Decision Making Model of Place to Live for New Students at PSU: The Case of International Graduate Students

Course Title: Decision Making in Engineering and Technology Management

Course Number: EMGT 530/630

Instructor: Dr. Dundar F. Kocaoglu

Term: Winter

Year: 2009

Author(s): Team 3

Abdulrhman Almobarak
Rafael Colon
Ibrahim Iskin
Songphon Munkongsujarit
Nuancharas Phopoonsak
Willi Schweinfort
Napong Tanatammatorn

ETM OFFICE USE ONLY

Report No.:
Type: Student Project
Note:

ABSTRACT

The project demonstrates the use of decision making model in the selection of a place to live for a new student who just came to Portland State University (PSU.) A hierarchical decision model (HDM) was selected as a tool and the model was constructed to fulfill the objective of selecting the best place to live. The goal with respect to cost efficiency, convenience, and safety were identified based on the objective. The criteria and sub-criteria were listed as the living condition with respect to each goal. The alternatives were chosen for both on-campus and off-campus housings. The experts were selected from a group of international graduate students to weight their preferences based on the HDM model. Finally, utility value was used to compare each characteristic of all alternatives and the alternative with the most preference score based on HDM was identified.

TABLE OF CONTENT

I. INTRODUCTION

Housing is one of the crucial basic needs that people have. Most international and non-local students who just came to Portland State University (PSU) face a problem of choosing a place to live. Their newness to the city and subsequent lack of familiarity with their surroundings makes selecting an ideal home difficult. According to the *Vanguard* (PSU student newspaper) [1], PSU has the highest number of international students in the state of Oregon. Most of them have a hard time choosing where to live. Therefore, a decision model was developed to assist new students in making the right decision on their housing selection in Portland by using international students as the target group.

Since such decision is a complex process that involves both quantitative and qualitative judgment. We proposed the use of the hierarchical decision model (HDM) as a tool to help the students through this complex decision process. Basically, HDM breaks down a complex decision that contains various elements into a number of smaller problems such that the decision problem is represented as a hierarchy. Thus, HDM helps the decision maker by presenting the decision problem in a simpler way to handle. The detailed information and description of HDM could be found in [2] - [3]. A number of complex real-life decision problems had been assessed with HDM tool such as the decision problems in [4] - [6].

II. METHODOLOGY

In order to develop a model to help a new student to select a place to live from many possible alternatives, a systematic approach was used to assist the decision making process of this project. Figure 1 shows the decision processes starting from assessing the problem statement, selecting an appropriate decision model, collecting data, and finally to calculating results.

Since the nature of the decision to be made in this project involves many factors ranging from straight-forward and easy-to-measure factors to complicated and subjective aspects, the HDM approach is then selected as a core in the decision methodology for this project. Along with the ability of HDM to provide a multi-level structure in the decision model, the pair-wise comparison and utility curve techniques are also used to complete the alternative evaluation by computing the relative weights and values of criteria and alternatives. The HDM and the accompanying techniques are discussed below.

A. HDM is a tool used in a decision making to rank and evaluate the available choices that you have and then determine the best among them. In this project we have different choices of places to live and we are to rank these choices and determine the best one among them based on the different criteria that each one has.

B. Pair-wise comparison is utilized to determine the relative importance for each criterion. When we apply this comparison we always consider the opinion of the experts, which are the international students in the case of this project. The first step here is to develop a questioner to be given to the experts. Then the comparisons are run through the "PCM" software program. Finally, the weight result of each criterion is evaluated to discern the importance of each one.

C. Utility value quantifies both subjective and objective measurement for each characteristic of the alternatives. This step evaluates each alternative based on its characteristics (or attributes) with the respect to the relative importance to the objective of the model. The utility curve is built from the experts rating based on personal preference. A questionnaire is developed for capturing the experts' opinion in order to construct the utility curves.

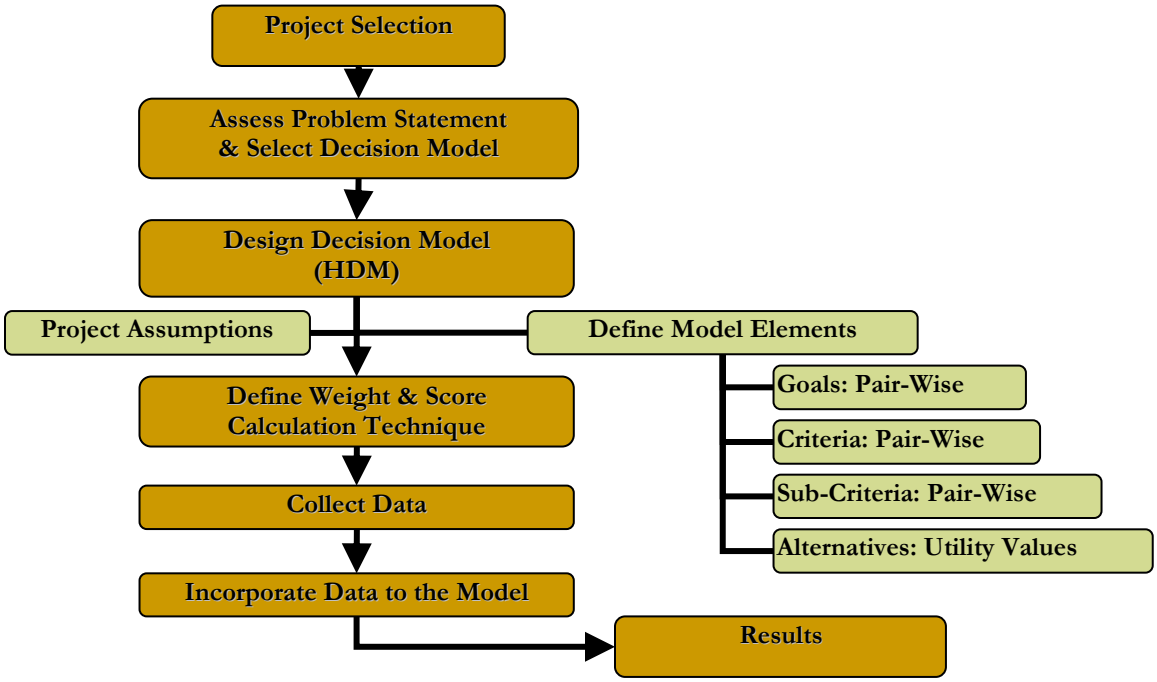


Figure 1-Decision approach

Assumptions

In order to reduce complexity and increase transparency, the following assumptions were made:

- The student has to be a new, full-time graduate student at PSU. He is also new to Portland, Oregon and lives alone with no family.
- It is assumed that that student has no car and therefore uses public transportation to move around in the city.
- The student is indifferent whether to live alone or share a room/apartment/house. The decision of "sharing/no sharing" is a whole decision model by itself, and has to be made before looking for possible apartments. In our case, however, the student can chose between various kinds of these living conditions and is equally likely to choose between them.
- The apartments chosen are all accessible to public transit.
- There were 12 experts, all international students, who were asked to state their opinion to generated weights within the HDM (using pair-wise comparison.)

III. DECISION MODEL

The hierarchical decision model used in this project consists of 4 levels as shown in figure 2.

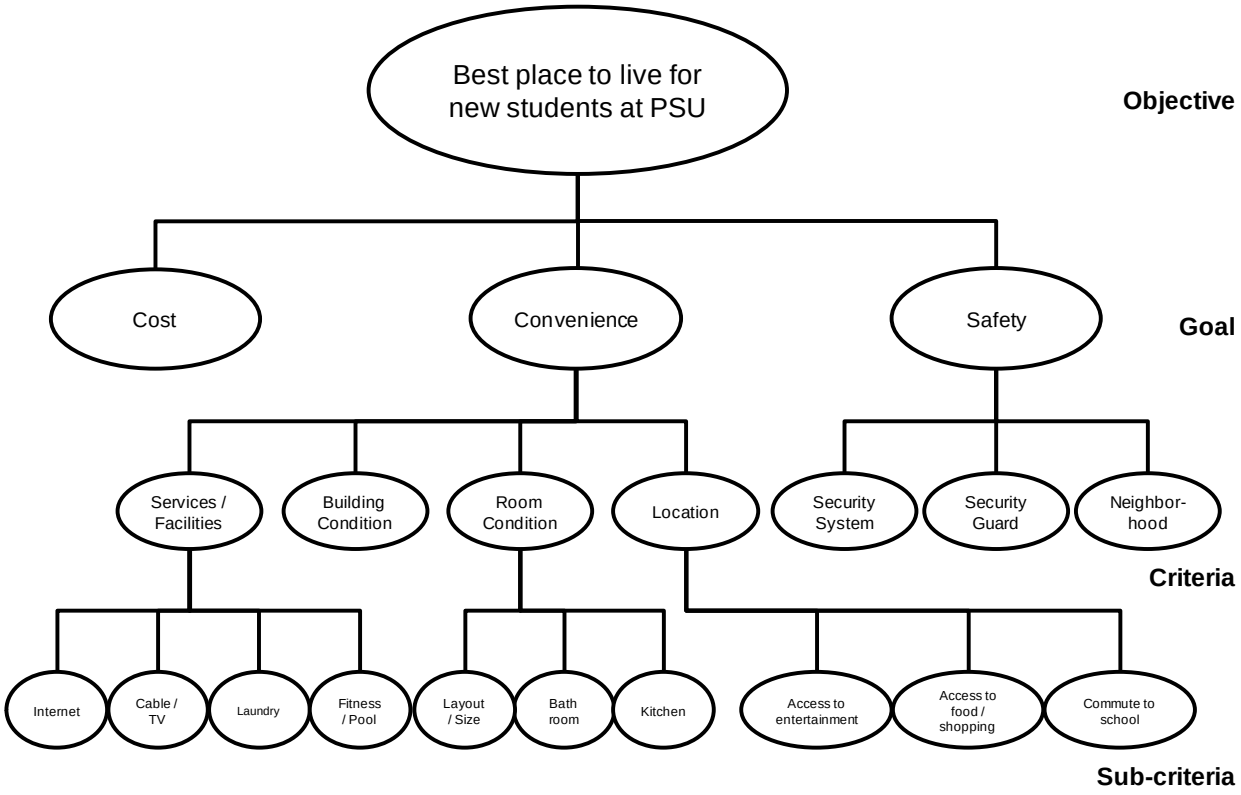


Figure 2-Heirachical decision model

Level 1 (Objectives):
This level states the decision that is to be modeled and made. In this case it is the question of finding the best place to live for a student who just started studying at PSU.

Level 2 (Goals):
Goals contribute to the objective, yet might have very distinguished backgrounds. They are the important requirements students consider when they choose a place to live.

Level 3 (Criteria):
Criteria typically are measurable and contribute to one or several goals.

Level 4 (Sub-criteria):
Some criteria might be broken down into sub-criteria in order to increase accuracy of the criterion's measurement. Furthermore, if criteria are influenced by several measures, this is the way to incorporate it.

The detailed information of all elements in each level is explained as follow:

Objective

The objective, as stated above is to find the best place to live for a new student at PSU. In this project, however, we focused only on a new full-time international graduate student at PSU as we identified a group of international graduate students at PSU as the experts in our project. It should be noted that the model could be used for any new students at PSU with similar goals and criteria in selecting the place to live.

This decision can be broken down into three goals (Cost, Convenience, Safety), which themselves consist of criteria and sub-criteria. By using brainstorming sessions and qualitative interviews with the students, all criteria relevant to this decision were indentified and included in the final hierarchical decision model.

Goals, Criteria and Sub-criteria

Goal 1: Cost

Total amount of money a student has to pay monthly to sufficiently live in the selected place. It includes rent, commuting cost to school, and basic utilities including water-sewer, electricity, and internet connection.

As for off-campus alternatives requiring transit to commute to PSU, an additional cost of $55 for a student-discounted All Zone Tri-Met transit pass is added to the monthly rent [7] - [8].

Goal 2: Convenience

The quality of being suitable or opportune, useful, convenient, and comfortable that supports both students' living and study purposes. There are many different aspects contributing to the convenience one can define. Based on inputs from the experts and PSU housing website, four criteria mostly concerned by the experts were identified and shown below.

Criterion 2.1: Building Condition

This criterion is considered with respect to inside and outside physical conditions of the building including built quality, year of built (age) or renovated, elevator operation, stairways, fire escape routes, hallways and lobby conditions, and cleanliness. Utility values will be based on experts' perceptions of the conditions and the likelihood these conditions will impact the living quality of residents.

Criterion 2.2: Room Condition

This criterion is considered with respect to the room itself where the student actually lives in. Three sub-criteria were identified by the experts.

a. Layout and room size – This is considered with regards to how much space is provided and how the space laid out for the student to live comfortably and practically i.e. a bedroom separated from the living area, available storage room, and size of closets.

b. Bathroom – This is considered with regards to size, bathtub, ventilation, cleanliness, and lavatories including working condition, material, and age. In addition, the availability of the bathroom whether the student has to share it with others is also considered, which a unique condition of some PSU residences is.

c. Kitchen – This is considered with regards to the completeness of kitchen appliances including stovetop, oven, dishwasher, ventilation, disposer, etc. In addition, the consideration is given to whether there is a kitchen in the room or the student has to share the kitchen.

Criterion 2.3: Location

This criterion is considered with respect to the accessibility to places and activities necessary for the student's everyday life. Three sub-criteria were identified by the experts for this criterion.

a. Access to entertainment – We defined the most important entertainment categories, which are cinemas, pubs and bars, game rooms. Accessibility is measured by distance to those places and traveling methods. An average distance to the nearest place of each category is used.

b. Access to shopping/food/grocery – General shopping center and grocery store are considered in this sub-criterion. Accessibility is measured by distance to the places and traveling methods.

c. Commute to school – Regular commuting methods, distance, and time from the living place to school is considered.

Criterion 2.4: Services/Facilities Availability

This criterion is considered with respect to the availability of extra utilities and services that contribute to more comfortable and desirable living condition. Three sub-criteria were identified by the experts for this criterion.

a. Internet Connection – Availability of internet connection is considered. The internet can be differentiated by delivery methods (wired or wireless), speed, and whether it is included in the rent.

b. Cable TV – Availability of cable television service is considered. The service can be differentiated by the available providers and whether it is included in the rent.

c. Laundry – This facility is considered by its availability (in unit or shared in the building), numbers of machines, operating condition, and price.

d. Fitness/Pool – This sub-criterion includes the availability of a fitness room and a swimming pool.

Goal 3: Safety

The safety to the student, belongings, and properties is included. Two major perspectives contributing to the safety include the safety of the location the place is located in and the safety features provided by the owner of the place. Three criteria were identified by the experts.

Criterion 3.1: Neighborhood
This criterion is considered with respect to the safety of the neighborhood, crime rates, close-by police stations, and street light.

Criterion 3.2: Security System
This criterion is considered with respect to the security systems provided by the property i.e. security door and access card, security camera, and emergency phone.

Criterion 3.3: Security Guard

This criterion is considered with respect to whether there is a security personnel available and when it is available (24 hours or night only).

Alternatives

Alternatives are included in the HDM at the very bottom of the model. In order to show interrelations, a very diverse set of different options is taken into account including on and off campus housing, apartments and host-families all across the city. Data was gathered by directly questioning people who actually live in these places, combined with other methods which are explained later in this paper. This leads to a set of data, which covers all criteria and sub-criteria and eventually lead to an alternative specific score.

Table 1 provides an overview of all alternatives. Detailed information is found in Appendix A.

Table 1-List of alternatives

Name of Alternative		Address
A1	Buckman Terrace	303 NE 16th Ave. Portland, OR 97232
A2	Ondine Dorm (shared room)	1912 SW 6th Ave. Portland, OR 97201
A3	Ondine Dorm (single room)	1912 SW 6th Ave. Portland, OR 97201
A4	South Park Apartment	1525 SW Park Ave. Portland, OR 97201
A5	Vue Apartment	1717 SW Park Ave. Portland, OR 97201
A6	Lovejoy Apartment	301 SW Lincoln St. Portland, OR 97201
A7	Montgomery Dorm	1802 SW 10th Ave. Portland, OR 97201
A8	Host family in NE	2512 NE 21st Ave. Portland, OR 97212
A9	Oswego Point Apartment	5033 Foothills Dr. Lake Oswego, OR 97034
A10	Goose Hollow Apartment	1630 SW Clay St. Portland, OR 97201
A11	Beaverton La Salle Apartment	15021 SW Millikan Way Beaverton, OR 97006

IV. MODEL IMPLEMENTATION

In order to implement the model the data from expert opinions for relative importance ratings of each level in hierarchical decision model and the utility values associated with certain characteristics of the alternatives were collected using questionnaires. The experts in this case were the international graduate students at Portland State University, thus it should be noted that the model would reflect and represent only the opinion of this group of expert. With different groups of experts, it is possible that the relative importance ratings and the utility functions would be different from the model shown in this report.

Pair-wise Comparison

In order to determine the relative importance ratings for goal, criteria and sub-criteria comparison, pair-wise comparisons of expert opinions are utilized. The questionnaires used for these comparison is presented in Appendix B. The result of the comparisons were obtained from the "PCM" software program [9], the output of the goal, criteria and sub-criteria comparisons are shown as a screen capture from the "PCM" software in Appendix C. The final relative importance weights for goal, criteria and sub-criteria to the objective are summarized in Table 2.

Table 2-Summary of relative importance weights of the model

Goal, Criteria and Sub-criteria	Weight (Goal to Objective)	Weight (Criteria to Goal)	Weight (Sub-criteria to Criteria)	Relative Weight (Criteria to Objective)	Final Weight
Cost	0.35				**0.35**
Convenience	0.31				
Services and Facilities		0.24		0.07	
Internet			0.46		**0.03**
Cable TV			0.11		**0.01**
Laundry			0.31		**0.02**
Fitness/Pool			0.12		**0.01**
Room Condition		0.28		0.09	
Layout/Size			0.31		**0.03**
Bathroom			0.34		**0.03**
Kitchen			0.35		**0.03**
Location		0.3		0.09	
Access to Entertainment			0.15		**0.02**
Access to Food/Shopping			0.37		**0.03**
Commute to School			0.48		**0.04**
Building Condition		0.18		0.06	**0.06**
Safety	0.33				
Neighborhood		0.52		0.17	**0.17**
Security System		0.31		0.10	**0.10**
Security Guard		0.17		0.06	**0.06**

Note that the total weights do not sum up to be 1.00, this is because the rounding error of PCM software for the weights of goal to objective level.

Utility Value

From Table 2, it is evident that there are 15 different characteristics or attributes of alternative that contribute to the objective of the model (to find the best place to live) based on goals, criteria and sub-criteria. In order to compare all alternatives and choose the best alternative that fits the objective of the model, the data of all attributes for all alternatives were collected and then translated into utility scores using utility values associated with each attribute. Utility values quantify both qualitative (subjective) and quantitative (objective) measurement of these attributes in order to make them comparable and make it possible to assign the summation of the score for the best alternative that fits the objective of the model. Table 3 provides the list of attributes and their associated metric for utility calculation.

Table 3-Attribute list and its associated metric of comparison

Goal, Criteria and Sub-criteria			Metrics
Cost			Average Utility Score out of 100
Convenience			
	Services and Facilities		
		Internet	Binary condition
		Cable TV	Binary condition
		Laundry	Binary condition
		Fitness/Pool	Binary condition
	Room Condition		
		Layout/Size	Average Utility Score out of 100
		Bathroom	Average Utility Score out of 100
		Kitchen	Average Utility Score out of 100
	Location		
		Access to Entertainment	Average Utility Score out of 100
		Access to Food/Shopping	Average Utility Score out of 100
		Commute to School	Average Utility Score out of 100
	Building Condition		Average Utility Score out of 100
Safety			
	Neighborhood (refer to crime rate information website [11])		Average Utility Score out of 100
	Security System		Binary condition
	Security Guard		Binary condition

The utility score ranges from 0 to 100 and represents the preference or desirability associated with the attribute from minimum preference to maximum preference. Note that the 'binary condition' in Table 3 represents the special case of utility value where the alternative would get the full score of 100 if it has the specific attribute and it would get the score of 0 if it does not have that specific attribute. Simply speaking, it could be viewed as the condition of 'have' or 'not have' – thus it is the binary condition.

In order to determine the utility score of each attribute, the expert opinion (preference) is utilized. A preference survey questionnaire is developed and distributed to the expert and the utility score for each attribute is calculated based on the average result of preference from the survey. The questionnaire used in this case is presented in Appendix D and the survey results as well as their associated utility curves are presented in Appendix E.

For measurement with quantitative value such as cost and distance (Access to Entertainment, Access to Food/Shopping and Commute to School) the preference is given based on the range of specific value (amount of money in dollar value for cost and distance in miles for distance.) Then, the utility score for each attribute is determined from the utility curve by matching the value of each attribute with its associated utility curve. Note that the utility curve for these characteristics is a continuous line ranging from 0 to 100. Specifically, the cost attribute is the monthly payment in dollar amount for each alternative. As for the distance attributes, distance between each of the alternatives and to their neighboring shopping places, entertainment places and PSU campus has been identified. To come up with numerical values of distances, we used Microsoft's Live Search Maps application [10] which enables its users to see the distance between two specific points in terms of miles. To determine the "Commute to School" attribute we used open addresses of each alternative as the starting point and their distances to the PSU Campus as the end point in the application. To determine the "Access to Food/Shopping" attribute, we used the open addresses of each alternative as the starting point and their nearest shopping places as the end point. We used our team experts to identify the most relevant shopping places for a graduate student and used the address data as an input. Similarly, to determine the "Access to Entertainment" attribute, we used four different types of entertainment places as the determinant. These types are cinemas, bars, cafés and night clubs. By using expert opinion, open addresses of four types of entertainment places for each alternative have been defined. By getting the averages of four distance values for each alternative we came up with one distance value.

As for qualitative or subjective measurement such as building condition and room condition (including layout/size, bathroom condition and kitchen condition,) the preference is given based on a set of pre-defined descriptive conditions given in 5 levels ranging from the best to the worst for each attribute. These utility values for each pre-defined condition level are determined from the average preference score acquired from the survey (See Appendix D and Appendix E.) Note that the utility curve for these qualitative characteristics is a discrete point associated with 5 different pre-defined condition level, thus there are only 5 possible utility values for each attribute. The actual condition of each attribute for all alternatives is determined to be one of five different pre-defined levels and verified by the actual residents of all alternatives. Then, these conditions are matched with their associated utility scores and resulted in the representing utility scores for each qualitative attribute.

Lastly, for the neighborhood safety attribute, the city crime index score based on the commercial web site was utilized [11]. This crime index is a standard measurement of safety level in the city neighborhood area with the score of 0 to 100 where 100 is the safest (the lowest crime rate.) Thus, we assumed the linear relationship between the utility value of neighborhood safety and the crime index. The utility value of neighborhood safety attribute of each alternative was then calculated from the average crime index of the area that the alternative is situated and its surrounding areas. The utility value of neighborhood safety for all alternatives and its associated crime index is shown in Appendix F.

V. RESULTS

The alternatives are compared with each other by the preference index which is calculated from multiplying the utility values of each attribute of the alternatives with its associated relative importance to the model objective and summing all of these values. Thus, if the alternative fits all the criteria perfectly, it would get 100 points; that is the desirability (preference index) of apartment are shown in percentage out of the maximum 100 points. The resulting score for all alternatives is shown in Table 4.

Table 4-Alternatives result score

Goal, Criteria and Sub-criteria	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11
Cost	12.08	31.46	9.17	8.23	8.23	9.04	31.35	32.67	26.95	25.89	2.33
Convenience	29.01	23.47	23.47	29.83	28.31	24.93	23.21	25.87	20.46	30.58	21.59
Services and Facilities	7.44	6.55	6.55	7.44	7.44	7.44	6.55	6.55	6.55	7.44	3.20
Internet	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42	0.00
Cable TV	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.00
Laundry	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31	2.31
Fitness/Pool	0.89	0.00	0.00	0.89	0.89	0.89	0.00	0.00	0.00	0.89	0.89
Room Condition	8.68	5.66	5.66	7.82	7.18	8.26	5.29	7.89	6.69	8.68	8.24
Layout/Size	2.69	0.92	0.92	2.69	2.42	2.69	0.92	2.69	1.95	2.69	2.69
Bathroom	2.95	2.53	2.53	2.53	2.16	2.53	2.16	2.16	2.53	2.95	2.95
Kitchen	3.04	2.20	2.20	2.60	2.60	3.04	2.20	3.04	2.20	3.04	2.60
Location	7.31	8.85	8.85	8.99	8.99	4.53	8.96	5.85	4.81	8.88	4.57
Access to Entertainment	1.11	1.12	1.12	1.12	1.12	1.11	1.12	1.10	0.98	1.13	0.91
Access to Shopping	2.06	3.27	3.27	3.42	3.42	3.42	3.42	0.86	0.09	3.42	0.00
Commute to School	4.13	4.46	4.46	4.45	4.45	0.00	4.42	3.90	3.74	4.33	3.66
Building Condition	5.58	2.42	2.42	5.58	4.70	4.70	2.42	5.58	2.42	5.58	5.58
Safety	10.96	12.55	12.55	12.55	12.55	18.87	12.55	3.30	19.50	14.81	8.18
Neighborhood	0.73	2.32	2.32	2.32	2.32	3.03	2.32	3.30	9.27	4.58	2.57
Security System	10.23	10.23	10.23	10.23	10.23	10.23	10.23	0.00	10.23	10.23	0.00
Security Guard	0.00	0.00	0.00	0.00	0.00	5.61	0.00	0.00	0.00	0.00	5.61
Total Desirability out of 100	**52.04**	**67.47**	**45.19**	**50.60**	**49.08**	**52.84**	**67.11**	**61.84**	**66.91**	**71.27**	**32.11**

According to Table 4, there are four leading alternatives which might be suitable as the best place to live for a new PSU student. These alternatives are A10 (Goose Hollow Apartment) with 71.27 points, A2 (Ondine Dorm-shared) with 67.47 points, A7 (Montgomery Dorm) with 67.11 points and A9 (Oswego Point Apartment) with 66.91 points.

If we have a deeper look on the data of the leading alternatives it can give useful ideas to determine why each of these alternatives is leading. For example, we can say that “Cost” is a very important determinant that makes alternatives A2 and A7 leading which is a quite logical proposition because cost of these apartments are quite low considering the others. For

alternative A10, "Convenience" is the key determinant which differentiates it from other candidate apartments. Also, for alternative A9, we can say that "Safety" has quite importance since alternative A9 has the highest point in that criterion compared to the other alternatives.

While analyzing the apartments for the final decision alternative A8 (NE Host Family) should be separated from other apartments as it is neither a student dormitory nor an apartment. If we have a look at the scores we can easily see that it has got zero score from "Security System" and "Security Guard" as it is an ordinary residential place which does not have any guard and security system. If we sum the loss of alternative A8 from "Safety" we come up with point of 15.84 (10.23 from "Security System" attribute and 5.61 from "Security Guard" attribute) which is quite considerable. Thus, its overall score is lower than the other four leading candidates mentioned above. By considering the common perception that North East is not as safe as South West where four leading places state students may not be considering alternative A8 as an option, but if we look at the "Neighborhood" criterion's scores for each place we see that it does not affect the overall score significantly except for alternative A9. If we consider this fact and neglect the scores of "Security System" and "Security Guard" alternative A8 would also be a leading alternative.

In conclusion, by considering the information above we conclude that alternative A10 (Goose Hollow Apartment) is the best place for a new PSU student to live as it is cheap and provides the best convenient environment as well as with its considerably safe location.

VI. DISCUSSIONS

There are always limitations to any model. In our case there are limitations associated with all levels of the HDM. Starting at the top our goal treats all international students as one. There is no differentiation based on nationality of the international student. There may be vastly different ideas behind choosing a living space based on the cultural of the students.

Our alternative selections face two major issues. First, did we get an alternative list that was representative of the entire Portland metro area? It is very possible that many desirable areas were left off the list. This is a limitation imposed by the knowledge of the HDM originators. The second limitation is that the model is based on selecting a single bedroom place. We know there are many students who prefer having roommates. Our model will not work for them.

In any hierarchical decision model there is always a built-in limitation revolving around the criteria selection. There is always the risk that some criteria are irrelevant and that others were forgotten. We could have added a criterion to access the importance of roommates.

The big worry with utility curves is whether the questionnaires were worded carefully enough. In our questionnaires there was a little confusion about whether access to places by distance was good or bad if it was close. Clear instructions are a major consideration for the utility curves.

There is always the opportunity for biasing. All of the expert data was filled in by international students, but once again they were all treated as one. We didn't make a note of what nationality

the expert was. If all of the experts were from one region of the world the results might be skewed.

The model would be improved if options for a nationality filter and roommates existed. This would work well if it were offered to all PSU students. The PSU international student office can utilize the model to provide prospective international students a choice to select housing. This would have the added effect of creating a model that learns. Data could be mined from what current students are looking for. The model weights could be modified over time. Adding an "other" box would provide a way to gain insight into what students were expecting in housing.

This data would be beneficial to PSU housing. They could use the model to provide appropriate housing for international students. This would make them more competitive in the market for student housing.

VII. CONCLUSION

The paper clearly demonstrates the application of the hierarchical decision model as a tool that helps simplifying the complex decision process. Hierarchical decision models assist the decision makers by providing a systematic way to evaluate all available alternative solutions to the problem according to the relative importance of the criteria and finally in identifying the best possible solution.

As the paper illustrated, the robustness of the model depends highly on the validity of the subjective expert's judgments for the relative importance of each specific criterion. Thus, the selection of the experts and the number of the experts involved in the model development process is vital. Moreover, since the expert's judgment differs from one problem to another, it is necessary to develop a new model when a change occurs. This makes the model become less interchangeable. Thus, as the circumstances change, the decision model has to be modified accordingly.

Since people's opinions differ from each other, based on their taste and needs, it is impossible to develop a decision model which is valid for everybody. In any case, such a model is only valid for the experts and their opinions, which are included. Finally, a sensitivity analysis is always a good option to verify the robustness of the model.

REFERENCES

[1] L. Bing, "Diversity by the numbers," *Vanguard*, p. 1, Feb. 26, 2009.

[2] D. I. Cleland and D. F. Kocaoglu, *Engineering Management*, New York: McGraw-Hill, 1981.

[3] D. F. Kocaoglu, "Hierarchical decision modeling," *PSU ETM EMGT 530/630 Decision Making in Engineering and Technology Management Class Notes*, Winter 2009.

[4] R. A. Taha, B. C. Choi, P. Chuengparsitporn, A. Cutar, Q. Gu, and K. Phan, "Application of hierarchical decision modeling for selection of laptop," in *Proceedings of Portland International Center for Management of Engineering and Technology (PICMET) Conference*, 2007, pp. 1160-1175.

[5] P. Ajgaonkar, A. Auysakul, R. Jefferis, and S. Shinriki, "Use of hierarchical decision modeling for site selection of a major league baseball stadium in Portland," in *Proceedings of Portland International Center for Management of Engineering and Technology (PICMET) Conference*, 2004.

[6] J. M. Buckingham and J. W. Ra, "Application of AHP and MAU in the selection of rural Alaskan airports at which to test remote video for information gathering," in *Proceedings of Portland International Center for Management of Engineering and Technology (PICMET) Conference*, 1999.

[7] Tri-Met: Fares, 2009. [Online]. Available: http://www.trimet.org/fares/index.htm. [Accessed: Feb. 28, 2009].

[8] PSU: Student FlexPass Program, 2009. [Online]. Available: http://transportation.pdx.edu/students/transit. [Accessed: Feb. 28, 2009].

[9] PSU ETM, *PCM Software*, Version 1.4, June 4, 1991.

[10] Microsoft: Live Search Maps, 2009. [Online]. Available: http://maps.live.com/. [Accessed: Feb. 28, 2009].

[11] Neighborhood Scout: Portland crime rates and statistic, 2009. [Online]. Available: http://www.neighborhoodscout.com/or/portland/crime/. [Accessed: Feb. 28, 2009].

APPENDIX A

List of alternatives and associated information is provided in this appendix.

A1	**Buckman Terrace** *303 NE 16th Ave. Portland, OR 97232*

Criteria	Information
#Bedrooms	1 bedroom
Bathroom	Yes, full bath with bath tub
Layout	550 sq. ft.
Kitchen	Yes, full kitchen with dish washer
Internet	Available
Fitness/Pool	Fitness Center, playground, near public tennis court
Laundry	Laundry Room
Cable TV	Available
Building Condition	5-story building, built 1998
Security System	Gated Entrance/Controlled Access
Security Guard	No
Cost (per month)	$730 (Hot Water, Sewer, Trash, Water included)

A2	**Ondine Dorm (shared room)** *1912 SW 6th Ave. Portland, OR 97201*

Criteria	Information
#Bedrooms	Shared room
Bathroom	Shared bathroom with one other room
Layout	220 sq. ft.
Kitchen	Shared kitchen with one other room
Internet	Available
Fitness/Pool	No
Laundry	Laundry room
Cable TV	Available
Building Condition	Concrete 1950 old
Security System	Gated Entrance/Controlled Access
Security Guard	No
Cost (per month)	$375 (Hot Water, Sewer, Trash, Water, Internet, electricity included)

A3	**Ondine Dorm (single room)** *1912 SW 6th Ave. Portland, OR 97201*

Criteria	Information
#Bedrooms	Single room
Bathroom	Shared bathroom with one other room
Layout	220 sq. ft.
Kitchen	Shared kitchen with one other room
Internet	Available
Fitness/Pool	No
Laundry	Laundry room
Cable TV	Available
Building Condition	Concrete 1950 old
Security System	Gated Entrance/Controlled Access
Security Guard	No
Cost (per month)	$578 (Hot Water, Sewer, Trash, Water, Internet, electricity included)

A4	**South Park Apartment** *1525 SW Park Ave. Portland, OR 97201*

Criteria	Information
#Bedrooms	Shared apartment, 2 bedrooms
Bathroom	1 bathroom with bath tub
Layout	813 sq. ft.
Kitchen	Stove, Oven, and Dish washer
Internet	Optional (separated bill)
Fitness/Pool	Fitness and Sauna but no pool
Laundry	Onsite laundry
Cable TV	Optional (separated bill)
Building Condition	Brick building
Security System	Key card access
Security Guard	No
Cost (per month)	$1,525 - $1,640 (Electricity fee, trash, and water fee not included)

A5	**Vue Apartment** *1717 SW Park Ave. Portland, OR 97201*

Criteria	Information
#Bedrooms	Shared apartment, 2 bedrooms
Bathroom	1 bathroom with bath tub
Layout	950 sq. ft.
Kitchen	Stove, Oven and Dish washer
Internet	Optional (separated bill)
Fitness/Pool	Fitness center but no pool
Laundry	Separated Laundry Room
Cable TV	Optional (separated bill)
Building Condition	Old building
Security System	Key card access
Security Guard	No
Cost ()per month)	$1,267 (Electricity fee, trash and water fee not included)

A6	**Lovejoy Apartment** *301 SW Lincoln St. Portland, OR 97201*

Criteria	Information
#Bedrooms	1 bedroom
Bathroom	Yes, full bath with bath tub
Layout	630 sq. ft.
Kitchen	Yes, full kitchen with dish washer
Internet	Available thru Comcast/Free Wi-Fi in lobby
Fitness/Pool	Fitness Center, swimming pool, sauna and spa
Laundry	Laundry Room/ New machines 2007
Cable TV	Available thru Comcast
Building Condition	Concrete, 14-story building
Security System	Card-Key Building Access and concierge service
Security Guard	Yes
Cost (per month)	$900

A7	**Montgomery Dorm** *1802 SW 10th Ave. Portland, OR 97201*

Criteria	Information
#Bedrooms	Single Sleeper
Bathroom	Yes, Community bathroom
Layout	117 sq. ft.
Kitchen	No but Community kitchen (microwave or stove included in every room, no dishwasher)
Internet	Available
Fitness/Pool	No
Laundry	Laundry Room
Cable TV	No
Building Condition	Wooden, old building 1925
Security System	Gated Entrance/Controlled Access
Security Guard	No
Cost (per month)	$390 (Hot Water, Sewer, Trash, Water, Internet, electricity included)

A8	**Host Family in NE** *2512 NE 21st Ave. Portland, OR 97212*

Criteria	Information
#Bedrooms	2 bedrooms
Bathroom	shared
Layout	645 sq. ft. (whole apartment includes both bedroom, living room and bathroom), 172 sq. ft. (bedroom)
Kitchen	Full kitchen, shared
Internet	Available
Fitness/Pool	No
Laundry	Available
Cable TV	Available
Building Condition	Old house, but in perfect condition
Security System	No
Security Guard	No
Cost (per month)	$300 (include water, internet and all other stuff)

A9	**Oswego Point Apartment** *5033 Foothills Dr. Lake Oswego, OR 97034*

Criteria	Information
#Bedrooms	1 bedroom
Bathroom	1
Layout	922 sq. ft.
Kitchen	Full remodeled kitchen with washer and dryer
Internet	No
Fitness/Pool	24-hour fitness center, a resort style indoor spa, and outdoor pool and spa, tanning beds.
Laundry	Inside the unit
Cable TV	No
Building Condition	Wood building, perfect condition
Security System	No
Security Guard	Yes
Cost (per month)	$950 - $1,100

A10	**Goose Hollow Apartment** *1630 SW Clay St. Portland, OR 97201*

Criteria	Information
#Bedrooms	Shared apartment, 2 bedrooms
Bathroom	Yes, full bath with bath tub
Layout	950 sq. ft.
Kitchen	Yes, full kitchen with dish washer
Internet	Available
Fitness/Pool	Yes (fitness center)
Laundry	Laundry Room
Cable TV	Available but should be paid
Building Condition	New building
Security System	Card-Key Building Access
Security Guard	No
Cost (per month)	$1,150 (Hot Water, Sewer, Trash, Water included)

A11	**Beaverton La Salle Apartment**
	15021 SW Millikan Way Beaverton, OR 97006

Criteria	Information
#Bedrooms	Shared apartment, 2 bedrooms
Bathroom	2
Layout	1359 sq. ft.
Kitchen	Full remodeled
Internet	No
Fitness/Pool	Outdoor pool
Laundry	Inside each unit
Cable TV	No
Building Condition	7-10 years old
Security System	No
Security Guard	Yes
Cost (per month)	$1,100 - $1,300

APPENDIX B

The questionnaire used to gather expert opinion in determining the weight of the decision model is provided in this appendix.

Expert ID: Date:

Expert Questionnaire: Relative Importance by Pair-Wise Comparison Technique
Decision model for selecting best place to live for new PSU students

Direction: Compare each pair on the same row with respect to the immediately upper hierarchy in the hierarchical decision model (HDM) diagram. Out of a total of 100 points for each pair, give points to the item on the left based on its relative importance comparing to the item on the right. See the HDM diagram below.

Compare these goals with respect to the main objective of the project. See the HDM diagram.

	Score	Score	
Cost			Convenience
Cost			Safety
Convenience			Safety

Compare these criteria with respect to each goal that the criteria support.

Goal 1 - Convenience

Services/Facilities			Building Condition
Services/Facilities			Room Condition
Services/Facilities			Location
Building Condition			Room Condition
Building Condition			Location
Room Condition			Location

Goal 2 - Safety

Neighborhood			Security System
Neighborhood			Security Guard
Security System			Security Guard

Compare these sub-criteria with respect to each criterion that the sub-criteria support.

Criterion 1 - Services/Facilities

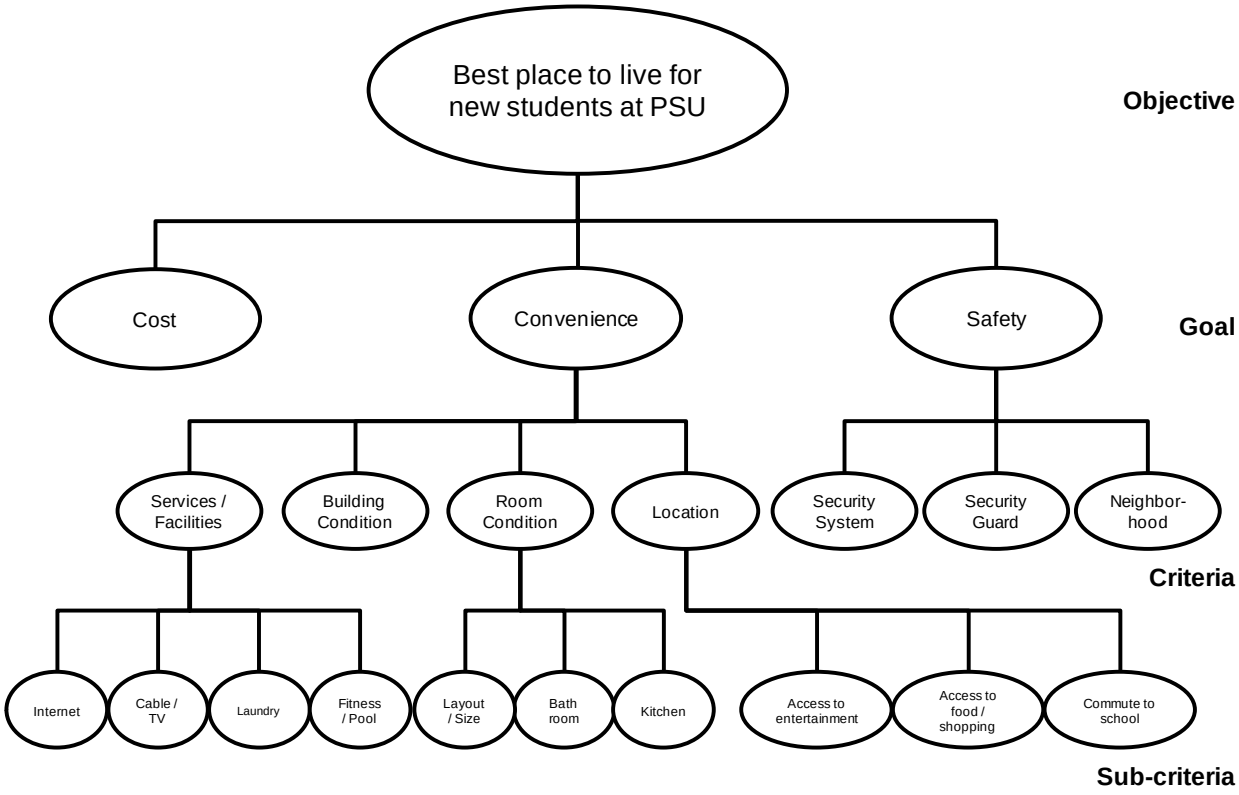
Internet			Cable TV
Internet			Laundry
Internet			Fitness/Pool
Cable TV			Laundry
Cable TV			Fitness/Pool
Laundry			Fitness/Pool

Criterion 2 - Room Condition

Layout/Size			Bath
Layout/Size			Kitchen
Bath			Kitchen

Criterion 3 - Location

Access to Entertainment			Access to Food/Shopping
Access to Entertainment			Commute to School
Access to Food/Shopping			Commute to School



APPENDIX C

The result of pair-wise comparisons from the expert opinion is shown in this appendix. The relative weight output of the goal, criteria and sub-criteria comparisons are shown in Table C1 to Table C6 along with the screen captures from the "PCM" software in Figure C1 to Figure C6, respectively.

Table C1-Goal contribution to the objective

Goals	Weight
Cost	0.35
Convenience	0.31
Safety	0.33

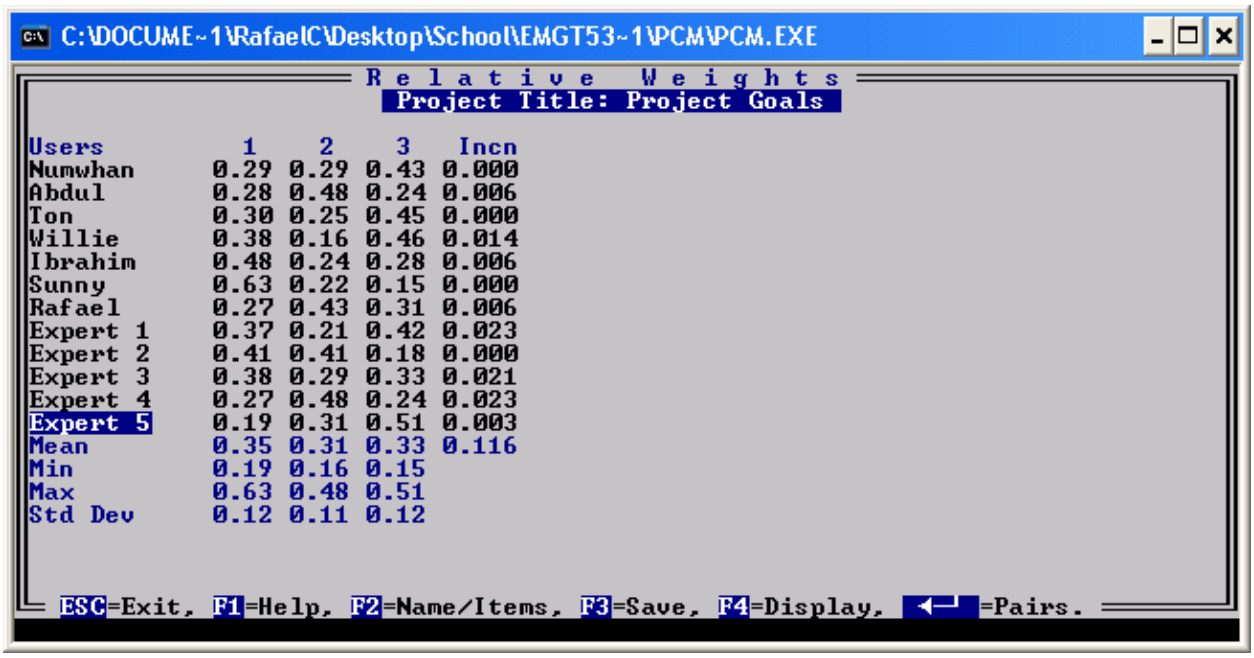


Figure C1-PCM printout of goal contribution to objective weighting

Table C2-Criteria contribution to goal 2: convenience

Criteria	Weight
Services/Facilities	0.24
Building Condition	0.18
Room Condition	0.28
Location	0.30

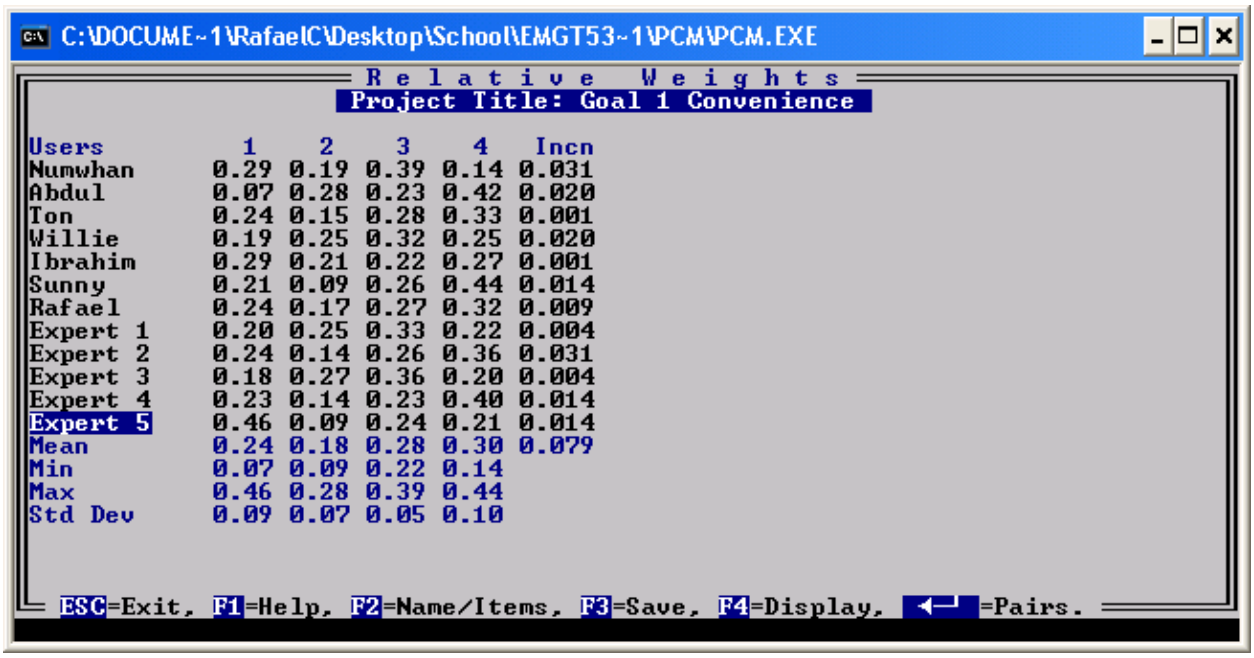


Figure C2-PCM printout of goal "convenience" weighting

Table C3-Criteria contribution to goal 3: safety

Criteria	Weight
Neighborhood	0.52
Security System	0.31
Security Guard	0.17

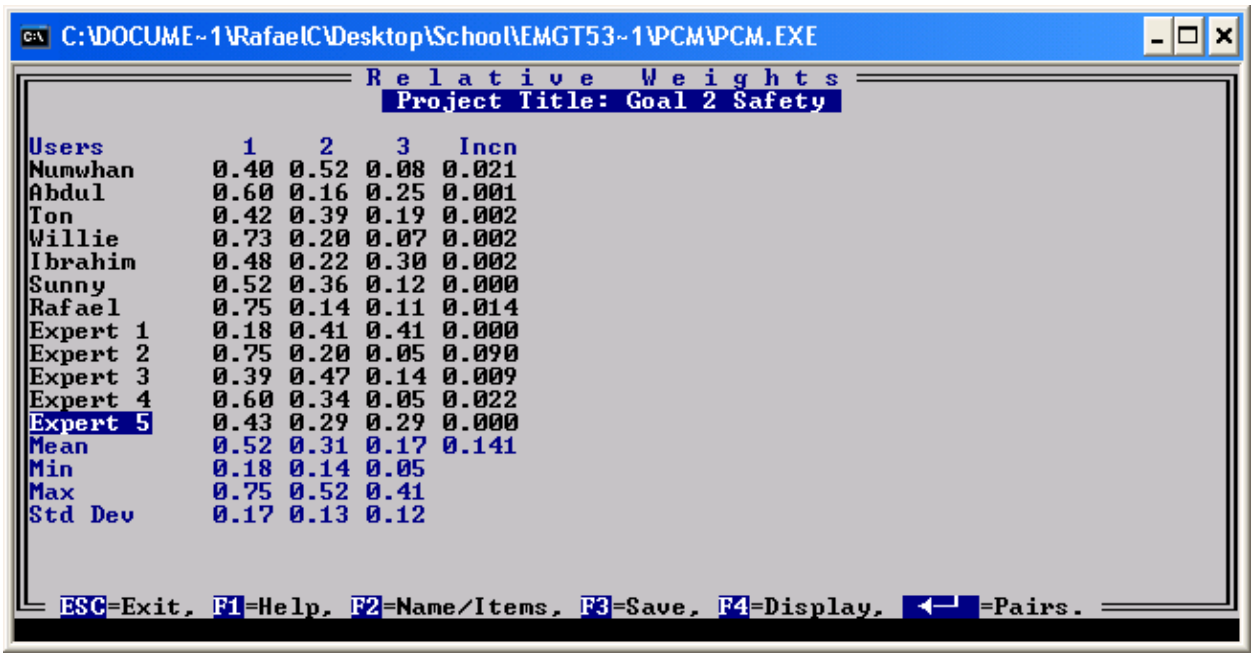


Figure C3-PCM printout of goal "safety" weighting

Table C4-Sub-criteria contribution to criterion 2.1: services/facilities

Sub-criteria	Weight
Internet	0.46
Cable TV	0.11
Laundry	0.31
Fitness/Pool	0.12

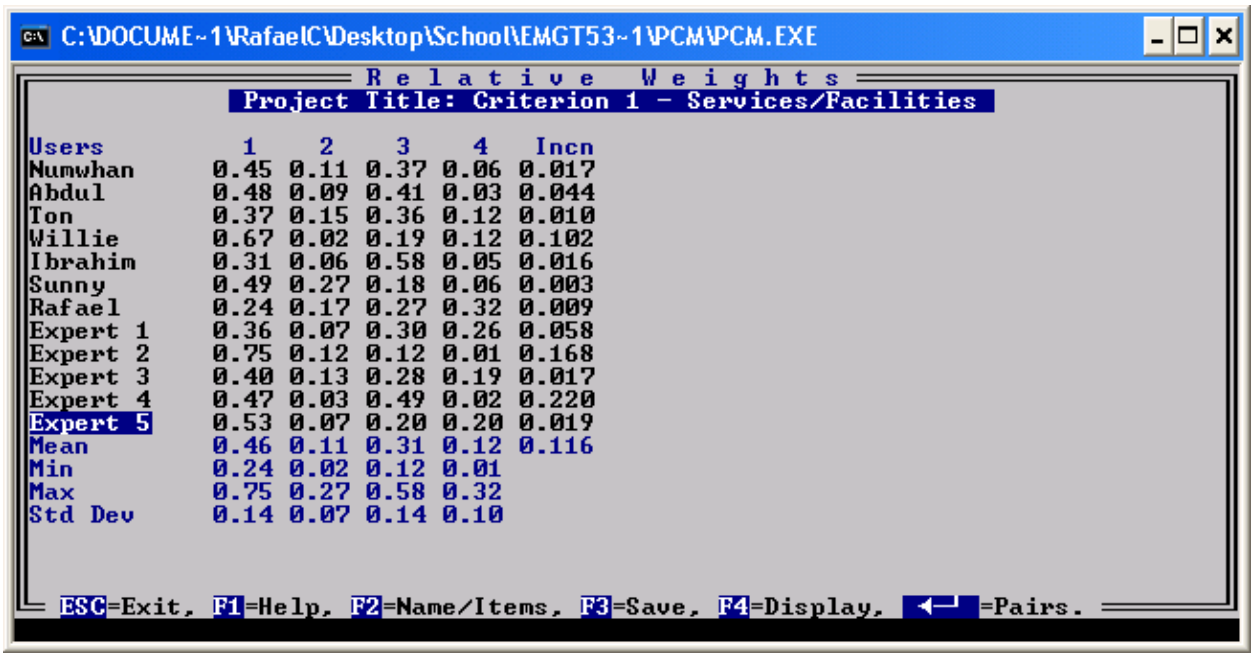


Figure C4-PCM printout of criterion "services/facilities" weighting

Table C5-Sub-criteria contribution to criterion 2.2: room condition

Sub-criteria	Weight
Layout/Size	0.31
Bath	0.34
Kitchen	0.35

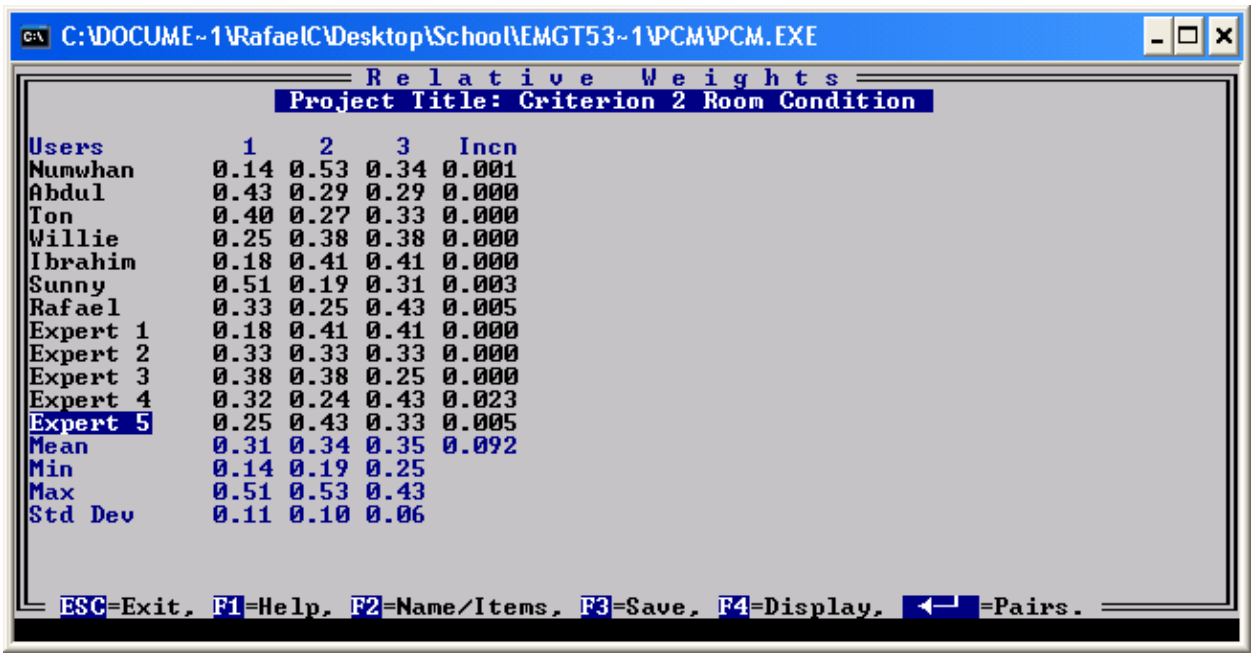


Figure C5-PCM printout of criterion "room condition" weighting

Table C6-Sub-criteria contribution to criterion 2.3: location

Sub-criteria	Weight
Access to Entertainment	0.15
Access to Food/Shopping	0.37
Commute to School	0.48

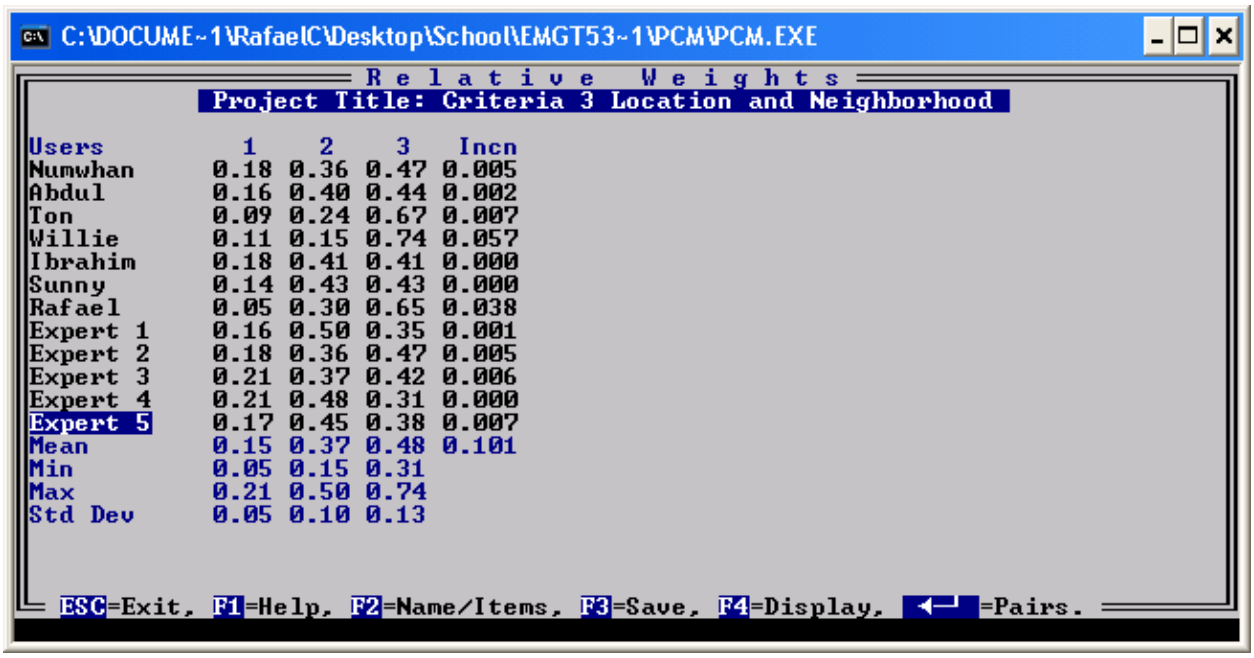


Figure C6-PCM printout of criterion "location" weighting

APPENDIX D

The survey used to gather expert opinion for constructing the utility curves is provided in this appendix.

Expert ID: Date:

Questionnaire: Preferences in Place of Living

Please enter a value between 0 and 100% in the right column indicating your degree of agreement with the statements/numbers stated in the left column.

Cost

Total Monthly Cost (rent, electricity water, internet, & transportation) (in $, per month)	**Willingness to pay (between 0% and 100%)**
0	
100	
200	
300	
400	
500	
600	
700	
800	
900	
1000	
1100	
1200	
1300	
1400	
1500	

Building Condition

Building Condition		Preference (between 0% and 100%)
a	Building is in excellent condition (recently built/ remodeled within the last 15 years). Everything is working properly and resident is not faced with any problems at all.	
b	Building is in good condition, but has some minor flaws. However residents are not heavily affected by it.	
c	Building is in an acceptable condition, yet it affects residents as it causes trouble.	
d	Building is in poor condition, causing a lot of problems for the residents	
e	Building condition is unacceptable	

Layout/Size

Layout and Size		Preference (between 0% and 100%)
a	Apartment/room provides a lot of space. Resident "loves" the perfect room.	
b	Apartment/room provides sufficient space. Layout enables resident to feel " at home"	
c	Apartment/room feels a little bit too small, still resident enjoys his/her time when being home	
d	Apartment/room hardly provides enough space. Residents feels uncomfortable at home	
e	Apartment/room way too small. Resident feels lie in prison	

Bathroom

Bathroom Condition		Preference (between 0% and 100%)
a	Very big, clean and new bathroom. Including all necessary utilities.	
b	Bathroom is in good condition, yet "not perfect"	
c	Condition's acceptable, room is overall clean. Utilities are all working with few flaws	
d	Poor condition. Dirty room, utilities are not working properly. or	
e	Condition unacceptable. Small, dirty and old. Utilities are not working properly.	

Kitchen

Kitchen Condition		Preference (between 0% and 100%)
a	Very big, clean and new kitchen. Including all necessary utilities.	
b	Kitchen is in good condition, yet "not perfect"	
c	Condition's acceptable, room is overall clean. Utilities are all working with few flaws	
d	Poor condition. Dirty room, utilities are not working properly	
e	Condition unacceptable. Small, dirty and old. Utilities are not working properly.	

Distance to PSU

Distance to PSU		Preference (between 0% and 100%)
a	1/4 mile	
b	1/2 mile	
c	1 mile	
d	2 miles	
e	4 miles	
f	8 miles	
g	16 miles	
h	20 miles	
i	30 miles	

Distance to Food/Shopping

Distance to Food/Shopping		Preference (between 0% and 100%)
a	1/8 mile	
b	1/4 mile	
c	1/2 mile	
d	1 miles	
e	2 miles	
f	4 miles	
g	6 miles	

Distance to Entertainment

Distance to Entertainment		Preference (between 0% and 100%)
a	1/8 mile	
b	1/4 mile	
c	1/2 mile	
d	1 miles	
e	2 miles	
f	4 miles	
g	6 miles	

APPENDIX E

The survey result for preferences of characteristic of place to live and the associated utility curves is presented in this appendix.

Table E1-Utility score for cost attribute

	Utility Score						
Total Monthly Cost	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Average**
0	100	100	100	100	100	100	**100.00**
100	100	100	100	95	95	100	**98.33**
200	100	100	100	90	90	100	**96.67**
300	95	100	100	80	85	100	**93.33**
400	90	100	95	70	80	100	**89.17**
500	85	90	85	65	75	100	**83.33**
600	70	80	65	50	60	100	**70.83**
700	50	70	30	15	30	95	**48.33**
800	20	60	20	10	15	85	**35.00**
900	10	50	15	5	5	70	**25.83**
1000	0	40	5	0	0	40	**14.17**
1100	0	30	0	0	0	25	**9.17**
1200	0	20	0	0	0	20	**6.67**
1300	0	10	0	0	0	15	**4.17**
1400	0	0	0	0	0	10	**1.67**
1500	0	0	0	0	0	5	**0.83**

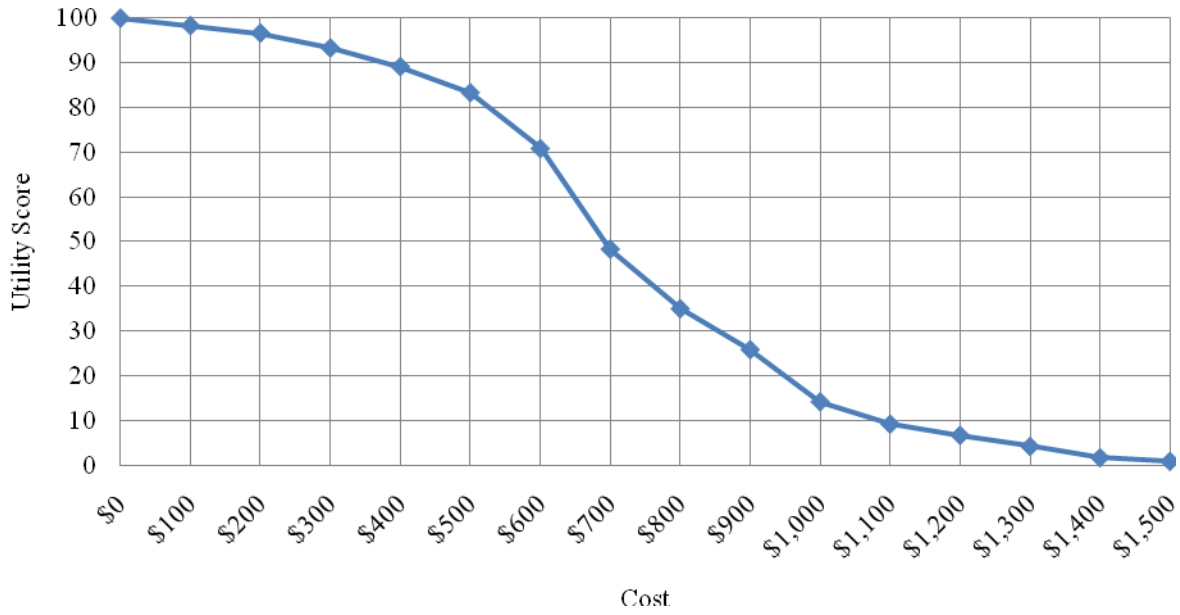


Figure E1-Utility curve for cost attribute

Table E2-Utility score for building condition attribute

Building condition	Utility Score						
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Average
A	100	100	100	100	100	100	**100.00**
B	80	60	85	90	100	90	**84.17**
C	20	50	35	70	75	10	**43.33**
D	10	35	10	20	30	5	**18.33**
E	0	0	0	0	0	0	**0.00**

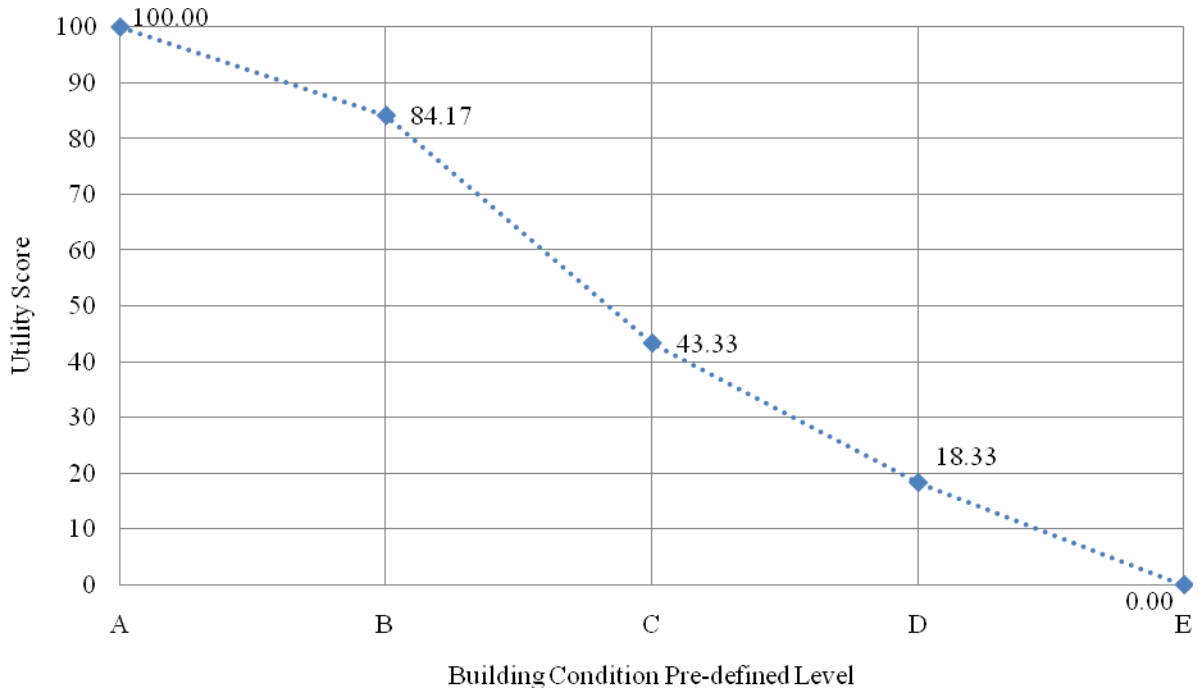


Figure E2-Utility curve for building condition attribute

Table E3-Utility score for layout/size attribute

Layout/size condition	Utility Score						
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Average
A	100	100	100	100	100	100	**100.00**
B	90	60	90	100	100	100	**90.00**
C	80	30	70	90	90	75	**72.50**
D	10	30	5	50	85	25	**34.17**
E	0	0	0	45	0	3	**8.00**

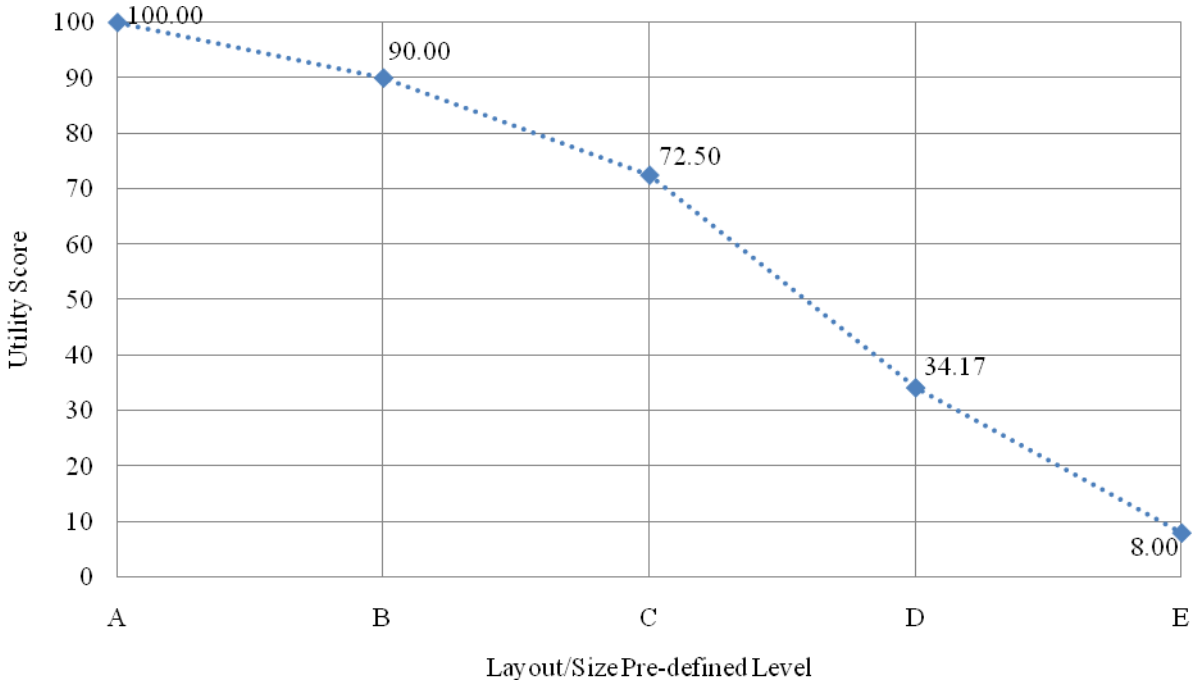


Figure E3-Utility curve for layout/size attribute

Table E4-Utility score for bathroom condition attribute

Bathroom condition	Utility Score						
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Average
A	100	100	100	100	100	100	**100.00**
B	75	60	85	100	100	95	**85.83**
C	50	65	65	80	90	90	**73.33**
D	10	30	15	15	50	15	**22.50**
E	0	30	0	0	0	1	**5.17**

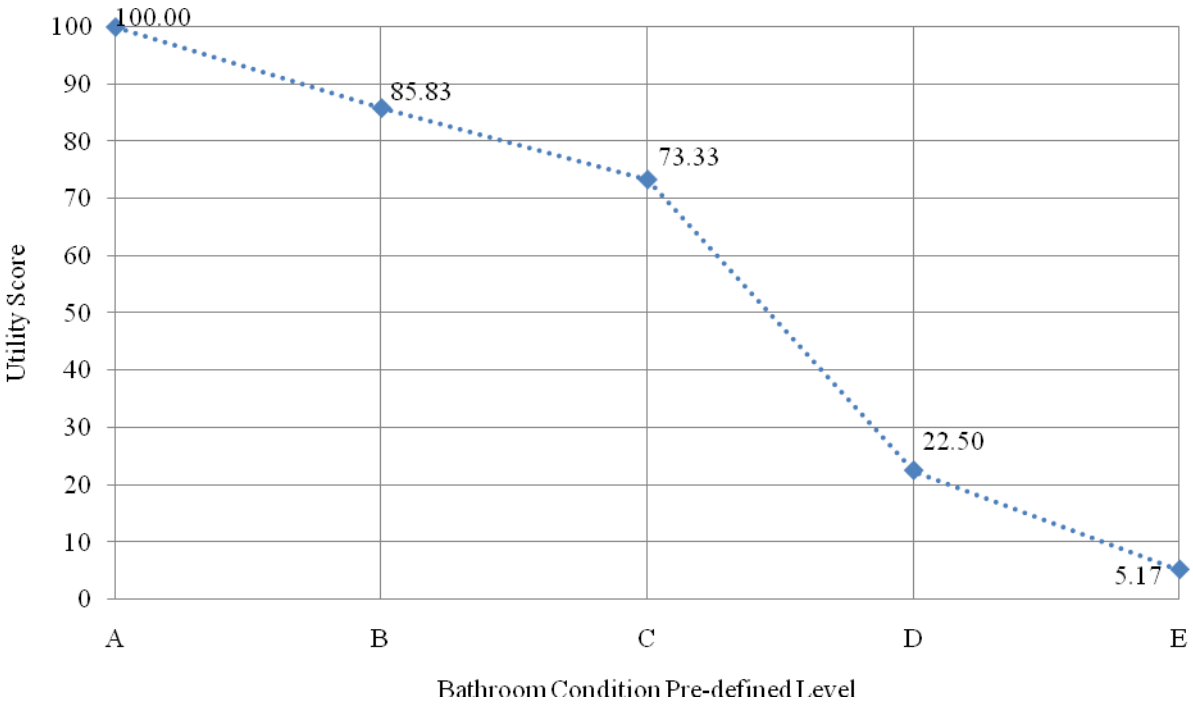


Figure E4-Utility curve for bathroom condition attribute

Table E5-Utility score for kitchen condition attribute

Kitchen condition	Utility Score						
	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Average
A	100	100	100	100	100	100	**100.00**
B	75	70	75	99	95	99	**85.50**
C	50	70	50	80	90	95	**72.50**
D	10	30	10	10	45	30	**22.50**
E	0	30	0	0	0	1	**5.17**

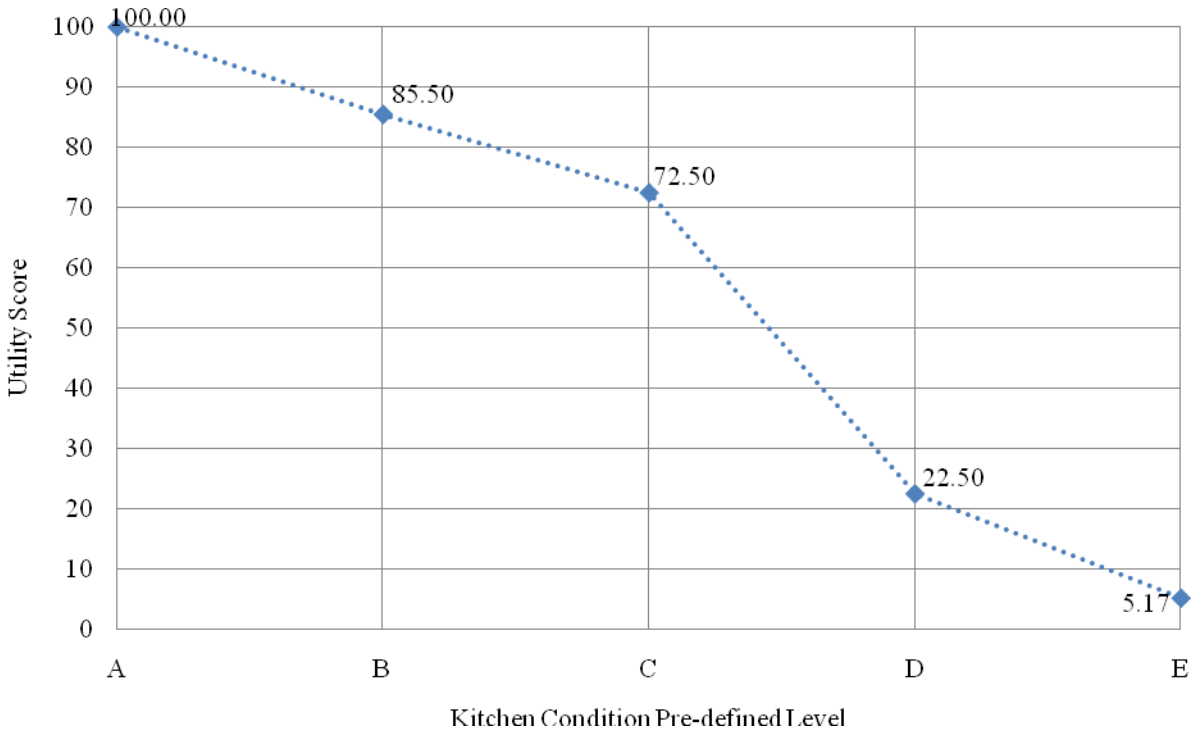


Figure E5-Utility curve for kitchen condition attribute

Table E6-Utility score for commute to school attribute

Distance to PSU		Utility Score						
		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Average
A	1/4 mile	100	100	100	100	100	100	**100.00**
B	1/2 mile	100	100	100	95	95	100	**98.33**
C	1 mile	100	100	100	90	90	100	**96.67**
D	2 miles	95	100	100	80	85	100	**93.33**
E	4 miles	90	100	95	70	80	100	**89.17**
F	8 miles	85	90	85	65	75	100	**83.33**
G	16 miles	70	80	65	50	60	100	**70.83**
H	20 miles	50	70	30	15	30	95	**48.33**
I	30 miles	20	60	20	10	15	85	**35.00**

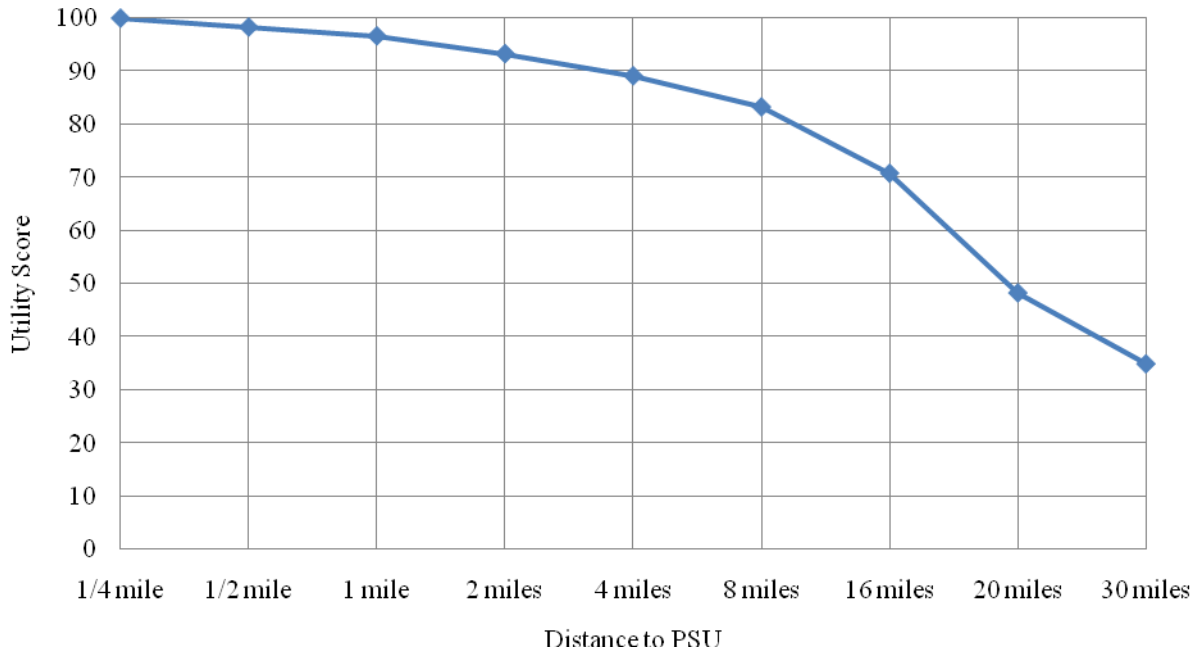


Figure E6-Utility curve for commute to school attribute

Table E7-Utility score for distance to food/shopping attribute

Distance to food/shopping		Utility Score						
		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Average
A	1/8 mile	100	100	100	100	100	100	**100.00**
B	1/4 mile	100	100	100	100	100	100	**100.00**
C	1/2 mile	100	95	100	100	100	100	**99.17**
D	1 miles	80	90	80	90	100	80	**86.67**
E	2 miles	50	80	65	80	75	50	**66.67**
F	4 miles	10	70	50	60	0	10	**33.33**
G	6 miles	0	50	30	20	0	0	**16.67**

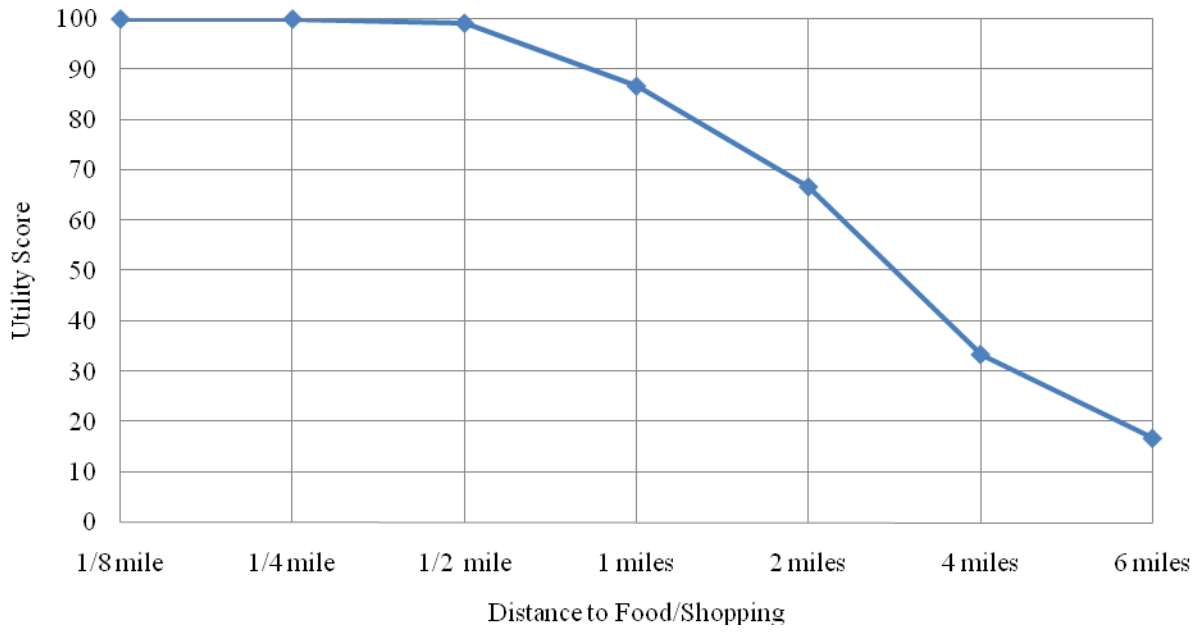


Figure E7-Utility curve for distance to food/shopping attribute

Table E8-Utility score for distance to entertainment attribute

Distance to entertainment		Utility Score						
		Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Average
A	1/8 mile	100	90	70	100	100	5	**77.50**
B	1/4 mile	100	85	85	100	100	5	**79.17**
C	1/2 mile	100	80	100	100	100	5	**80.83**
D	1 miles	100	75	100	100	100	5	**80.00**
E	2 miles	80	70	85	100	100	30	**77.50**
F	4 miles	50	65	75	90	90	50	**70.00**
G	6 miles	25	60	30	80	70	100	**60.83**

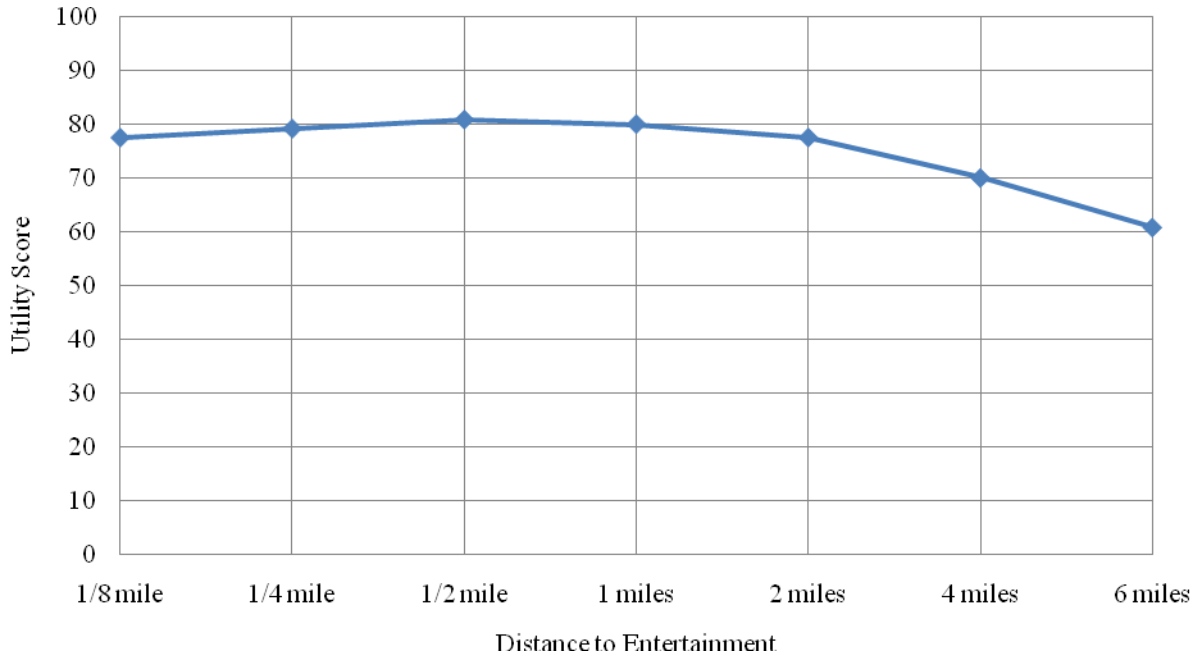


Figure E7-Utility curve for distance to entertainment attribute

APPENDIX F

Utility value for neighborhood safety and its associated crime index from the web site < http://www.neighborhoodscout.com/> is presented in Table F1. The city neighborhood area map is shown in Figure F1.

Table F1-Average crime index for all alternatives

Alternative	Name	Area Crime Index	Total Score	Number of Areas Included	Average Crime Index
A1	Buckman Terrace	Burnside/Sandy (0) + Sandy/28th (1) + Multnomah/16th (12) + Broadway/28th (4)	17	4	**4.25**
A2	Ondine Dorm (shared room)	PSU/Clay (0) + Market/Clay (1) + Marquam/OHSU (46) + Naito/Market (7)	54	4	**13.50**
A3	Ondine Dorm (single room)	PSU/Clay (0) + Market/Clay (1) + Marquam/OHSU (46) + Naito/Market (7)	54	4	**13.50**
A4	South Park Apartment	PSU/Clay (0) + Market/Clay (1) + Marquam/OHSU (46) + Naito/Market (7)	54	4	**13.50**
A5	Vue Apartment	PSU/Clay (0) + Market/Clay (1) + Marquam/OHSU (46) + Naito/Market (7)	54	4	**13.50**
A6	Lovejoy Apartment	NatioPky/Market (7) + PSU/Clay (0) + Marquam/OHSU (46)	53	3	**17.67**
A7	Montgomery Dorm	PSU/Clay (0) + Market/Clay (1) + Marquam/OHSU (46) + Naito/Market (7)	54	4	**13.50**
A8	Host family in NE	Klickitat/20th (45) + Irvington (16) + Multnomah/16th (12) + Broadway/28th (4)	77	4	**19.25**
A9	Oswego Point Apartment	Lake Oswego	54	1	**54.00**
A10	Goose Hollow Apartment	Market/Clay (1) + Portland Heights (79) + Burnside/Morrison (0)	80	3	**26.67**
A11	Beaverton La Salle Apartment	Jenkins/Murrey	15	1	**15.00**

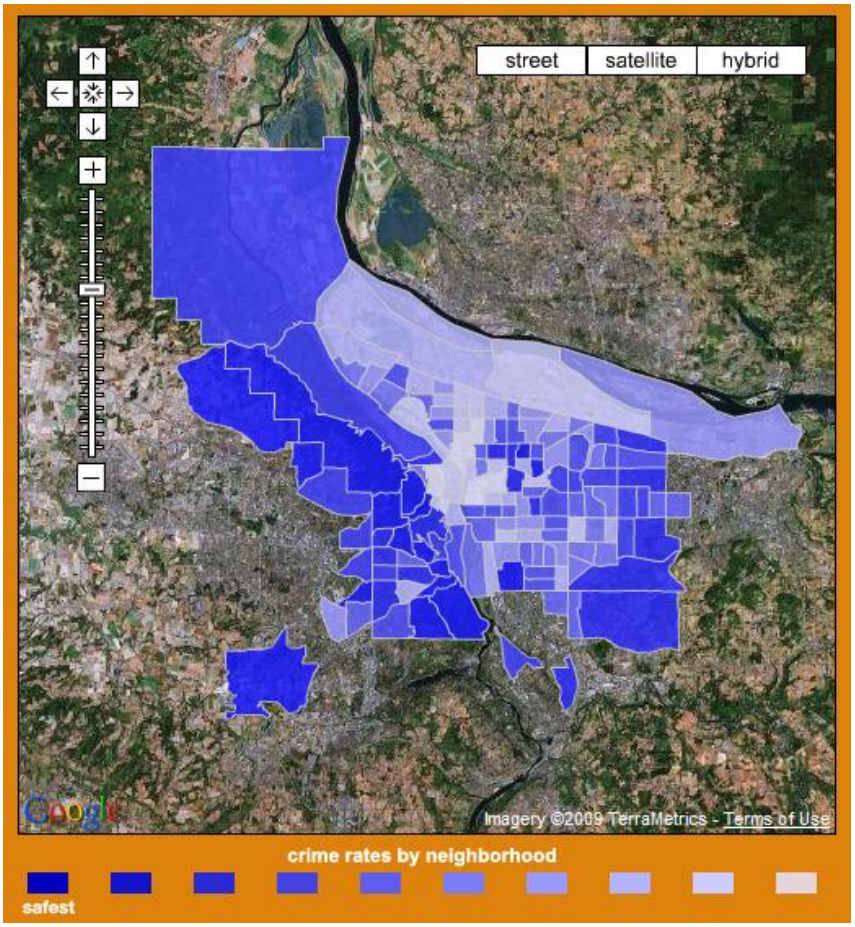


Figure F1-Portland neighborhood crime rate map