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**IMPROVING RESIDENTIAL HOUSING PROJECT PURCHASE BY
USING INTEGRATED MULTI-ATTRIBUTE DECISION MAKING AND
SENTIMENT ANALYSIS TECHNIQUE**

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**DOCTOR OF PHILOSOPHY
UNIVERSITI UTARA MALAYSIA
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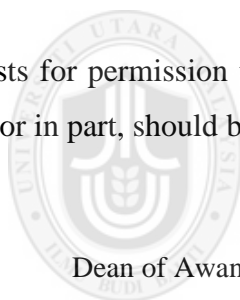
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Abstrak

Pembuatan keputusan pembelian rumah kediaman adalah sangat kompleks disebabkan oleh alasan-alasan seperti kriteria yang bercanggah yang susah untuk dimodel, jenis keputusan yang jarang berlaku, hasil keputusan yang tidak pasti dan tidak dapat diundur semula, pelaburan yang tinggi dan beban kewangan jangka panjang. Tidak seperti jenis pembelian yang lain, membuat keputusan membeli rumah lebih berisiko malah 'traumatik'. Ia sering dikaitkan dengan penyesalan dan kemungkinan kerugian dalam kalangan pembeli rumah. Lazimnya, model Pembuat Keputusan Berbilang Kriteria (MADM) digunakan dalam pembuatan keputusan bagi membantu dan menyusun pemilihan projek perumahan secara sistematik. Walaubagaimanapun, terdapat kekurangan dalam proses penilaian pada model MADM disebabkan oleh pengetahuan pembeli rumah yang terbatas, tidak mengambil kira pendapat umum dan sumber maklumat yang terhad. Tambahan pula, kaedah MADM memerlukan pembeli rumah untuk hanya bergantung kepada pengalaman dalam penilaian mereka yang berpotensi membawa kepada keputusan yang tidak tepat. Oleh itu, kajian ini membangunkan model yang ditambah baik dengan menggabungkan MADM dan tiga pendekatan dalam Analisis Sentimen bagi mengenalpasti dan mengklasifikasikan kriteria daripada pendapat umum melalui ulasan dalam talian. Data daripada forum hartanah dalam talian dan ulasan 'Google' digunakan untuk mengekstrak pendapat umum melalui ulasan dalam talian. Tiga projek perumahan bertingkat tinggi yang terletak di Malaysia digunakan sebagai projek kes untuk menunjukkan pembangunan model dan pengesahan kerangka kerja yang dicadangkan. Tiga pendekatan Analisis Sentimen telah digunakan; Leksikon, 'Machine Learning' dan hibrid. Berdasarkan klasifikasi yang ditetapkan oleh model, lokasi, kemudahan dan ciri rumah merupakan tiga kriteria yang paling penting dalam membuat keputusan pembelian perumahan kediaman. Selain itu, pengelasan menggunakan pendekatan Analisis Sentimen-MADM hibrid mengatasi pendekatan Leksikon dengan ketepatan yang lebih baik. Model yang dibangunkan ini dapat membantu pembeli rumah untuk membuat keputusan mengikut praktik terkini. Selain itu, ia boleh digeneralisasikan kepada aplikasi berbilang kriteria yang menggunakan pendapat umum dalam talian sebagai rujukan.

Kata kunci: Pembelian perumahan, Pembuat Keputusan Berbilang Kriteria (MADM), Analisis Sentimen, Pendapat umum dalam talian

Abstract

The residential house purchase decision making is highly complex due to reasons such as conflicting criteria which is hard to model, infrequent type of decisions, uncertain and irreversible decision outcomes, high investment, and long-term financial burden. Unlike many other types of purchasing, housing purchase decision-making is riskier and sometimes even ‘traumatic’. It is often associated with feeling of regret and the possibility of loss among homebuyers. Typically, the Multi Attribute Decision Making (MADM) models are used to systematically assist and structure residential housing project selection decision making. However, the MADM models impose deficiencies in the evaluation process due to insufficient knowledge of homebuyers, ignorance of public opinions and limited sources of information. Furthermore, the application of MADM models requires homebuyer to rely on their evaluation experience which potentially led to an imprecise decision. Hence, this study developed an improved model by integrating MADM and three approaches of Sentiment Analysis to capture and rank criteria from public opinions through online reviews. Properties online forums and google reviews were selected to extract public opinions through online reviews. Three high-rise residential projects located in Malaysia were used as case projects for demonstrating the model development and validation of the proposed framework. Three Sentiment Analysis approach were considered; Lexicon, Machine Learning and hybrid. Based on the ranking established by the models, it shows that location, facility, and house attributes are the most important criteria in residential housing purchase decision making. In addition, classification using a hybrid MADM-Sentiment Analysis approach outperforms the Lexicon approach with better accuracy. The developed model can assist homebuyer in making decision for the current practice. Moreover, it can be generalised to other related multi-criteria applications with the use of online public opinions as reference.

Keywords: Housing purchase, Multi Attributes Decision Making (MADM), Sentiment Analysis, Online public opinions

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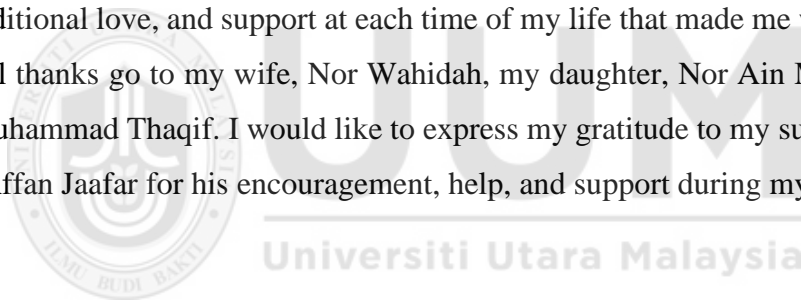


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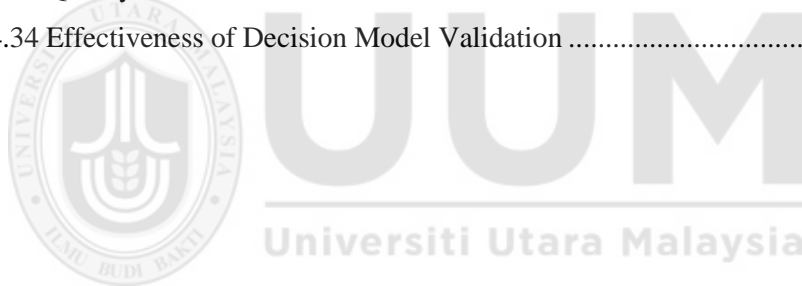
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List of Abbreviations

AHP	Analytic Hierarchy Process
ANN	Artificial Neural Network
ANN	Artificial Neural Network
ELECTRE	Elimination and Choice Translating Reality
eWOM	Electronic Word of Mouth
HoQ	House of Quality
k-NN	k-Nearest Neighbors
MADM	Multi Attributes Decision Making
MCDM	Multi Criteria Decision Making
ML	Machine Learning
MODM	Multi Objective Decision Making
MRA	Multiple Regression Analysis
MRA	Multiple Regression Analysis
NB	Naïve Bayes
NB (Kernel)	Naive Bayes with Kernel Density Estimator
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluation
PROMETHEE	Preference Ranking Organization Method for Enrichment Evaluation
REIT	Real Estate Investment Market
REIT	Real Estate Investment Market
ROC	Rank Order Centroid
SA	Sentiment Analysis
SO	Semantic Orientation
SVM	Support Vector Machine
TF-IDF	Term-Frequency-Inverse Document Frequency
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
UGC	User-generated content
VIKOR	VIšekriterijumsko KOmpromisno Rangiranje
WOM	Word of Mouth
WPM	Weighted Product Model
WSM	Weighted Sum Model

List of Publications

- Nursal, A. T., Omar, M. F., & Nawi, M. N. M. (2021). Sentiment Analysis on Property Online Review to Understand Public Opinions and Preferences For High-Rise Residential Projects In Malaysia. *Language Learning*, 71(4). (Accepted)
- Nursal, A. T., Omar, M. F., & Nawi, M. N. M. (2021). Text Pre-Processing for The Frequently Mentioned Criteria from Online Community Homebuyer Dataset. *International Journal of Interactive Mobile Technologies*, 15(06), 171–184.



CHAPTER ONE

INTRODUCTION

1.1 Research Background

The residential property market in Malaysia has always been an important component of the domestic economy. Housing development programs are normally used to stimulate economic activity. The Ministry of Finances, Valuation, and Property Services Department categorises the property market in Malaysia into six segments, namely, the residential, commercial, industrial, agricultural, development land, and other sub-sectors. It is further segmented into the condominium, detached, semi-detached, terrace, townhouse, low-cost, flat, and low-cost flat. In Malaysia, residential housing is the dominant property in the real estate market. It recorded the highest percentage of 65.2% of the overall real estate market. Figure 1.1 illustrates a summary of different types of residential supply in Malaysia.

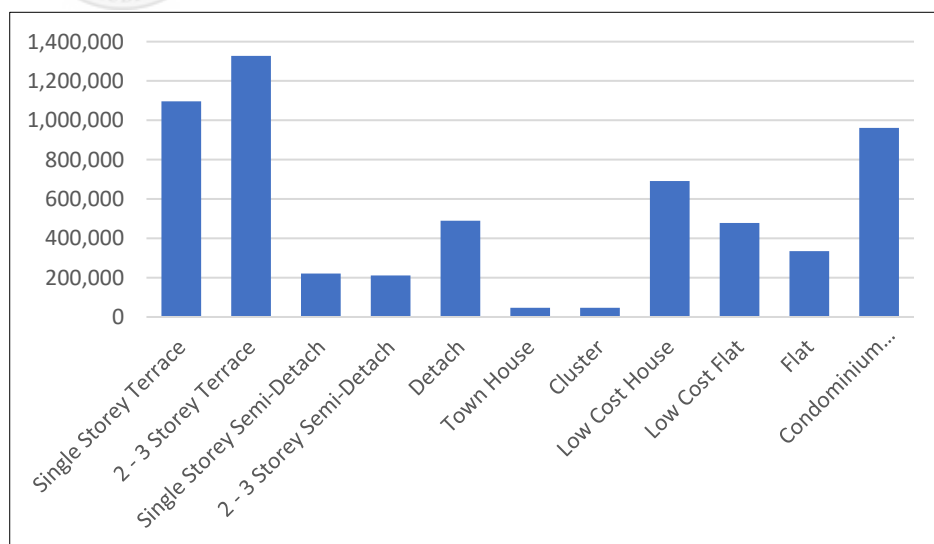


Figure 1.1 Summary of supply of residential units by type in Malaysia (NAPIC, 2021)

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Appendix A

Guideline for the Annotation Task

Instruction:

This data is about three condominiums. Kindly fill in columns Polarity.

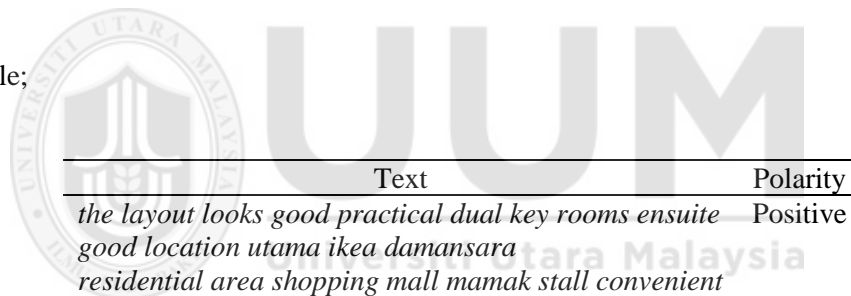
Identify polarity

Column – There are two choices to fill in the polarity column: Positive/Negative

Positive - contains the text contain positive opinion (Example: the price is good enough for me, affordable)

Negative - means the text contain negative opinion (Example: worst design ever, also expensive)

Example;



Text	Polarity
<i>the layout looks good practical dual key rooms ensuite</i>	Positive
<i>good location utama ikea damansara residential area shopping mall mamak stall convenient</i>	

Appendix B

Lexicon Validation

First Annotators								
Lexicon Dictionary	True Positive	True Negative	False Positive	False Negative	Accuracy	Precision	Recall	F1-score
SentiWordNet	1088	517	562	129	0.699	0.659	0.894	0.758
VADER	1022	602	342	96	0.787	0.749	0.914	0.823
WordNet								
Second Annotators								
Lexicon Dictionary	True Positive	True Negative	False Positive	False Negative	Accuracy	Precision	Recall	F1-score
SentiWordNet	1075	515	554	126	0.700	0.659	0.895	0.759
VADER	1008	753	335	95	0.830	0.750	0.913	0.824
WordNet	1088	556	546	142	0.704	0.665	0.884	0.759

Appendix C

Sample of Questionnaire for Criteria Identification and Validation

Instruction: These criteria are about homebuyer preference, kindly categories each of the criteria, if any of the pre-determined categories are not suitable, please assign a new category. For example: '√' for the right criteria, and suggest a new category if any of the pre-determined categories are not suitable as shown below;

<i>Category</i>	<i>Criteria</i>	<i>Expert</i>
<i>Facilities</i>	<i>facility</i>	√
	<i>pool</i>	√
	<i>park</i>	<i>Location</i>
	<i>mall</i>	<i>Location</i>

Kindly fill in columns expert

Category	Criteria	Expert
Location	location place area surround view access traffic transportation security	
Facilities	facility pool park mall	
House attributes	design quality maintenance	
Price	price	
View	view	
Management	management	
Surrounding area	surround	
Developer	developer	
Investment	invest	

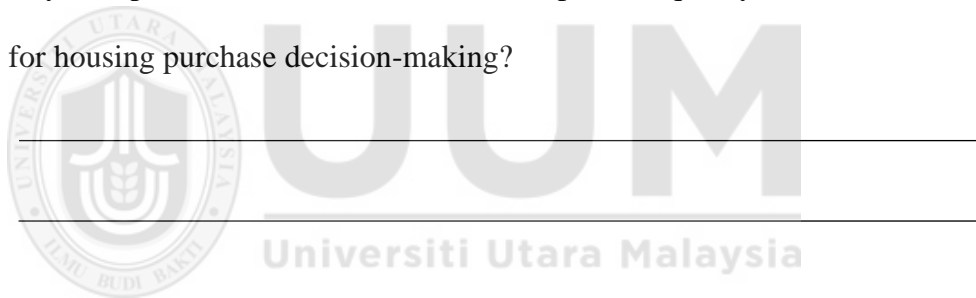
Appendix D

Sample of Questionnaire for Model Validation

Objective: This process is to measure the usability of the proposed model for solving the high-rise residential housing purchase. The validation is consists of two criteria which are decision quality and decision-making efficiency. Please take approximately 10 – 12 minutes to complete the form.

Based on decision model usage, please answer the following questions;

1. In your opinion, does the decision model provide quality decision outcomes for housing purchase decision-making?



2. In your opinion, does the decision model effectively represent real-world housing decision-making problems?

Appendix E

MADM Assessment

TOPSIS Assessment

TOPSIS (Positive Dataset)

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	85.716	28.115	12.252	11.018	2.038	10.263	13.552
Project B	63.235	24.534	15.863	10.190	6.855	3.361	17.524
Project C	52.330	28.285	14.245	14.521	6.814	4.016	14.866
$\sum x^2$	14084.380	2192.375	604.662	436.097	97.579	132.761	711.740

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.722	0.600	0.498	0.528	0.206	0.891	0.508
Project B	0.533	0.524	0.645	0.488	0.694	0.292	0.657
Project C	0.441	0.604	0.579	0.695	0.690	0.349	0.557

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.26752	0.13666	0.05431	0.03852	0.00413	0.03919	0.07925
Project B	0.19736	0.11925	0.07032	0.03562	0.01388	0.01283	0.10247
Project C	0.16333	0.13749	0.06314	0.05076	0.01380	0.01534	0.08693
V+	0.26752	0.13749	0.07032	0.05076	0.01388	0.03919	0.10247
V-	0.16333	0.11925	0.05431	0.03562	0.00413	0.01283	0.07925

Project	di+	di-	ci	Result - rank
Project A	0.000520623310	0.005931854616	0.919314205	1
Project B	0.003089757162	0.001024518589	0.249015538	2
Project C	0.005859749987	0.000399330198	0.063800141	3

TOPSIS (Negative Dataset)

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	29.261	10.328	11.225	4.673	2.979	3.245	10.401
Project B	43.147	10.368	6.838	5.228	2.535	4.792	8.241
Project C	33.569	14.340	7.033	7.602	4.175	5.246	4.546
$\sum x^2$	3844.770	419.811	222.213	106.960	32.728	61.008	196.758

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.472	0.504	0.753	0.452	0.521	0.415	0.742
Project B	0.696	0.506	0.459	0.505	0.443	0.613	0.587
Project C	0.541	0.700	0.472	0.735	0.730	0.672	0.324

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.17480	0.11473	0.08208	0.03298	0.01042	0.01828	0.11567
Project B	0.25774	0.11517	0.05000	0.03690	0.00886	0.02699	0.09165
Project C	0.20053	0.15930	0.05142	0.05366	0.01459	0.02955	0.05055
V+	0.17480	0.11473	0.05000	0.03298	0.00886	0.01828	0.05055
V-	0.25774	0.15930	0.08208	0.05366	0.01459	0.02955	0.11567

Project	di+	di-	ci	Result - rank
Project A	0.002636130688	0.004719341718	0.641609601	2
Project B	0.004330336766	0.001937143414	0.309078507	3
Project C	0.001618981680	0.004226948496	0.723058328	1

Final rank TOPSIS

Project	CC aggregation	Normalize	Final Rank
Project A	1.560923806	1	1
Project B	0.558094044	0	3
Project C	0.786858469	0.228118902	2

VIKOR Assessment

VIKOR (Positive Dataset)

Weight	0.3704	0.2276	0.109	0.073	0.02	0.044	0.156
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	47.25190974	17.96496693	7.974120544	8.246056309	2.054984875	4.264720603	10.99002102
Project B	53.02447627	17.89862787	6.252159764	7.158270611	6.006381657	3.483547504	8.929267897
Project C	41.0512751	21.85195758	9.846360696	9.655410086	6.648894525	1.037362362	10.18101503
Best (Xi+)	53.02447627	21.85195758	9.846360696	9.655410086	6.648894525	4.264720603	10.99002102
Worst (Xi-)	41.0512751	17.89862787	6.252159764	7.158270611	2.054984875	1.037362362	8.929267897

	Location	Facility	Developer	Price	Security	Investment	House attributes	Si	Ri
Project A	0.1786	0.2238	0.0568	0.0412	0.0200	0.0000	0.0000	0.5203	0.2238
Project B	0.0000	0.2276	0.1090	0.0730	0.0028	0.0107	0.1560	0.5790	0.2276
Project C	0.3704	0.0000	0.0000	0.0000	0.0000	0.0440	0.0612	0.4756	0.3704
S*, R* (Min)	0.4756	0.2238							
S-, R- (Max)	0.5790	0.3704							

	Si	Ri	Qi (v=0.5)	Rank
Project A	0.5203	0.2238	0.2161	1
Project B	0.5790	0.2276	0.5130	3
Project C	0.4756	0.3704	0.5000	2

VIKOR (Negative Dataset)

Weight	0.3704	0.2276	0.109	0.073	0.02	0.044	0.156
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	66.4931	27.5379	12.0653	11.3166	1.8515	5.0387	14.8276
Project B	14.1940	6.8662	8.9294	3.3802	1.4715	0.4472	7.2081
Project C	24.0577	10.4055	8.0888	7.0915	1.0111	1.0111	5.3109
Best (Xi+)	14.1940	6.8662	8.0888	3.3802	1.0111	0.4472	5.3109
Worst (Xi-)	66.4931	27.5379	12.0653	11.3166	1.8515	5.0387	14.8276

	Location	Facility	Developer	Price	Security	Investment	House attributes	Si	Ri
Project A	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560	1.0000	0.3704
Project B	0.0000	0.0000	0.0230	0.0000	0.0110	0.0000	0.0311	0.0651	0.0311
Project C	0.0699	0.0390	0.0000	0.0341	0.0000	0.0054	0.0000	0.1484	0.0699
S*, R* (Min)	0.065094815	0.031098222							
S-, R- (Max)	1	0.3704							

	Si	Ri	Qi (v=0.5)	Rank
Project A	1	0.3704	1	3
Project B	0.065094815	0.031098222	0	1
Project C	0.148368523	0.069858112	0.10	2

Final Rank VIKOR

Project	Aggregation	Normalize	Final Rank
Project A	1.21612219	1	3
Project B	0.513024394	0	1
Project C	0.601653043	0.126054512	2

SAW Assessment

SAW (Positive Dataset)

Weight	0.370408163	0.22755102	0.156122449	0.108503401	0.072789116	0.044217687	0.020408163
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	85.71593682	28.114715	12.25197968	11.01802908	2.037786588	10.26344203	13.55221444
Project B	63.23538923	24.5335343	15.86287836	10.18983738	6.855141769	3.36058875	17.52355957
Project C	52.33014045	28.28503626	14.24501906	14.52126368	6.814188465	4.016077776	14.86613762
Max	85.71593682	28.28503626	15.86287836	14.52126368	6.855141769	10.26344203	17.52355957

Weight	0.339732143	0.214732143	0.152232143	0.110565476	0.079315476	0.054315476	0.033482143	Ai	Rank
	Location	Facility	Developer	Price	Security	Investment	House attributes		
Project A	1	0.993978397	0.772368003	0.758751395	0.29726396	1	0.773371095	0.85842943	1
Project B	0.737731997	0.867367964	1	0.701718363	1	0.327432916	1	0.797283315	3
Project C	0.610506545	1	0.898009726	1	0.9940259	0.391299309	0.848351476	0.797912132	2

SAW (Negative Dataset)

Weight	0.370408163	0.22755102	0.156122449	0.108503401	0.072789116	0.044217687	0.020408163
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	29.26131817	10.32833566	11.22498001	4.672884394	2.979165885	3.244769418	10.40108523
Project B	43.14704185	10.36760786	6.837609351	5.227730198	2.534615698	4.791832485	8.240879353
Project C	33.56900632	14.34046882	7.032805751	7.602295058	4.174692544	5.24578208	4.545661717
Min	29.26131817	10.32833566	6.837609351	4.672884394	2.534615698	3.244769418	4.545661717

Weight	0.370408163	0.22755102	0.156122449	0.108503401	0.072789116	0.044217687	0.020408163		
	Location	Facility	Developer	Price	Security	Investment	House attributes	AI	Rank
Project A	1	1	0.60914223	1	0.850780318	1	0.437037253	0.916627723	1
Project B	0.678176693	0.996212029	1	0.893864874	1	0.677145837	0.55159911	0.844989138	2
Project C	0.871676626	0.720223013	0.972244875	0.614667592	0.607138291	0.618548268	1	0.797198391	3

Project	Cumulative value	Normalize	Rank
Project A	1.775057153	1	1
Project B	1.642272454	0.262088434	2
Project C	1.595110523	0	3
Min	1.595110523		
Max	1.775057153		



Appendix F

Sensitivity Analysis Assessment

VADER polarity

1. TOPSIS

Positive dataset

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	50.551	19.885	10.472	9.402	1.906	3.620	11.832
Project B	54.962	19.628	12.857	9.334	5.579	3.837	3.837
Project C	43.842	23.728	12.388	12.245	6.166	5.445	15.193
χ^2	7498.335	1343.659	428.416	325.466	72.787	57.477	385.542

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.584	0.542	0.506	0.521	0.223	0.478	0.603
Project B	0.635	0.535	0.621	0.517	0.654	0.506	0.195
Project C	0.506	0.647	0.599	0.679	0.723	0.718	0.774

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.21624	0.12344	0.05515	0.03805	0.00447	0.02101	0.09401
Project B	0.23510	0.12184	0.06771	0.03777	0.01308	0.02227	0.03049
Project C	0.18754	0.14730	0.06524	0.04955	0.01446	0.03160	0.12070
V+	0.23510	0.14730	0.06771	0.04955	0.01446	0.03160	0.12070
V-	0.18754	0.12184	0.05515	0.03777	0.00447	0.02101	0.03049

Project	di+	di-	ci	Rank
Project A	0.0011	0.0024	0.6943	2
Project B	0.0045	0.0012	0.2169	3
Project C	0.0011	0.0046	0.8028	1

Negative dataset

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	25.323	10.264	2.905	3.624	1.299	1.519	4.790
Project B	24.100	9.157	7.803	3.674	1.632	0.684	4.574
Project C	24.800	11.933	7.484	6.602	2.680	0.877	3.128
$\sum x^2$	1837.148	331.602	125.330	70.221	11.534	3.546	53.647

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.591	0.564	0.260	0.433	0.382	0.807	0.654
Project B	0.562	0.503	0.697	0.438	0.481	0.363	0.625
Project C	0.579	0.655	0.668	0.788	0.789	0.466	0.427

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.21884	0.12825	0.02829	0.03157	0.00765	0.03550	0.10201
Project B	0.20827	0.11443	0.07597	0.03201	0.00961	0.01599	0.09742
Project C	0.21432	0.14912	0.07287	0.05751	0.01578	0.02050	0.06662
V+	0.20827	0.11443	0.02829	0.03157	0.00765	0.01599	0.06662
V-	0.21884	0.14912	0.07597	0.05751	0.01578	0.03550	0.10201

Project	di+	di-	ci	Rank
Project A	0.000967817272	0.001723920045	0.640448841	1
Project B	0.001613179436	0.001202565355	0.427086062	2
Project C	0.001993199638	0.000753582297	0.274350973	3

TOPSIS Final Rank

Project	CC aggregation	Normalize	Final Rank
Project A	1.334769899	1	1
Project B	0.643950891	0	3
Project C	1.077199872	0.627152664	2

2. VIKOR

Positive dataset

Weight	0.370408163	0.22755102	0.109	0.073	0.02	0.044	0.156
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	47.25190974	17.96496693	7.974120544	8.246056	2.054985	4.264720603	10.99002102
Project B	53.02447627	17.89862787	6.252159764	7.158271	6.006382	3.483547504	8.929267897
Project C	41.0512751	21.85195758	9.846360696	9.65541	6.648895	1.037362362	10.18101503
Best (Xi+)	53.02447627	21.85195758	9.846360696	9.65541	6.648895	4.264720603	10.99002102
Worst (Xi-)	41.0512751	17.89862787	6.252159764	7.158271	2.054985	1.037362362	8.929267897

	Location	Facility	Developer	Price	Security	Investment	House/building attributes	Si	Ri
Project A	0.1786	0.2237	0.0568	0.0412	0.0200	0.0000	0.0000	0.5203	0.2237
Project B	0.0000	0.2276	0.1090	0.0730	0.0028	0.0107	0.1560	0.5790	0.2276
Project C	0.3704	0.0000	0.0000	0.0000	0.0000	0.0440	0.0612	0.4757	0.3704
S*, R* (Min)	0.4757	0.2237							
S-, R- (Max)	0.5790	0.3704							

	Si	Ri	Qi (v=0.5)	Rank
Project A	0.520294225	0.223732588	0.215988247	1
Project B	0.578998336	0.22755102	0.513016591	3
Project C	0.475650304	0.370408163	0.50	2

Negative dataset

Weight	0.370408	0.22755102	0.109	0.073	0.02	0.044	0.156
	Location	Facility	Developer	Price	Security	Investment	House/building attributes
Project A	66.49312	27.53790424	12.06531563	11.31662	1.851452	5.038653877	14.82763755
Project B	14.19401	6.866168656	8.929358357	3.380153	1.47146	0.447166324	7.208068797
Project C	24.05772	10.40548232	8.088791898	7.091519	1.01114	1.01114008	5.310937719
Best (Xi+)	14.19401	6.866168656	8.088791898	3.380153	1.01114	0.447166324	5.310937719
Worst (Xi-)	66.49312	27.53790424	12.06531563	11.31662	1.851452	5.038653877	14.82763755

	Location	Facility	Developer	Price	Security	Investment	House attributes	Si	Ri
Project A	0.370	0.228	0.109	0.073	0.020	0.044	0.156	1.000	0.370
Project B	0.000	0.000	0.023	0.000	0.011	0.000	0.031	0.065	0.031
Project C	0.070	0.039	0.000	0.034	0.000	0.005	0.000	0.148	0.070
S*, R* (Min)	0.065	0.031							
S-, R- (Max)	1.000	0.370							

	Si	Ri	Qi (v=0.5)	Rank
Project A	0.999959	0.370408163	1	3
Project B	0.065095	0.031098222	0	1
Project C	0.148362	0.069859651	0.10	2

VIKOR Final Rank

Project	Aggregation	Normalize	Final Rank
Project A	1.215988247	1	3
Project B	0.513016591	0	1
Project C	0.601652221	0.12608706	2

3. SAW

Positive dataset

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
Alternatives	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	47.2519	17.9650	7.9741	8.2461	2.0550	4.2647	10.9900
Project B	53.0245	17.8986	6.2522	7.1583	6.0064	3.4835	8.9293
Project C	41.0513	21.8520	9.8464	9.6554	6.6489	1.0374	10.1810
Max	53.0245	21.8520	9.8464	9.6554	6.6489	4.2647	10.9900

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560		
Alternatives	Location	Facility	Developer	Price	Security	Investment	House attributes	Ai	Rank
Project A	0.8911	0.8221	0.8099	0.8540	0.3091	1.0000	1.0000	0.8740	1
Project B	1.0000	0.8191	0.6350	0.7414	0.9034	0.8168	0.8125	0.8609	3
Project C	0.7742	1.0000	1.0000	1.0000	1.0000	0.2432	0.9264	0.8715	2

Negative dataset

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	66.4931	27.5379	12.0653	11.3166	1.8515	5.0387	14.8276
Project B	14.1940	6.8662	8.9294	3.3802	1.4715	0.4472	7.2081
Project C	24.0577	10.4055	8.0888	7.0915	1.0111	1.0111	5.3109
Min	14.1940	6.8662	8.0888	3.3802	1.0111	0.4472	5.3109

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560		
	Location	Facility	Developer	Price	Security	Investment	House attributes	AI	Rank
Project A	0.2135	0.2493	0.6704	0.2987	0.5461	0.0887	0.3582	0.3014	3
Project B	1.0000	1.0000	0.9059	1.0000	0.6872	1.0000	0.7368	0.9424	1
Project C	0.5900	0.6599	1.0000	0.4766	1.0000	0.4422	1.0000	0.7079	2

SAW Final Rank

Project	Cumulative value	Normalize	Rank
Project A	1.175347113	0	3
Project B	1.803263525	1	1
Project C	1.579484118	0.643615929	2

WordNet Polarity

1. TOPSIS

Positive Dataset

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	50.551	19.885	10.472	9.402	1.906	3.620	11.832
Project B	54.962	19.628	12.857	9.334	5.579	3.837	3.837
Project C	43.842	23.728	12.388	12.245	6.166	5.445	15.193
χ^2	7498.335	1343.659	428.416	325.466	72.787	57.477	385.542

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.584	0.542	0.506	0.521	0.223	0.478	0.603
Project B	0.635	0.535	0.621	0.517	0.654	0.506	0.195
Project C	0.506	0.647	0.599	0.679	0.723	0.718	0.774

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.2162	0.1234	0.0551	0.0380	0.0045	0.0210	0.0940
Project B	0.2351	0.1218	0.0677	0.0378	0.0131	0.0223	0.0305
Project C	0.1875	0.1473	0.0652	0.0495	0.0145	0.0316	0.1207
V+	0.2351	0.1473	0.0677	0.0495	0.0145	0.0316	0.1207
V-	0.1875	0.1218	0.0551	0.0378	0.0045	0.0210	0.0305

Project	di+	di-	ci	Rank
Project A	0.0011	0.0024	0.6943	2
Project B	0.0045	0.0012	0.2169	3
Project C	0.0011	0.0046	0.8028	1

Negative Dataset

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	25.323	10.264	2.905	3.624	1.299	1.519	4.790
Project B	24.100	9.157	7.803	3.674	1.632	0.684	4.574
Project C	24.800	11.933	7.484	6.602	2.680	0.877	3.128
x^2	1837.148	331.602	125.330	70.221	11.534	3.546	53.647

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.591	0.564	0.260	0.433	0.382	0.807	0.654
Project B	0.562	0.503	0.697	0.438	0.481	0.363	0.625
Project C	0.579	0.655	0.668	0.788	0.789	0.466	0.427

	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	0.21884	0.12825	0.02829	0.03157	0.00765	0.03550	0.10201
Project B	0.20827	0.11443	0.07597	0.03201	0.00961	0.01599	0.09742
Project C	0.21432	0.14912	0.07287	0.05751	0.01578	0.02050	0.06662
V+	0.20827	0.11443	0.02829	0.03157	0.00765	0.01599	0.06662
V-	0.21884	0.14912	0.07597	0.05751	0.01578	0.03550	0.10201

Project	di+	di-	ci	Rank
Project A	0.000967817272	0.001723920045	0.640448841	1
Project B	0.001613179436	0.001202565355	0.427086062	2
Project C	0.001993199638	0.000753582297	0.274350973	3

TOPSIS Final Rank

Project	CC Aggregation	Normalize	Final Rank
Project A	1.334769899	1	1
Project B	0.643950891	0	3
Project C	1.077199872	0.627152664	2

2. VIKOR

Positive Dataset

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	50.5511	19.8847	10.4716	9.4024	1.9057	3.6201	11.8321
Project B	54.9621	19.6276	12.8569	9.3342	5.5794	3.8374	3.8374
Project C	43.8417	23.7279	12.3879	12.2447	6.1665	5.4448	15.1927
Best (Xi+)	54.9621	23.7279	12.8569	12.2447	6.1665	5.4448	15.1927
Worst (Xi-)	43.8417	19.6276	10.4716	9.3342	1.9057	3.6201	3.8374

	Location	Facility	Developer	Price	Security	Investment	House attributes	Si	Ri
Project A	0.1469	0.2133	0.1090	0.0713	0.0200	0.0440	0.0462	0.6507	0.2133
Project B	0.0000	0.2276	0.0000	0.0730	0.0028	0.0388	0.1560	0.4981	0.2276
Project C	0.3704	0.0000	0.0214	0.0000	0.0000	0.0000	0.0000	0.3918	0.3704
S*, R* (Min)	0.3918	0.2133							
S-, R- (Max)	0.6507	0.3704							

	Si	Ri	Qi (v=0.5)	Rank
Project A	0.650665965	0.213283321	0.5	2
Project B	0.498068462	0.22755102	0.250617171	1
Project C	0.39183772	0.370408163	0.50	2

Negative Dataset

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	50.5511	19.8847	10.4716	9.4024	1.9057	3.6201	11.8321
Project B	54.9621	19.6276	12.8569	9.3342	5.5794	3.8374	3.8374
Project C	43.8417	23.7279	12.3879	12.2447	6.1665	5.4448	15.1927
Best (Xi+)	43.8417	19.6276	10.4716	9.3342	1.9057	3.6201	3.8374
Worst (Xi-)	54.9621	23.7279	12.8569	12.2447	6.1665	5.4448	15.1927

	Location	Facility	Developer	Price	Security	Investment	House attributes	Si	Ri
Project A	0.2235	0.0143	0.0000	0.0017	0.0000	0.0000	0.1098	0.3493	0.2235
Project B	0.3704	0.0000	0.1090	0.0000	0.0172	0.0052	0.0000	0.5019	0.3704
Project C	0.0000	0.2276	0.0876	0.0730	0.0200	0.0440	0.1560	0.6081	0.2276
S*, R* (Min)	0.3493	0.2235							
S-, R- (Max)	0.6081	0.3704							

	Si	Ri	Qi (v=0.5)	Rank
Project A	0.349293	0.223482425	0	1
Project B	0.501891	0.370408163	0.79478526	3
Project C	0.608121	0.22755102	0.51	2

VIKOR Final Rank

Project	CC Aggregation	Normalize	Final Rank
Project A	0.5	0	1
Project B	1.045402431	1	3
Project C	1.013845755	0.942140566	2

3. SAW

Weight	0.370408	0.22755102	0.109	0.073	0.02	0.044	0.156
Alternatives	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	50.55108	19.88472758	10.47164792	9.402439963	1.9057088	3.62013687	11.83213083
Project B	54.96209	19.62763774	12.85688072	9.334249575	5.57937282	3.83737732	3.837377317
Project C	43.84167	23.72788214	12.38794051	12.24467114	6.16649717	5.44481555	15.19265931
Max	54.96209	23.72788214	12.85688072	12.24467114	6.16649717	5.44481555	15.19265931

Weight	0.370	0.228	0.109	0.073	0.020	0.044	0.156		
Alternatives	Location	Facility	Developer	Price	Security	Investment	House attributes	Ai	Rank
Project A	0.920	0.838	0.814	0.768	0.309	0.665	0.779	0.833	2.000
Project B	1.000	0.827	1.000	0.762	0.905	0.705	0.253	0.812	3.000
Project C	0.798	1.000	0.964	1.000	1.000	1.000	1.000	0.921	1.000

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560
	Location	Facility	Developer	Price	Security	Investment	House attributes
Project A	25.3235	10.2637	2.9054	3.6243	1.2989	1.5192	4.7895
Project B	24.1000	9.1573	7.8027	3.6742	1.6319	0.6844	4.5742
Project C	24.8004	11.9332	7.4838	6.6019	2.6802	0.8775	3.1280
Min	24.1000	9.1573	2.9054	3.6243	1.2989	0.6844	3.1280

Weight	0.3704	0.2276	0.1090	0.0730	0.0200	0.0440	0.1560		
	Location	Facility	Developer	Price	Security	Investment	House attributes	AI	Rank
Project A	0.9517	0.8922	1.0000	1.0000	1.0000	0.4505	0.6531	0.8792	1
Project B	1.0000	1.0000	0.3724	0.9864	0.7959	1.0000	0.6838	0.8772	2
Project C	0.9718	0.7674	0.3882	0.5490	0.4846	0.7800	1.0000	0.8170	3

SAW Final Rank

Project	Cumulative value	Normalize	Rank
Project A	1.712378425	0.477594429	2
Project B	1.688947391	0	3
Project C	1.738007918	1	1