from this component are the priorities, i.e., the relative ranking of the selection criteria. Using the process described above, these values are entered in a matrix as described below and illustrated in Table 5.

1. Ones are entered on the diagonal.
2. In the first row of Table 4, the column Pairwise Rank 2 (PR 2) contains 1, so the reciprocal of PR 1 (1/5) is entered into the reliability/cost cell in the lower left corner of the matrix.
3. In the second row, PR 2 is 1, so the reciprocal of PR 1 (1/3) is entered into the cost/distance cell in the lower left corner of the matrix.
4. In the third row, PR 2 is 5, so PR 2 (5) is entered into the reliability/distance cell in the lower left corner of the matrix.
5. The top, right section of the matrix is filled in with the reciprocals of the corresponding cells in the bottom left.

The eigenvector is calculated and normalized by dividing each component of the eigenvector by the total of the eigenvector values, as shown in the table below. The priorities indicate that cost is the most important selection criteria, as the priority score is the highest.

Table 5. Priorities Matrix for AHP Electric Car Example

	Cost	Reliability	Distance per Charge	Eigenvector	Priorities (Normalized Eigenvector)
Cost	1	5	3	35.0	0.63
Reliability	1/5	1	1/5	4.5	0.08
Distance	1/3	5	1	16.3	0.29
Totals				55.8	1.000

The process is repeated for each of the three cars within each of the three criteria (for a total of nine pairwise comparisons). The responses are shown in Table 6.

Table 6. Alternatives Matrix for AHP Electric Car Example

Comparison	Criteria	PR 1/ PR 2	Criteria	PR 1/ PR 2	Criteria	PR 1/ PR 2
A/B	Cost	3/1	Reliability	1/5	Distance	1/3
A/C	Cost	7/1	Reliability	1/5	Distance	1/9
B/C	Cost	1/5	Reliability	1/1	Distance	1/7

The same process described above for the criteria is used to construct three matrices and calculate the ratings of each car. The final step is to integrate the results to calculate the overall AHP rank of the alternatives for each car, as shown in the equation and table below.

$$Overall\ AHP\ Rank = \sum_{i=1}^{n} (P_i \times A_i)$$

where P = priority rank for selection criterion *i*
A = alternative rank for selection criterion *i*
n = the total number of selection criteria

Table 7. Summary of Results for AHP Electric Car Example

Car	Cost	Reliability	Distance	Overall AHP Rank	Calculations
A	0.65	0.09	0.06	0.44	(0.63 x 0.65) + (0.08 x 0.09) + (0.29 x 0.06)
B	0.28	0.46	0.15	0.25	(0.63 x 0.28) + (0.08 x 0.46) + (0.29 x 0.15)
C	0.07	0.45	0.79	0.31	(0.63 x 0.07) + (0.08 x 0.45) + (0.29 x 0.79)
Priority	0.63	0.08	0.29		

The outcome of this analysis indicates the purchasers should buy car with the highest overall AHP rank (Car A at 0.44). This outcome is largely due to the importance of cost in the decision making process. Car C came in as the second choice, as distance per charge was substantially more important than reliability. The consistency ratios for all of the matrices were under 10%.

The Barriers Approach

The AHP method can be used to develop a more nuanced assessment of the savings to be attributed to an efficiency intervention. By applying the AHP approach to the process of deciding to install efficiency measures, we can deconstruct the decision making process and quantify program influence. This approach allows us to account for the wide range of elements that contribute to the decision to install measures. Table 8 shows how the AHP elements used in our example above relate to the Barriers Approach.

Table 8. Mapping AHP to the Barriers Approach

AHP Component	AHP Electric Car Example	Barriers Approach Example	Comments
Goal	Select best electric car	Quantify influence of the efficiency intervention	AHP: rank each car individually to select the best car based on the established criteria Barriers Approach: aggregates scores over many participants to quantify influence
Selection Criteria	Desired characteristics	Barriers to installing efficiency measures	AHP: cost, reliability, distance per charge Barriers Approach: money, information, time
Alternatives	Electric cars	Influential factors for overcoming the barriers	AHP: three types of electric cares Barriers Approach: direct influence of the intervention, indirect influence of other utility or regulatory efforts, external influences
Outcome	Overall AHP Rank	Program Pairwise Influence Score	AHP: combines relative importance of criteria with the qualities of each alternative Barriers Approach: combines relative importance of barriers with the intervention and external influences

The Barriers Approach was tested on a small sample for a residential audit program. The following section discusses how the AHP concepts were applied to develop the Barriers Approach and conduct this research.

Description of the Barriers Approach

An alternative approach to quantifying program influence needs to account for the range of possible influences, both intervention-related and external, that affect the decision to install energy efficiency measures. The conceptual framework for investigating the decision-making process and quantifying program influence is shown below.

Table 9. Steps in the Barrier Approach

Step	Description	AHP Example Equivalent	Comments
1	Identify the barriers	None	Necessary research to define options
2	Quantify the relative importance of the barriers	Priorities matrix, see Table 5	Normalized eigenvector reflects the Barrier Scores
3	Identify the influential factors	None	Necessary research to define options
4	Quantify the relative importance of the intervention and external influences	Alternatives Matrix, see Table 6	Normalized eigenvector reflects the Program Contribution Scores
5	Calculate the Pairwise Program Influence Score	Overall AHP Rank, see Table 7	Integrate the barriers (priorities) and influences (alternatives)

This approach directly measures how the program intervention is working and can provide valuable feedback to program staff. Each of the steps is described briefly below.

Identifying the Barriers. Extensive research has been conducted to document the common barriers that prevent residential customers from taking actions to improve the energy efficiency of their homes.[2] A previous study was conducted on the audit program used for this research and it documented the following key barriers: (1) high cost of measures; (2) finding a contractor; (3) waiting for old equipment to break; and (4) ineligible for financing (NMR, 2012).

Based on these findings and a review of responses to open-ended questions in recent surveys for related residential programs, we identified four barriers to installing efficiency measures:

1. concerns about **money** (up-front costs)
2. lack of **information**
3. **time** constraints
4. finding a **contractor**

Of these four, the lack of information is the broadest, as it could range from information about costs, benefits and payback to health and safety issues and the specifics of the installation.

The audit program is designed to overcome two of these barriers: lack of information and finding a contractor. It could also help homeowners with time constraints by saving time in research and/or selecting a contractor. No monetary assistance is provided through the audit program, although money is a driving component in the decision making process for many homeowners.

Assess Relative Importance of the Barriers and Develop the Barrier Score. Due to the wide range of viewpoints among residential homeowners, defining the barriers required four steps:

1. Respondents identified as many concerns that applied to them from a comprehensive list; they were asked to **rank the concerns** on a 0 to 10 scale and add concerns, as needed.
2. Each of the concerns ranked above 5 was then **mapped to one of the four main barriers** (time, money, information, finding a contractor).
3. The assignment to the four main barriers was **verified with the respondent**.
4. The responses on the 0 to 10 scale were used to **rank the four main barriers in order of importance** and this ranking was also verified with the respondent.

Respondents were asked to compare the barriers two at a time and rank them on a scale where 1 meant that they were of the equal importance and 5 meant that the first (more important) barrier was extremely more important than the other.[3]

The Barrier Score reflects the percent contribution of each barrier to the lack of action. The scores for all of the barriers add to 100% for each respondent. No respondent identified more than three barriers. Although money was not a barrier addressed by the audit program, it represents a substantial hurdle for many homeowners and was included in the barrier score.

Identify Influential Factors. For each barrier, numerous influences may encourage homeowners to proceed with installing efficiency measures. For example, sources of information about energy efficiency measures are abundant, *e.g.*, the energy audit, another (nonprogram) contractor, friends and family, advertisements for specific products, Internet research, etc.

For each barrier, a list of influential factors was constructed and respondents were asked to identify the influential factors that affected their decision. Respondents were invited to add to the list of factors and to comment on the wording. The influential factors were grouped into three types of

[2] Various publications discuss these common barriers. For example, see: http://aceee.org/research-report/a135 and http://www.resnet.us/professional/ratings/HP03;
[3] In the surveys, the AHP 1 to 9 scale was modified to 1 to 5, as many survey respondents are likely to be more familiar with the 1 to 5 scale.

influence:

1. Direct influence from the energy audit
2. Indirect influence from the audit program (such as the Web site)
3. External influence (such as friends and family or nonprogram contractors)

The respondent was asked to confirm these influences.

Quantify Intervention Effects. Pairwise questions were developed to compare the direct, indirect and external influences for each barrier. The strategy mirrored the approach used to identify the barriers, as follows:

1. Respondents were asked to **rank the influences** on a 0 to 10 scale and add to the list.
2. Each of the factors ranked above 5 was **mapped to one of three main types of influence**.
3. The selection of the influence(s) from the three categories was **verified with the respondent**.
4. The responses on the 0 to 10 scale were used to **rank the influences in order of importance**.
5. **Pairwise comparisons** were used to quantify the relative importance of the influences for each barrier.

The Program Contribution Scores for each barrier were calculated using matrix algebra as described above. If the homeowner attributed all of the influence to only one influential factor, the pairwise comparison step was unnecessary.

Calculate the Pairwise Program Influence Score. Consistent with the calculation of the overall AHP rank, the Pairwise Program Influence Score combines the Barrier Scores and the Program Contribution Scores for each respondent, as shown below.

$$PPI = \sum_{i=1}^{n} (BS_i \times PC_i)$$

where BS = Barrier Score for barrier *i*
PC = Program Contribution score for barrier *i*
n = the total number of barriers identified by the survey respondent

Example of the Barriers Approach and Pairwise Program Influence Score Calculations

An example of the barrier mapping process for one respondent is shown in Table 10. The ranking column shows the barriers in order of importance as identified by the respondent. The pairwise response columns show the respondent's ranking for the favored factor and the reciprocal for the less favored factor (as is entered into the matrix).

Table 10. Ranking Barriers for a Respondent

Highly Ranked Items	Barrier	Ranking	Pairwise Responses
1) Needing information about savings energy and what to install 2) Finding a reliable source of information	Information	#1	Information/Time: 1 (roughly equal) Information/Money: 5 (information is strongly more important)
1) Finding time for research	Time	#2	Time/Money: 3 (time is moderately more important) Time/Information: 1 (equal)

Highly Ranked Items	Barrier	Ranking	Pairwise Responses
No options were ranked above 5 on the 0-10 scale	Contractor	No ranking	Not included in pairwise comparisons
1) Figuring out how to pay for the efficiency upgrades	Money	#3	Money/Information: 1/5 (reciprocal of information/money) Money/Time: 1/3 (reciprocal of time/money)

The barriers matrix and solution are presented in Table 11. The Barrier Scores are the normalized eigenvector and represent the relative importance of each barrier.[4] The consistency ratio is 2%.[5]

Table 11. Barriers Pairwise Matrix

	Information	Time	Money	Eigenvector	Barrier Scores
Information	1	1	5	1.71	0.48
Time	1	1	3	1.44	0.41
Money	1/5	1/3	1	0.41	0.11

This example includes two options for program contribution: intervention and external influences. As the matrix algebra is simple, the responses and results are combined in Table 12. With only two options, there is no need for a consistency check.

Table 12. Program Contribution Scores

Component	Influential Factors on Decision to Install	Program Ranking	Pairwise Responses	Program Contribution Score
Information	Energy audit (program) Nonprogram contractor	Program ranked #1 Nonprogram ranked #2	Program/NP: 7/1	88%
Time	Energy audit Personal time management	Program ranked #2 Nonprogram ranked #1	NP/Program: 3/1	25%
Money	No program influence	Nonprogram ranked #1	No pairwise	0%

For this example, the Pairwise Program Influence Score is 52%, as shown in the following equation. To take this analysis one step further, net program savings could be calculated as follows:

[4] In this example, the linear scale from the Saaty text was used, i.e., the values on the 1-9 scale were directly entered into the matrix. However, the final PPIS for the cognitive interviews were calculated using the balanced scale with values of {1:1; 2:1.22; 3:1.5; 4:1.86; 5:2.33; 6:4.5; 7:5.67; 9:9}, *e.g.*, if the respondent selected 5 on the 1-9 scale, 2.33 was entered into the matrix. (Franek, 2014) The balanced scale was selected as the weights from the linear scale are unequally dispersed. For a two by two matrix, selecting 5 (the midpoint) on the 1-9 linear scale gives the favored barrier a weight of 83%,; the same entry on the balanced scale gives the favored barrier a weight of 70% (halfway between equal weights [50%] and the top of the scale [90%]). The wording of the pairwise questions was modified to reflect the balanced scale.

[5] In the 13 cognitive interviews, a large majority of respondents listed only one or two barriers, so the consistency check was not necessary.

$$NPI = PPIS \times GPI$$

where

NPI is the net program impacts
PPIS is the average Pairwise Program Influence Score for all respondents
GPI is the gross program impacts

The gross program impacts could be energy or demand savings, reductions in greenhouse gas emissions or other metrics. In addition, the PPIS could be weighted to reflect the mix of measures in each home or other considerations.

$$PPIS = (BS_{info} \text{ x } PC_{info} + BS_{time} \text{ x } PC_{time} + BS_{money} \text{ x } PC_{money})$$

$$= (0.48 \text{ x } 0.88 + 0.41 \text{ x } 0.25 + 0.11 \text{ x } 0.00) = 0.52$$

Applying the Barriers Approach

The Barriers Approach was tested on a residential audit program. Cognitive interviews were fielded for a small sample (13). All interviews were audio recorded and provided to four expert reviewers. Each reviewer came to an independent assessment of the Pairwise Program Influence Score (PPIS) and the PPIS was compared to the story told by the respondent. A conference call was held to assess the validity of responses and whether the scores matched the responses. The panel of reviewers agreed that the cognitive interviews supported the validity of this approach, *i.e.*, the interviews captured the concerns and issues of the respondents and the respondents' PPIS were consistent with the story that they told. These results are indicative of the potential of this approach.

The versatility of the AHP provides a strong foundation for expanding the application of this approach to evaluating a wide variety of types of efficiency interventions. The structure of the analysis can accommodate a broad range of barriers and influential factors. While other methods (such as comparison area and sales data analyses) are restricted to specific technologies, the Barriers Approach could be applied at the technology, end use, facility or community level. Some possibilities are explored below.

- The influence of energy efficiency labeling for new homes could be investigated through interviews with home buyers to assess how the labels affect the purchase.
- Rebates programs could be assessed through interviews with purchasers to determine the impact of the rebate in comparison to other influences in the decision to purchase the product.
- Energy codes could be evaluated through interviews with code officials and builders to ascertain the influence of the code on the efficiency level of a random sample of buildings and assess whether the code was effective in raising the minimum efficiency.

The limiting issue may be the complexity of the decision making process, as the number of questions increases as a factorial of the number of barriers.

Conclusions

This novel expansion of the AHP method to estimate the actual influence of efficiency interventions shows promise. As interventions are designed to overcome market barriers, the Barriers Approach is an improvement over other methods as it measures the success of efficiency interventions in these terms and addresses persistent concerns about the validity of the previous methods.

The cognitive interviews provided a wealth of information about the decision making process, and, consequently, we were able to compare the results of the Barrier Approach to the story told by the respondents to verify the method produced reliable results. The cognitive interviews demonstrate the construct validity, *i.e.*, that the questions can be understood, reliably answered and provide the information needed to assess program influence.

Estimating the impacts of efficiency interventions over and above the level of naturally occurring efficiency relies on assigning numerical values to subjective decision making. The Barrier Approach has a number of advantages over previous approaches:

- It is internally consistent in that it is measuring the effectiveness of the intervention in overcoming market barriers through a systematic approach to quantifying the decision making process (internal validity).
- It is based on a strong theoretical foundation to quantify decision making (external validity).
- It relies on questions that can be reliably understood and answered by the respondents (construct validity).
- The resulting score can be directly applied to program impacts to estimate the “net” impacts of a program.
- It is highly versatile and has the potential to be applied to a wide range of types of energy efficiency interventions, including energy efficiency regulations, codes and labeling (broad applicability).

The primary disadvantage may be the need to limit the number of barriers and influential factors to be able to keep the interviews at a reasonable length and level of complexity.

The sample size of 13 is small and additional research is needed to test this method on a larger scale. Other details that could not be included in this paper due to length, such as the scaling method and consistency checks, may also be topics of future research.

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