Portland State University Maseeh College of Engineering and Computer Science Department of Engineering and Technology Management



# ETM 530/630 – Decision Making Spring 2017

# **Individual Project Paper**

# Maximizing Home Resale Value through Home Improvement Investments

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#### ABSTRACT

In this report, the decision topic of maximizing home resale value through home improvement investments will be explored. Home improvements can quickly add value to a home and in turn can positively affect home resale value in the future when the homeowner decides to put their house on the market again. But the question, should home improvement projects be executed solely by a professional licensed contractor, solely by the homeowner through a do-it-yourself (DIY) approach, or through a combination of the two, remains. This question is explored in this study and report. Given the climate of the housing market in Portland, Oregon, this topic is particularly relevant for those living in the area.

Hierarchical Decision Modeling (HDM) is the method used to analyze the topic. Ten individuals, considered topic experts in the realm of home improvement for the sake of this study, were surveyed. They will serve as the expert panel. In a questionnaire sent to the expert panel to gauge their level of expertise, all ten experts on the panel said that they prefer either implementing a combination of utilizing both a professional licensed contractor and the DIY approach. However, the results of the study revealed otherwise. Hiring a professional licensed contractor received the highest final score. When asked to weigh the criteria (functional necessities, structural, curb appeal, and aesthetic upgrades), the panel ranked structural highest, followed by aesthetic upgrades, functional necessities, and curb appeal. When asked to weigh the influencing factors, landscaping, exterior paint, and foundation were ranked the highest.

There are several limitations to the study and are several questions left unanswered. Among the remaining questions left unanswered are: how can the model be further optimized, what would the results of the study look like using a different expert panel demographic, and would the same results be achieved should the former two questions be addressed. The limitations of the study are directly related to the unanswered questions and will be discussed in this report.

#### INTRODUCTION

The housing market in the Portland, Oregon metropolitan area is a challenging climate for home buyers. This is particularly true in Washington County which includes the cities of Beaverton and Hillsboro, among others. According to the U.S. Department of Housing and Urban Development's May 2016 Comprehensive Housing Market Analysis of the area, the Beaverton-Hillsboro housing submarket is considered, "tight as the demand for homes increases and prices continue to appreciate, a trend that has been sustained since 2012" [1]. With the average sales price of an existing home being \$318,300 and \$382,700 for that of a new home, as the comprehensive analysis states, a significant hurdle is posed for first time home buyers who are often millennials saddled with an estimated average \$37,127 of student loan debt [2]. Due to the increasing popularity of Portland's quirky culture, breathtaking scenery, and an attractive job market that draws talent to companies like Columbia Sportswear, Nike, Daimler, and Intel, an already "tight" market can become nearly impossible to penetrate with this particular potential home buyer demographic. Naturally, finding the perfect home that requires no home improvement or renovation efforts at the price point of \$300,000 may not be the most realistic and achievable goal. This is a classic case of low supply and high demand.

Potential first time millennial home buyers have many decisions to make. They may choose to rent, buy a home higher or lower than the \$300,000 price point, or settle for home at or around the \$300,000 price point that may require some home improvement efforts. The purchase of a home is a significant investment of both time and money, thus the topic of maximizing home

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resale value through home improvement investments, the focus of this study, is a worthy decision making topic to be explored.

In this study, Hierarchical Decision Modeling (HDM), a variation of the Analytical Hierarchy Process (AHP) methodology, will be used in order to determine the best course of action for maximizing home resale value through home improvement investments; hire a professional licensed contractor to execute all home improvements, employ a do-it-yourself (DIY) approach, or implement a combination of the two.

#### **METHODOLOGY**

HDM, a variation of AHP that is widely taught at Portland State University's (PSU) Department of Engineering and Technology Management (ETM), was selected for this study for several reasons. HDM is a multi-criteria decision-making model that weighs overarching global criteria against influencing factors with regard to the decision at hand. **Figure 1** is a screenshot image of a generic HDM model tree as viewed in PSU's online HDM tool. Note that for the purpose of this study, the HDM tree has four levels; Level 1, the decision; Level 2, the criteria; Level 3, the influencing factors; Level 4, the options. These terms will be used interchangeably throughout this report. Subjective expert opinion is surveyed to determine the most favorable option.



Figure 1: Screenshot of the Generic HDM Model as shown in PSU's Online HDM Tool

HDM relies on this expert opinion in order to assign values to pairwise comparisons at each level of the decision hierarchy. Instead of making a decision only taking into consideration the overall problem at hand, HDM breaks the problem down into sub-problems, or pairwise comparisons, for each expert to analyze and weigh in on. This allows the expert to focus on certain aspects of the problem level by level, one pairwise comparison at a time, which allows the expert to focus on individual aspects of the problem without getting overwhelmed. **Figure 2**  is a screenshot image of a Level 1 pairwise comparison view of a generic HDM model as viewed in PSU's online HDM tool. **Figure 2** is a representation of how each expert that will view the model as they input their scores into each pairwise comparison. Note that 100 points are to be spread across for each pairwise comparison. This means that the final resulting output of PSU's online HDM tool will be in ratio form and can easily be converted into a percentage.



Figure 2: Screenshot of the Generic HDM Model Pairwise Comparison View for Level 1 of the Model Tree.

An equation is used to calculate a final aggregate score to determine the most favored outcome or option of a decision. The following basic HDM equation is used to determine the final aggregate score of the decision. **Table 1** defines the symbols of the equation.

$$S = \sum_{i=1}^{l} C_{i} \sum_{j=1}^{J} F_{j} \sum_{k=1}^{K} O_{k}$$

**Table 1:** Basic HDM Equation Definitions

Symbol	Definition
S	Aggregate score of the decision
Ci	Relative contribution of each criteria (C <sub>i</sub> ) to the decision (D)
Fj	Relative contribution of each factor (F <sub>j</sub> ) to each criteria (C <sub>i</sub> )
Ok	Relative contribution of each option $(O_k)$ to each influencing factor $(F_j)$
1	Number of nodes at C
J	Number of nodes at F
К	Number of nodes at O

For the purpose of this model, the decision, criteria, influencing factors and options are defined

by the following:

- Level 1 Decision How to Maximize Home Resale Value through Home Improvement Investments
- Level 2 Criteria Type of Home Improvement
- Level 3 Influencing Factors Home Improvement Project
- Level 4 Options Source of Home Improvement

Note that there are also a series of calculations that happen in the background of PSU's online HDM tool that occur on three matrices [3]. The exact intricacies of these calculations will not be discussed in this report. Rather, the final outputs will be discussed and analyzed.

HDM is both subjective (relies on the opinions of experts) and quantitative (relies on experts assigning values to pairwise comparisons) in nature which makes it the ideal model for this study. According to Dr. Dundar F. Kocaoglu, known as Dr. K in the PSU ETM department and who is also the creator of HDM, "When multiple decision makers are involved, the HDM

approach is an effective way to form consensus among decision makers where the members of the group have different goals." [3]. This study relies on multiple decision makers, experts, to determine the most favorable outcome of the decision at hand. In the case of this study, and like most social experiments, these experts may indeed have different goals. In order to account for this, PSU's online HDM tool calculates a discontinuity score which measures the disagreement between the experts as a group. A score of 10% disagreement or less is generally considered acceptable. PSU's online HDM tool also calculates inconsistency scores for each individual expert which measures how consistent an individual expert's judgement is. Again, an individual inconsistency score of 10% or less is generally considered acceptable.

#### DECISION (LEVEL 1) AND OPTIONS (LEVEL 4)

In this section, the decision problem statement and the options associated with it will be defined.

#### Decision (D)

The problem statement for this study is: how to maximize home resale value through home improvement investments. The options are: hire a professional licensed contractor to execute all home improvements, employ a DIY approach, or implement a combination of the two. There are positives and negatives to each option. One must take into consideration the time, money, and effort (also known as sweat equity) required for home improvement projects before selecting an option. The experts were encouraged to take these items into consideration when

selecting their scores for the Level 2 pairwise comparisons. The options related to this decision are further defined below.

#### Professional Licensed Contractor (O1)

Using a professional licensed contractor to do all home improvement projects is likely the most expensive option out of the three. One might expect better or higher quality results by using a professional licensed contractor for home improvement projects such as foundation or roofing work than they would doing these projects themselves. This isn't always the case as discussed in the next subsection. Weighing the cost of hiring a professional licensed contractor against the potential payback in the form of a higher home resale value is something the experts were asked to take into consideration when selecting their scores for each pairwise comparison.

#### <u>Do-It-Yourself</u> (O<sub>3</sub>)

The DIY approach also has several positives and negatives associated with it. The DIY approach is an "increasingly popular consumer behavior," with many intricacies behind the motivations of the DIY individual as well as the potential positive outcomes of DIY behaviors [4]. According to Wolf and McQuitty, some of the motivations are: relative economic benefits, lack of product quality in the professional sector, lack of product availability, the need for customization, achieving an enhanced sense of empowerment, constructing an identity as a craftsman, being part of a DIY community, and the need for uniqueness [4]. Not all of these motivations may directly impact future home resale value. But, they are potential motivators that may drive the experts to weigh criteria, influencing factors, and options more heavily in favor of DIY or

alternatively more heavily in the other two options. There are also positive outcomes of DIY behaviors not directly related to home resale value such as: a sense of accomplishment, control, and enjoyment [4]. Again, although not directly related to home resale value, these items may contribute to the high inconsistency values some experts received as well as the high discontinuity score that was revealed in the study. These values will be discussed in the following sections of this report.

#### CRITERIA (LEVEL 2) AND INFLUENCING FACTORS (LEVEL 3)

In this section, a description of each criteria category, its associated influencing factors, and an explanation as to why each node was selected for the model will be defined.

#### FUNCTIONAL NECESSITIES (C1)

Functional necessities are features of a house that are necessary to the overall function of the home such as a roof (F<sub>11</sub>), siding (F<sub>12</sub>), water heater (F<sub>13</sub>), furnace (F<sub>14</sub>), and foundation (F<sub>15</sub>). A leaky or unstable roof will quickly devalue a house. The same is true for old, peeling siding, a water heater that only allows for hot or cold water but, not both, a furnace that is inefficient and may drive costs up in the winter or summer, or a cracked or unstable foundation. Putting home improvement efforts into addressing these influencing factors can generally be considered money well spent and will likely have a positive effect on home resale value. It is for these reasons that each node was selected for the model.

#### STRUCTURAL (C<sub>2</sub>)

Structural influencing factors are features of a house that directly affect the structure of the house but are not necessarily critical to its function such as a garage door (F<sub>21</sub>), patio (F<sub>22</sub>), trim (F<sub>23</sub>), additional bedrooms (F<sub>24</sub>) and additional bathrooms (F<sub>25</sub>). Having a garage door is not a functional necessity but certainly nice to have especially if a homeowner owns a vehicle, yard equipment, bicycles, or anything else that might be best stored in a garage. The same is true for a patio, trim, and having additional bedrooms and additional bathrooms. Having a patio, additional bedrooms, and additional bathrooms are great features of a home for homeowners who like to entertain and/or have growing families. It is for these reasons that each node was selected for the model. Trim is considered structural because it directly affects the structure of a home. For the purpose of this model, trim is not considered a functional necessity but, could just as easily be considered an influencing factor under curb appeal or aesthetic upgrades. This limitation is discussed in following sections.

#### CURB APPEAL (C<sub>3</sub>)

Curb appeal influencing factors are features of a house that directly affect the outward appearance of a home and in turn may affect the perception of the quality of the interior such as landscaping (F<sub>31</sub>), exterior paint (F<sub>32</sub>), and a driveway (F<sub>33</sub>). Beautiful landscaping, fresh exterior paint, and a freshly paved or new aggregate driveway may go a long way in terms of home resale value and are directly related to curb appeal. These influencing factors are not considered functional necessities or structural influencing factors as they are not necessarily required for the function or structure of a home. It is for these reasons that each node was

selected for the model. For the purpose of this model, driveway is not considered an influencing factor under the functional necessity, structural, or aesthetic upgrade criteria. But, it could easily fall into any of the four. This limitation is discussed in following sections.

#### AESTHETIC UPGRADES (C<sub>4</sub>)

Aesthetic upgrades are features of a home that are generally aesthetic in nature such as airconditioning (F<sub>41</sub>), interior paint (F<sub>42</sub>), window treatments (F<sub>43</sub>), counters (F<sub>44</sub>), cabinets (F<sub>45</sub>), and flooring (F<sub>46</sub>). Fresh interior paint, window treatments that black out light, natural stone counters, and brand-new cabinets and flooring are certainly nice to have and can go a long way in terms of resale value. These influencing factors directly affect the perception of a home's value and can positively affect home resale value. It is for these reasons that each node was selected for the model. Air-conditioning in Portland considered an aesthetic upgrade for the purpose of this study because it typically isn't needed very often in the area. Although this hasn't been the case in more recent years, Portland summers are typically mild as compared to other parts of the U.S., like in the more Southern or Eastern States. Therefore, for this study, air-conditioning is considered an aesthetic upgrade. The limitation of this influencing factor is discussed in the following sections of this report.

**Figure 3** is a visual representation of the HDM model tree specific to this study with the decision, criteria nodes, influencing factors nodes, and option nodes, as described in this section, filled in appropriately.

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Figure 3: HDM Model Tree Specific to this Study

## DATA SOURCES AND DATA

Ten experts were used in order to quantify the HDM model. All experts have educational and professional backgrounds in engineering with analytical minds suitable for a study of this kind. The following questionnaire was used to determine each expert's level of expertise in the realm of home improvement.

#### Expert Questionnaire

- 1. Do you own your own home?
- 2. How many homes have you owned?
  - a. How old are you?
- 3. How many home improvement projects have you completed in the last year?
- 4. Do you have significant home improvement skills (i.e. carpentry skills, landscaping skills, can you lay tile or paint, etc.)?
- 5. How often do you go to Home Depot or Lowes per month?
- 6. Do you prefer hiring out (contractor), doing things yourself (DIY), or a combination of the two?

**Table 2** is the result of the questionnaire. Six out of ten experts own their own home and have owned one or more homes thus far in their lifetime. All ten experts are between the ages of 22 and 39, which loosely puts all experts in the millennial generational category. Note that this assertion can be a topic of intense debate depending on the audience. But, that is a topic for another study. For this report, all experts will be considered millennials. Nine out of ten experts

have performed one or more home improvement projects in the past year and five out of ten experts completed five or more. Expert 1 completed 15 home improvement projects and Expert 5 completed nine home improvement projects. On a scale of one to ten, with one meaning an expert has no significant home improvement skills and ten meaning an expert has significant home improvement skills, five out of ten experts ranked their skill level as five or above. This means five out of ten experts consider themselves to have moderately significant home improvement skills. Eight out of ten experts go to a home improvement store, such as Home Depot or Lowes, at least once per month with two experts, Expert 1 and Expert 4, reporting going five times per month. Finally, seven out of ten experts said they prefer implementing a combination of DIY and hiring a professional contractor for completing home improvement projects. Three out of ten expert prefer only the DIY approach and zero out of ten experts prefer solely hiring a professional contractor.

Question	Answer	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10
1	Y/N	Y	Ν	Y	Y	Y	Y	Ν	Ν	Ν	Y
2	#	2	0	1	1	3	1	0	0	0	1
2a	#	30	22	39	26	39	37	26	25	26	27
3	#	15	0	1	5	9	6	2	6	3	4
4	1-10	7	3	4	4	5	7	2	5	4	5
5	#	5	1	3	5	2	2	0	1	0	3
6	Contractor, DIY, Combo	DIY	Combo	Combo	Combo	Combo	Combo	Combo	DIY	Combo	DIY

Table 2: Expert Panel Questionnaire Data

**Table 3** is the final resulting data outputted from PSU's online HDM tool. Professional licensed contractor received a final score of 0.39, DIY received a final score of 0.30, and combination of contractor and DIY received a final score of 0.31, making professional licensed contractor the

most favored option but, not by much. Eight out of ten experts had inconsistency scores of less than 10%. Experts 4 and 5 had inconsistency scores of 10% and 13%, respectively. The discontinuity score for the group of experts was 12.3%. See **Appendix A** for the fully quantified HDM model and see **Appendix B** for a compilation of the expert data.

Expert	Professional Licensed Contractor	DIY	Combination Contractor and DIY	Inconsistency
Expert 1	0.13	0.51	0.35	0.07
Expert 2	0.33	0.46	0.21	0.06
Expert 3	0.23	0.42	0.35	0.02
Expert 4	0.52	0.15	0.33	0.10
Expert 5	0.38	0.27	0.35	0.13
Expert 6	0.60	0.16	0.25	0.08
Expert 7	0.40	0.24	0.36	0.05
Expert 8	0.34	0.25	0.41	0.06
Expert 9	0.75	0.07	0.18	0.08
Expert 10	0.25	0.48	0.27	0.03
Mean	0.39	0.30	0.31	
Minimum	0.13	0.07	0.18	
Maximum	0.75	0.51	0.41	
Std. Deviation	0.18	0.15	0.07	
Disagreement				0.123

#### Table 3: HDM Model Final Resulting Data

#### ANALYSIS AND KEY FINDINGS

Each expert has a slightly different motivation for maximizing home resale value through home improvement investments which may account for the 12.3% discontinuity score, the two inconsistency scores that were above 10%, and the fact that all three options (professional licensed contractor, DIY, combination of the two) had very similar scores. Some experts, with more time to allot to home improvement projects and significant home improvement skills, may prefer a DIY approach over hiring a professional licensed contractor. Especially if they believe their results will be higher quality than that of a professional licensed contractor and/or if they might be able to save money. Other experts, who may have little time to allot to home improvement projects and only moderately significant home improvement skills, might choose to go with a professional licensed contractor over DIY. Or, they may choose to do a combination of the DIY approach and hiring a professional licensed contractor. Again, the expert panel was encouraged to weigh many factors in making their decisions such as: their own time, skill level, cost to complete a project on their own, the quality of their own work, the cost of hiring a professional licensed contractor, and the quality of the professional licensed contractor's work. In the end, this study was about maximizing the investment of home improvement projects with regards to home resale value. Any one or all of these factors might have played a part in each expert's ranking of each pairwise comparison. So, even though zero out of ten experts said they prefer solely hiring a professional licensed contractor to complete all home improvement projects and seven out of ten experts said they prefer a combination of hiring a professional licensed contractor and implementing a DIY approach, professional licensed contractor narrowly beat the other two options.

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The reason for the high inconsistency scores from Experts 4 and 5 is a bit more challenging to pinpoint and could be attributed to different motivations as discussed in previous sections. Also, during the data collection some experts asked the author clarifying questions to ensure their complete understanding of the methodology. Others, such as Experts 4 and 5, did not. A lack of understanding or a lack of complete understanding of the methodology might have also contributed to their higher than expected inconsistency scores.



Figure 4: Criteria Distribution

Out of the four criteria (functional necessities, structural, curb appeal, aesthetic upgrades) structural received the highest score of 34%, followed by aesthetic upgrades with a score of 24% and functional necessities close behind with a score of 23%, as shown in **Figure 4**. These results were different than originally anticipated. Although structural influencing factors such as a garage door, patio, trim, additional bedrooms, and additional bathrooms would certainly be nice additions to a home and would surely increase home resale value, one would think

functional necessities would have received the highest score, not the lowest. Functional necessities such as a roof, siding, water heater, furnace, and foundation, are all aspects of a home that homeowners heavily rely on. Without any one of those aspects, a home cannot function properly. However, given the phrasing of the problem statement, categorization of the criteria and influencing factors, the experts chose their scores based on what they thought would add the greatest value and in turn most positively affect home resale value.



Figure 5: Influencing Factors Scores

**Figure 5** shows the ranking of influencing factors color coded by criteria group in relation to **Figure 4**. Landscaping (curb appeal), exterior paint (curb appeal), and foundation (functional necessities) were ranked highest among the expert panel. Trim (structural), air-conditioning (aesthetic upgrades), and patio (structural) were ranked lowest. Again, these results were slightly surprising. But, after taking into consideration the motivations of each expert, landscaping is both something that goes a long way in terms of perception of a home's value and is something homeowners can likely do themselves. The same is true for painting the exterior of a home. Given that the expert panel prefers either a combination of hiring a licensed contractor or employing a DIY approach, this makes sense. Foundation received the third highest score likely due to its impact to the overall function of a home. A house with a cracked or unstable foundation will likely detract any potential future homebuyers from considering purchasing the house right from the start. However, given that foundation work requires significant skill and time, it makes sense that it wasn't ranked the highest.



Figure 6: Functional Necessities Percent Distribution

**Figures 6** shows the distribution percentages for each influencing factor for the functional necessities criteria. Foundation was ranked highest at 32%, followed by roof at 24%. Siding, water heater, and furnace were ranked nearly the same at 15%, 15%, and 14%, respectively. These results make sense. A cracked foundation or a leaky roof will quickly detract potential homebuyers from considering purchasing a home. In this particular grouping of pairwise

comparisons, siding, a water heater, and a furnace would certainly be ranked lower than a foundation and roof. Although peeling siding, an old water heater, and an inefficient furnace would also quickly detract potential homebuyers, compared to foundation and roof, the experts prioritized the given influencing factors on what they thought would have the greatest effect on resale value.



Figure 7: Structural Percent Distribution

**Figure 7** shows the distribution percentages for each influencing factor for the structural criteria. Additional bathrooms were ranked highest at 30%, closely followed by additional bedrooms at 29%, garage door at 18%, patio at 13%, and trim at 10%. Again, experts were asked to prioritize each influencing factor based on its likelihood of positively affecting home resale value. Often realtors will say that bathrooms, both the quality and quantity, sell houses. Keeping this information in mind, it makes sense that additional bathrooms were ranked the highest. The same goes for additional bedrooms. Additional bedrooms will be particularly

appealing for those with growing families or a desire to host guests. The number of bathrooms and bedrooms are often indicators of the size of a home. Typically, the larger the home, the higher the resale value. For these reasons, a garage door, patio, and trim would have a lower priority as compared to the other influencing factors.





**Figure 8** shows the distribution percentages for each influencing factor for the curb appeal criteria. Landscaping was ranked at 42%, closely followed by exterior paint at 38%, and then driveway at 20%. As mentioned above, landscaping can go a long way in terms of a home's perceived value. The same is true for exterior paint and a new driveway. When it comes to real estate, perception can have a big impact on resale value. Again, these are two influencing factors that a homeowner can likely do themselves without the assistance of a licensed contractor. A driveway however, freshly paved or new aggregate, is something that requires skill and time. Skill and time that homeowners may not have. If homeowners do not have

certain skills, they might be more inclined to make mistakes, be required to fix their mistakes,

and/or restart the project in its entirety. Not only will time be wasted but, money will be as

well. Again, experts were encouraged to keep this in mind when providing their rankings.



Figure 9: Aesthetic Upgrades Percent Distribution

**Figure 9** shows the distribution percentages for each influencing factor for the aesthetic upgrades criteria. Cabinets and flooring were scored the same at 22% followed by counters at 18%. Window treatments, interior paint, and air-conditioning were all ranked at 13%. New and modern cabinets and flooring can quickly add value to a home, positively affecting resale value. These results make sense. Again, experts were asked to rank each influencing factor by based on its likelihood of positively affecting home resale value. For this particular set of pairwise comparisons, experts thought cabinets and flooring would have the greatest effect. Though window treatments, fresh interior paint, and a central air-conditioning system would surely positively affect home resale value, when compared to cabinets and flooring, cabinets and flooring won.



Figure 10: Radar Chart Overlaying Options Over Criteria

**Figure 10** is a representation of each option relative to each other and their associated average criteria scores. The radar chart shows that the combination of contractor and DIY was the most balanced of all options. However, because the professional licensed contractor option scored very high in the functional necessities and structural criteria, it ultimately received the highest overall score, making it the most favored option. The DIY option scored very high in curb appeal, likely due to the experts' confidence that they could do landscaping and exterior paint home improvement projects on their own without the assistance of a professional licensed contractor. Experts' confidence in their own abilities decreases when it comes to doing foundation and roof home improvement projects which is evident by the spike in the professional licensed contractor option for that criteria.

#### **FUTURE RESEARCH**

There were several limitations of this study such as phrasing of the problem statement, phrasing of the nodes of the HDM model, and expert panel selection. These limitations and a discussion of potential resolutions and future research to address these limitations are explored in this section.

#### Phrasing of the Problem Statement

Maximizing home resale value through home improvement investments can be interpreted in many different ways making it highly subjective. The value of time and money vary among experts. Depending on the expert, one person may weigh the value of their time higher than the value of their money. While another expert may have the opposite thought process. DIY motivations and outcomes along with the quality of the home improvement project (whether completed through the DIY approach or through a professional licensed contractor) add another layer of complexity to the problem. Although experts were encouraged to take all of these items into consideration when keeping home resale value in mind. But, perhaps in a further study these overlooked aspects of the model may be further clarified with a more specific problem statement to achieve more favorable agreement among experts.

#### Phrasing of the Nodes

Similar to the phrasing of the problem statement, certain aspects of the model's nodes can be interpreted in a number of different ways. The criteria might have been misleading due to using words such as necessities and upgrades. Influencing factors such as trim, driveway, and air-

conditioning, can also be misleading at times. Trim was categorized under the structural criteria but it could have also been categorized under curb appeal. Driveway was categorized under curb appeal but could just as easily been categorized under functional necessities. The nature of the criteria and influencing factors are highly subjective. One person might view a driveway as a functional necessity while another may view it as part of a home's structure or an aspect of curb appeal. Air-conditioning was perhaps the most incorrectly categorized influencing factor. It was put under the aesthetic upgrades criteria but, may have been better suited under the structural criteria. Whether this influenced the final output of the model is unclear. Airconditioning had an average score of 13% of the aesthetic upgrades criteria. This is relatively low in comparison to flooring and cabinets under the same criteria. However, perhaps airconditioning would have received a higher score had it properly been categorized. The same might be true for trim and driveway. Changing the categorization of the influencing factors or the phrasing of the criteria might yield different results. Further study would need to be executed in order to flesh out these details.

#### **Expert Panel Selection**

This study only surveyed a certain demographic; potential millennial home buyers with educational and professional backgrounds in engineering. Future research may include repeating the study with a different expert panel demographic with experts that may be closer to retirement age or that may have more extensive backgrounds in construction and/or home improvement.

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Ultimately, although imperfect, this study was a solid first step in the direction of determining how to maximize home resale value through home improvement investments when given the options of hiring a professional licensed contractor to execute all home improvements, employing a DIY approach, or implementing a combination of the two. Further refinement of the model, with nodes that are more easily distinguishable and stand alone, using the same expert panel or a different expert panel may yield different and/or potentially more favorable results.

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## **APPENDIX A – FINAL, QUANTIFIED MODEL**

Note that the normalized weights for Level 3 of the final quantified HDM model is split into three separate images for readability.



## **APPENDIX B – AHP/HDM PCM DATA TABLES**

Note that the Level 3 pairwise comparison data table is split into two images for readability.

Level-1	Maximize Home Resale Value through Home Improvement Investments
Functional Necessities	0.23
Structural	0.34
Curb Appeal	0.19
Aesthetic Upgrades	0.24
Inconsistency	0.08

Level-2	Functional Necessities	Structural	Curb Appeal	Aesthetic Upgrades
Roof	0.24	0.00	0.00	0.00
Siding	0.15	0.00	0.00	0.00
Water Heater	0.15	0.00	0.00	0.00
Furnace	0.14	0.00	0.00	0.00
Foundation	0.33	0.00	0.00	0.00
Garage Door	0.00	0.18	0.00	0.00
Patio	0.00	0.13	0.00	0.00
Trim	0.00	0.10	0.00	0.00
Additional Bedrooms	0.00	0.29	0.00	0.00
Additional Bathrooms	0.00	0.30	0.00	0.00
Landscaping	0.00	0.00	0.42	0.00
Exterior Paint	0.00	0.00	0.38	0.00
Driveway	0.00	0.00	0.20	0.00
Air-Conditioning	0.00	0.00	0.00	0.13
Interior Paint	0.00	0.00	0.00	0.13
Window Treatments	0.00	0.00	0.00	0.13
Counters	0.00	0.00	0.00	0.18
Cabinets	0.00	0.00	0.00	0.22
Flooring	0.00	0.00	0.00	0.22
Inconsistency	0.07	0.06	0.03	0.06

Level-3	Roof	Siding	Water Heater	Furnace	Foundation	Garage Door	Patio	Trim	Additional Bedrooms	Additional Bathrooms
Professional Licensed Contractor	0.61	0.48	0.27	0.55	0.73	0.27	0.17	0.20	0.53	0.48
DIY	0.15	0.18	0.36	0.19	0.06	0.46	0.54	0.53	0.16	0.18
Combination Contractor and DIY	0.25	0.34	0.36	0.27	0.22	0.27	0.29	0.28	0.32	0.34
Inconsistency	0.06	0.12	0.03	0.06	0.09	0.07	0.05	0.04	0.08	0.06

Level-3	Landscaping	Exterior Paint	Driveway	Air- Conditionin g	Interior Paint	Window Treatments	Counters	Cabinets	Flooring
Professional Licensed Contractor	0.11	0.23	0.56	0.54	0.06	0.24	0.40	0.43	0.28
DIY	0.60	0.55	0.18	0.22	0.66	0.45	0.22	0.17	0.28
Combination Contractor and DIY	0.28	0.22	0.26	0.25	0.28	0.31	0.38	0.40	0.44
Inconsistency	0.06	0.04	0.07	0.05	0.13	0.07	0.09	0.07	0.05

# The final result:Level-1Maximize Home Resale<br/>Value through Home<br/>Improvement InvestmentsProfessional Licensed<br/>Contractor0.39DIY0.30Combination Contractor<br/>and DIY0.31Inconsistency0.07