Build Real Estate Evaluation Model based on Customer Requirement after COVID-19

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Abstract: - In Taiwan, real estate is not only the high price product but also is necessities. Every family needs real estate to live. Maybe, some citizens decide to rent house in the short period. But, major part of citizen will purchase real estate in the future. In past researches, evaluating performance of real estate mainly consider the function and condition of this house such as location, house type, floor, building age etc. However, the demand of specific consumer is importance factors to evaluate the performance of this customer. Especially, the requirement of real estate for consumer has been changed after COVID-19. The goal of this study is to build the evaluation model and relative criteria to evaluate performance of real estate in order to fit with the requirement of specific real estate consumer. A case study is implemented for the reader to realize the proposed method. Sensitive analysis will be executed and proposed method will be compared with traditional multi criteria method to justify the usefulness of this method. Some conclusion and future research will be taken over as ending.

Key-Words: Real Estate Investment; Fuzzy Number; VIKOR; COVID-19.

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1 Introduction

Real estate is very important necessities for customer [1]. In Taiwan, male citizen who have houses under their names in the country have an average of 1.52 transactions per person, while female citizen who have houses under their names have an average of 1.44 transactions per person (Refer to Table 1). Volume of Taiwan total citizen is 23,548,633. On average, a half of citizens can possess their house if everyone buys single real estate. So, real estate not only is an expensive necessity but also can be bought by major part of citizens once in a lifetime.

Table 1. Statistics of Taiwan property tax holders

Gender	Volume of People (A)	Volume of House (B)	Average (A/B)
Male Holder	4,279,686	6,484,769	1.52
Female Holder	3,507,587	5,047,081	1.44
	Total Citizen (C)	Total House (D)	Average(D/C)
	23,548,633	11,531,850	48.97%

Bilateral matching theory is the core of the theory. The concept of bilateral matching was first summarized and put forward by Erwin Ross. “Bilateral” emphasizes that participants in the market belong to two disjoint sets. “Matching” emphasizes the bilateral nature of market exchanges. And both parties have stability preferences. Bilateral matching theory takes bilateral matching as the research object and studies the matching process of disjoint two parties with stable preferences.

In practical, customer usually choose their house (real estate) based on their financial ability. This is the matching process; major part of rich customer prefers to live in the mansion to show status and major part of poor customer like to live in small house based on economics consideration. Bilateral matching theory can be applied on the real estate evaluation based on customer requirement. In this model, customer preference for real estate will be adjusted by triangular fuzzy number in order to match customer’s economics ability and luxury degree of real estate.

This study includes seven main chapters. In chapter two, literature review has been discussed. In chapter three, some notation and operation about linguistic variable and fuzzy number should be in introduced. In chapter four, proposed model should be introduced. After that, case study could be implemented in order to let reader understand this method. Sensitive analysis should be executed and proposed method will be compared with some traditional multi criteria method to justify the usefulness of this method. Finally, some conclusion and future research will be discussed as ending.

2 Literature Review

Below literatures are past study about real estate relative research. Pourkhabbaz et al. [2] designed the framework to choose suitable locations for agri-cultural land by integrating simple additive weighting (SAW), analytic network process (ANP) and VIKOR under geographic information system environment. Ho et al. [3] considered housing goals and risk attitudes of real estate consumer and used fuzzy goal programming with an S-shaped utility function to help real estate consumers select their preferred house in the internet. Morteza et al. [4] combined fuzzy technique for order preference by similarity to an ideal solution (fuzzy TOPSIS) with analytic network process to analyze suitable tourism operation location in Qeshm Island of Iran with the goal of maximizing enterprise profit. Wu and Kou [5] collected experts' opinion under twelve criteria and designed consensus model for integrating their opinions. AHP is used to analyze real estate investment target. Del Giudice et al. [6] collected data in a central urban area of Naples and applied genetic algorithms (GA) to analyze the relationship between geographical location of housing units and real estate rental prices. Based on their experiment, the predict ability of formula generated by GA is better than it generated by multiple regression analysis (MRA). Guarini et al. [7] considered governmental factors, regulatory dimensions and technical content to decide which multi criteria decision method is suitable to handle real estate selection problem in Europe. In this research, they designed overall suitability index (IS) to evaluate and select one kind of MCDM which includes MACBETH, TOPSIS, ANP, AHP, MAUT, PROMETHEE and ELECTRE for expert to make real estate investment selection. Omidipoor et al. [8] arranged some real estate evaluation criteria such as land price, area, proximity to transportation stations etc and implement decision support system by combined AHP techniques with geographic information system (GIS) and into the web platform for making real estate investment decision in in Tehran, Iran. Renigier-Biłozor et al. [9] integrated automated valuation model (AVM), Rough Set Theory (RST), Value Tolerance Relation (VTR) and Fuzzy logic to evaluate and monitor price of real estate. Comu et al. [10] collected thirteen real estate project criteria and integrated project delivery method (PDM) with Fuzzy analytical hierarchy process (Fuzzy AHP) to evaluate and prioritize the appropriate real estate projects in Turkey. Nguyen et al. [11] designed grey multi-criteria decision-making support model to analyze real estate alternatives in Vietnam. In their method, DEMATEL was applied to acquire subjective weights of each criterion. Grey relational analysis (GRA) was used to rank real estate alternatives. Myskova handled waste water treatment plant investment project selection problem by RBSTP. They also analyzed the advantages and disadvantages of the RBSTP method [12] Above literatures has been arranged as Table 2.

Table 2. Literature of research

Author	Year	Method	Target
Myskova et al.	2013	RBSTP	Waste water treatment plant investment project selection
Pourkhabbaz et al	2014	(1) SAW (2) AHP (3) VIKOR	Agri-cultural land selection
Ho et al.	2015	(1) Fuzzy goal programming (2) S-shaped utility function	Real estate selection
Morteza et al.	2016	(1) ANP (2) Fuzzy TOPSIS	Tourism operation location selection
Wu and Kou	2016	(1) consensus model (2) AHP	Real estate selection
Del Giudice	2017	Genetic algorithms	Real estate price forecasting
Guarini et al.	2018	(1) suitability index (2) MACBETH (3)TOPSIS(4)ANP (5)AHP (6)MAUT (7)PROMETHEE (8)ELECTRE	Real estate investment selection
Omidipoor et al.	2019	(1)AHP (2)GIS	Real estate investment decision
Renigier-	2019	(1)Automated	Real estate

Biłozor et al.		valuation model (2)Rough Set Theory (3)Value Tolerance Relation (4)Fuzzy logic	price forecasting
Comu et al.	2020	(1) Project delivery method (2) Fuzzy AHP	Real estate investment project selection
Nguyen et al.	2020	(1) DEMATEL (2) Grey relational analysis	Real estate investment decision

According to above researches, each kind of multi criteria decision making method (MCDM method) has been used to make real estate investment decision. Besides, some paper will integrate geographic information system (GIS) and machining learning technology to forecasting price of real estate. However, major part of citizen buys real estate (house) for living and only a few citizens purchase real estate as investment target [13]. Owner-occupied homebuyers will purchase real estate according to their housing needs and the future price trend of real estate is not their main consideration.

To my best knowledge, major part of literatures discusses about real estate investment mainly consider the future price trend of real estate. In the past literatures, real estate has been considered as investment target. But, the function of real estate is used to live. So, it needs a mechanism to evaluate performance of real estate based on live requirement of owner-occupied homebuyers. This mechanism does not exist in the past research until now. The goal of this study is to build the evaluation model and relative criteria to evaluate performance of real estate in order to fit with the requirement of specific real estate consumer.

3 Preliminary

3.1 Linguistic Variable

Linguistic variable is the useful tool which can let experts or decision makers to express opinion friendly.

Definition 1. Suppose that $V_0^z, V_1^z, \dots, V_{z-1}^z$ means linguistic variables. Above linguistic variables will compose as linguistic term set V. z represents the scale of linguistic variable [14-15].

Definition 2. Suppose that F:V->R means the transfer function. The execution process of above function is to transfer linguistic variable into real value r (r$\in$[0,1]) [16]. The execution calculation process of above function could refer to.

$$F(V_y^z) = \frac{y}{z-1} = r \quad (1)$$

Definition 3. There are two characteristics in linguistic set V[16].

$$\text{If } F(V_a^z) > F(V_b^z) \text{ then } V_a^z > V_b^z \quad (2)$$

Suppose that Neg() means negative function in linguistic set V.

$$\text{Neg}(V_a^z) = V_{z-1-a}^z \quad (3)$$

Definition 4. Suppose that F^{-1} :R->V means linguistic transfer inverse function which can transfer crisp value r (r$\in$[0,1]) into linguistic variable [16].

$$F^{-1}(r) = V_{r*(z-1)}^z \quad (4)$$

3.2 Triangular Fuzzy Number

Triangular fuzzy number is important concept in fuzzy theory. The definition of triangular fuzzy number can refer to Definition 5 and Definition 6.

Definition 5. Suppose that G means fuzzy set $G=\{\langle k, \mu_F(k)\rangle | k \in K\}$, where K means the universe of discourse, $\mu_G: K \to [0,1]$ means the membership function, $\mu_G(k)$ means the membership degree of element k to Set G [17].

Definition 6. Suppose that $\tilde{S} = (s_l, s_m, s_r)$ mean triangular fuzzy number (TFN). s_l , s_m *and* s_r represents the left point, middle point and right point in TFN. TFN can be formulated by follow function [18].

$$u_{\tilde{S}}(x) = \begin{cases} \frac{x-s_l}{s_m-s_l}, s_m > x \geq s_l \\ 1 - \frac{x-s_m}{s_r-s_m}, s_r > x \geq s_m \\ 0, others \end{cases} \quad (5)$$

3.3. Maximum Deviation Method

The maximum deviation method under linguistic environment is developed by Wu and Chen [19]. Generally speaking, the maximum deviation method will be used to obtain the weights according to the maximum deviation ideas. The concept of maximum deviation method is that the criteria should possess relatively more weight if experts' opinions in this criteria has relatively high deviation degree.

Definition 7. Suppose that $\tilde{\phi}_{ij}^h$ means performance of real estate i respect to dimension j for expert h's opinion. According to the content of past literatures, the function of maximum deviation method can be described as follows [19-21].

$$w_j^* = \frac{\sum_{y=1}^{h} \rho_h \sum_{i=1}^{n} \sum_{p=1}^{n} \left(F(\tilde{\phi}_{ij}^y) - F(\tilde{\phi}_{pj}^y)\right)^2}{\sum_{j=1}^{m} \sum_{y=1}^{h} \sum_{i=1}^{n} \sum_{p=1}^{n} \left(F(\tilde{\phi}_{ij}^y) - F(\tilde{\phi}_{pj}^y)\right)^2} \quad (6)$$

where ρ_h means the importance of expert h, n means the volume of real estates.

4 Proposed method

4.1 Notation of Proposed Method

General speaking, real estate selection problem should be formulated based on Table 3[22-23].

Table 3. Notation of Proposed Method

Set Name	Set Name	Description
Member set	$\boldsymbol{\Lambda}=\{\Lambda_1, \Lambda_2, \dots, \Lambda_k\}$	k means volume of consumers in the family
Member importance set	$\rho=\{\rho_1, \rho_2, \dots, \rho_k\}$	k means volume of Members in the family
Real estate target	$R=\{R_1, R_2, \dots, R_m\}$	m represents volume of Real estate target.
Criteria set	$C=\{C_1, C_2, \dots, C_n\}$	n represents volume of criteria.
Criteria Weight set	$W=\{w_1, w_2, \dots, w_n\}$	n represents volume of criteria.
Decision matrix X	$X = \begin{matrix} \\ \Lambda_1 \\ \Lambda_2 \\ \dots \\ \Lambda_m \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & \dots & C_n \end{matrix} \\ \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \dots & \dots & \dots & \dots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix} \end{matrix}$	
Decision matrix E	$E = \begin{matrix} \\ \Lambda_1 \\ \Lambda_2 \\ \dots \\ \Lambda_m \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & \dots & C_n \end{matrix} \\ \begin{bmatrix} e_{11} & e_{12} & \dots & e_{1n} \\ e_{21} & e_{22} & \dots & e_{2n} \\ \dots & \dots & \dots & \dots \\ e_{m1} & e_{m2} & \dots & e_{mn} \end{bmatrix} \end{matrix}$	

4.2 Execution Process of Proposed Method

At the beginning, real estate enterprise will organize a committee for handling real estate evaluation problem and invite some experts into this committee (Experts comes from university, company and government). Real estate enterprise will decide real estate criteria and real estate target for the member in family to evaluate performance of each real estate based on family member's requirement. And maximum deviation method is used to evaluate weight of each criterion. VIKOR is employed to analyse which real restate is suitable to this family. The execution step of proposed method is as follows (Refer to Fig 1).

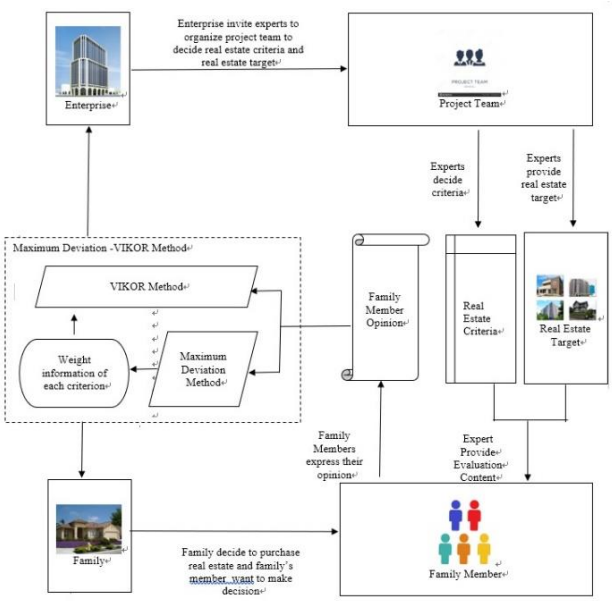

Fig. 1: Execution process of proposed method

Step 1. Organize committee

At first, real estate enterprise should invite expert to organize this committee.

Step 2. Decide criteria

Experts will collect real estate relative literatures and decide criteria.

Step 3. Decide real estate alternative

Real estate enterprise will select some real estate alternative for family members to consider to purchase based on their requirement.

Step 4. Family members express their opinion

Family members' opinions (the performance of real estate targets respect to the entire criteria) should be collected. Suppose that $\tilde{x}_{ijk}$ be the opinion of family member k about performance of country i with respect to criterion j.

Step 5. Integrate family members' opinion

Family members' opinion can be integrated by follow equation

$$\tilde{x}_{ij}=\Delta^{-1}\left(-\sum_{k=1}^{K}\Delta\left(\tilde{x}_{ijk}\right)/\mathrm{K}\right) \quad (7)$$

Step 6. Transfer family members' opinion as evaluation value.

Although, high performance of real estate is good for family member. However, it also means high price for real estate with high performance because every consumer will be attracted in this kind of real estate. So, a suitable real estate should be in-qualified (not over-qualified) for the family because the over-qualified real estate can generate a few

benefits for family but the price in this kind of real estate will be very high because the quality is relatively high compare with other real estate.

In this research, three kinds of function have been used to transfer family members' opinion into suitable evaluation value. The function is as follows.

(1) Decrease function (Refer to Fig 2)

$$e_{ij} = u_j\left(\Delta(\tilde{x}_{ij})\right)=1-\frac{\Delta(\tilde{x}_{ij})-s_l}{s_r-s_l} \quad (8)$$

where s_r=1, s_l=0

In decrease function (Refer to Fig 2), the evaluation value of $\tilde{x}_{ij}$ is high if the original family members' opinion is low.

(2) Triangular Fuzzy Number function (Refer to Fig 3)

$$e_{ij} = u_j\left(\Delta(\tilde{x}_{ij})\right)=\begin{cases}\frac{\Delta(\tilde{x}_{ij})-s_l}{s_m-s_l}, s_m > \Delta(\tilde{x}_{ij}) \geq s_l \\ 1-\frac{\Delta(\tilde{x}_{ij})-s_m}{s_r-s_m}, s_r > \Delta(\tilde{x}_{ij}) \geq s_m \\ 0, others\end{cases} \quad (9)$$

where s_r=1, s_l=0 s_m is the best prefer quality for family.

(3) Level function (Refer to Fig 4)

$$e_{ij} = u_j\left(\Delta(\tilde{x}_{ij})\right)=\begin{cases}0.5, s_r > \Delta(\tilde{x}_{ij}) \geq s_1 \\ 1, s_1 > \Delta(\tilde{x}_{ij}) \geq s_2 \\ 0.5, s_2 > \Delta(\tilde{x}_{ij}) \geq s_l\end{cases} \quad (10)$$

where s_r=1, s_l=0, s_1 and s_2 are critical point for family member.

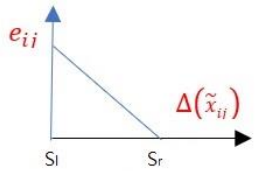

Fig. 2: The membership function of decrease function

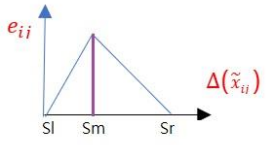

Fig. 3: The membership function of triangular fuzzy number

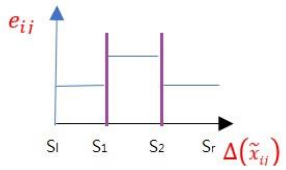

Fig. 4: The membership function of level function

Step 7. Calculate weight of each criteria

And then, weight of each real estate criterion based on maximum deviation method should be acquired based on below equation.

$$w_j^*=\frac{\sum_{y=1}^{h}\rho_h\sum_{i=1}^{n}\sum_{p=1}^{n}\left(\Delta(\tilde{x}_{ijy})-\Delta(\tilde{\phi}_{pjy})\right)^2}{\sum_{j=1}^{m}\sum_{y=1}^{h}\sum_{i=1}^{n}\sum_{p=1}^{n}\left(\Delta(\tilde{\phi}_{ijy})-\Delta(\tilde{\phi}_{pjy})\right)^2} \quad (11)$$

Step 8. Calculate PIS and NIS of real estate

Afterward, positive ideal solution (PIS) and negative ideal solution (NIS) must be calculated based on below equation.

$$f_j^*=max_i(e_{ij}) \quad (12)$$

$$f_j^-=min_i(e_{ij}) \quad (13)$$

Step 9. Calculate total performance and individual regret value of real estate

Total performance of real estate (the largest group utility) S_i can be acquired by following equation.

$$S_i=\sum_{j=1}^{n} w_j * \frac{f_j^*-e_{ij}}{f_j^*-f_j^-} \quad (14)$$

The individual regret value of real estate (the smallest individual regret) R_i can be acquired by following equation.

$$R_i=max_j\left[w_j * \frac{f_j^*-e_{ij}}{f_j^*-f_j^-}\right] \quad (15)$$

Step 10. Calculate Q value

Q value will be calculated to acquire rank of each real estate for family.

$$Q_i=v*\frac{S_i-S^*}{S^--S^*}+(1-v)*\frac{R_i-R^*}{R^--R^*} \quad (16)$$

where v mean decision parameter, $S^*=min_iS_i$, $S^-=max_iS_i$, $R^*=min_iR_i$, $R^-=max_iR_i$.

The fewer Q_i, the better real estate.

5 Case Study

A case study is implementing in practical real estate selection problem for this research. One of Taiwan real estate enterprise wants to help a family to select the suitable real estate for this family to live. The family has five members. Among them, four adult families will evaluate performance of each real estate. But, each family member has different preference for selecting real estate respect to each criterion. Proposed model has been designed for helping the family to select suitable real estate to live. The relative process is executed as below step based on proposed method.

Step 1. Organize committee

One of Taiwan real estate enterprise wants to redesign real estate criteria and seven experts are invited to organize the committee.

Step 2. Decide criteria

Experts collected seven criteria to evaluate performance of real estate. Those criteria are space (C_1), location (C_2), building age (C_3), floor (C_4), surrounding life functions (C_5) and equipment and decoration (C_6). Those criteria are suitable to evaluate performance of real estate. There are some literatures which apply above criteria to make real estate selection (refer to Table 4).

Table 4. Real estate selection criteria

Criterion No.	Criterion Name	Literatures
(C_1)	space	[1,24, 27]
(C_2)	location	[5, 23-24]
(C_3)	floor	[6-7, 24-25]
(C_4)	building age	[9, 24, 27]
(C_5)	surrounding life functions	[10, 24, 26]
(C_6)	equipment and decoration	[7, 27]

Step 3. Decide real estate alternative

In this study, five real estate alternatives are chosen for making real estate purchase decision based on family members' requirement.

Step 4. Family members express their opinion

In this case, the family has five members. Among them, four adult families will evaluate performance of each real estate. Family member's opinion can refer to Table 5 and Table 6.

Table 5. Linguistic variable

Linguistic variable	Abbreviation
Extremely Poor	EP
Very Poor	VP
Poor	P
Medium Poor	MP
Fair	F
Medium Good	MG
Good	G
Very Good	VG
Extremely Good	EG

Table 6. Performance of each real estate

	Family Member 1's opinion					Family Member 2's opinion				
	Λ_1	Λ_2	Λ_3	Λ_4	Λ_5	Λ_1	Λ_2	Λ_3	Λ_4	Λ_5
C_1	F	G	EG	MP	F	MG	VG	EG	MP	G
C_2	MG	F	P	EG	VG	MG	VG	P	MG	EG
C_3	VG	F	F	G	VG	MG	MG	MP	MG	EG
C_4	MG	F	P	P	P	F	MG	MG	P	MP
C_5	MG	G	G	MP	MG	VG	VG	MG	F	VG
C_6	F	MG	MG	MG	MG	MG	G	F	MG	P
	Family Member 3's opinion					Family Member 4's opinion				
	Λ_1	Λ_2	Λ_3	Λ_4	Λ_5	Λ_1	Λ_2	Λ_3	Λ_4	Λ_5
C_1	F	G	VG	MP	F	MG	MG	VG	F	G
C_2	MG	MG	MP	EG	EG	G	MG	MP	VG	EG
C_3	VG	F	F	G	VG	G	MG	MG	MG	EG
C_4	F	MP	MP	MP	P	MP	VP	MP	P	EP
C_5	MG	F	G	F	F	G	VG	MG	MG	MG
C_6	MG	MG	VP	G	F	VG	G	MG	MP	F

Step 5. Integrate family members' opinion

In this work, formula 7 is used to integrate family members' opinion. (Please refer to Table 7)

Table 7. Family members' integration opinion (crisp value type)

	Λ_1	Λ_2	Λ_3	Λ_4	Λ_5
C_1	0.5625	0.7500	0.9375	0.4063	0.6250
C_2	0.6563	0.6563	0.3125	0.8750	0.9688
C_3	0.7813	0.5625	0.5000	0.6875	0.9375
C_4	0.5000	0.4063	0.4063	0.2813	0.2188
C_5	0.7188	0.7500	0.6875	0.5000	0.6563
C_6	0.6563	0.6875	0.4688	0.5938	0.4688

Step 6. Transfer family members' opinion as evaluation value.

In this study, each criterion will use each kind of function to transfer family members' opinion as evaluation value. The transfer function which is used in each criterion can refer to Table 8. The transfer result can refer to Table 9.

Table 8. The transfer function and its parameter for each criterion

Criterion No.	Criterion Name	Function	Parameter
(C_1)	Space	Triangular Fuzzy Number function	s_m=(5/8) EG
(C_2)	Location	Decrease function	
(C_3)	Floor	Level function	s_l=(4/8) F s_l=(6/8) G
(C_4)	Building age	Decrease function	
(C_5)	Surrounding life functions	Triangular Fuzzy Number	s_m=(5/8) MG
(C_6)	Equipment and decoration	Triangular Fuzzy Number	s_m=(5/8) MG

Table 9. Transfer result of family member's opinion

	Λ_1	Λ_2	Λ_3	Λ_4	Λ_5
C_1	0.9000	0.6667	0.1667	0.3499	1.0000
C_2	0.3437	0.3437	0.6875	0.1250	0.0312
C_3	1.0000	1.0000	0.5000	1.0000	0.5000
C_4	0.5000	0.5937	0.5937	0.7187	0.7812
C_5	0.7499	0.6667	0.8333	0.2000	0.9165
C_6	0.9165	0.8333	0.2499	0.9501	0.2499

Step 7. Calculate weight of each criteria
In this study, maximum deviation method (formula 11) are applied to acquired weight of each criterion. (Refer to Table 10).

Table 10. Weight of each criterion

	C_1	C_2	C_3
Weight	0.0938	0.1421	0.0831
	C_4	C_5	C_6
Weight	0.2252	0.1769	0.2789

Step 8. Calculate PIS and NIS of real estate
Positive ideal solution and negative ideal solution can be calculated as Table 11.

Table 11. PIS and NIS

	C_1	C_2	C_3	C_4	C_5	C_6
PIS	1.0000	0.6875	1.0000	0.7812	0.9165	0.9501
NIS	0.1667	0.0312	0.5000	0.5000	0.2000	0.2499

Step 9. Calculate total performance and individual regret value of real estate
Total performance and individual regret value of each real estate can be calculated as Table 12.

Step 10. Calculate Q value
In this research, decision parameter set up as 0.5. After calculating the Q value of each real estate, the rank of each real estate is Λ_2>Λ_4>Λ_1>>Λ_5>Λ_3.

Table 12. Total performance and individual regret value

	Λ_1	Λ_2	Λ_3	Λ_4	Λ_5
Total performance	0.3654	0.3703	0.6265	0.4219	0.5041
Individual regret value	0.2252	0.1502	0.2789	0.1769	0.2789
Q value	0.2914	0.0094	1.0000	0.2121	0.7656
Rank	3	1	5	2	4

6 Sensitive Analysis and Comparison Result of Different Multi Criteria Decision Method

6.1 Sensitive Analysis

In order to justify the steadiness of proposed method, we adjust decision parameter to analyze the rank of each real estate (Refer to Fig 5). According to analysis result, we can know that real estate Λ_2 is the suitable real estate alternative except decision parameter set up as 1.0. So, proposed method is relatively steady method in choosing real estate for the family.

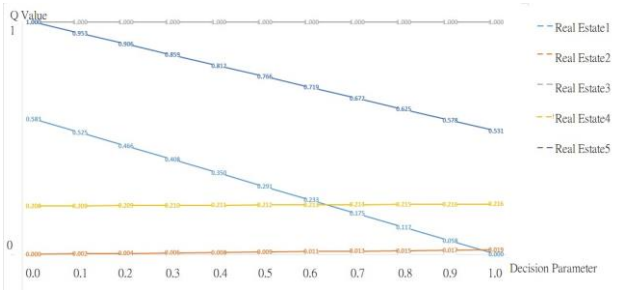

Fig. 5: Sensitive analysis of proposed model

6.2 Comparison Result of Different Multi Criteria Decision Method

Proposed method also compares with traditional multi criterion decision making method. According to experiment result, we can know that real estate Λ_1 is the "best" real estate which is decided by each kind of traditional multi criterion decision making method. But, the sequence of real estate Λ_1 is ranked No. 3 by proposed method. This is because proposed method will adjust performance of each estate based on family members' requirement. In some criteria, family members do not need highest performance of real estate and real estate with highest performance usually need highest price to purchase. This will waste family's budget because the function of best real estate exceeds the requirement of family member' requirement and benefit of over-qualified function for family member is low. Best real estate is usually not the suitable real estate for the family.

Table 13. Rank of each real estate between different MCDM method

	Rank				
	1	2	3	4	5
VIKOR + Maximum Deviation Method with Fuzzy Number Function	Λ_2	Λ_4	Λ_1	Λ_5	Λ_3
VIKOR + Maximum Deviation Method without Fuzzy Number Function	Λ_1	Λ_2	Λ_4	Λ_3	Λ_5
TOPSIS + Maximum Deviation Method	Λ_1	Λ_2	Λ_5	Λ_4	Λ_3
SWA + Maximum	Λ_1	Λ_2	Λ_5	Λ_4	Λ_3

Deviation Method					

6.3 Discussion

Although, this detail tool such as triangular fuzzy number, VIKOR, maximum deviation method is not new. But, past research does not integrate above three tool to evaluate performance of real estate. Because, past research usually evaluate performance of real estate based on the luxury degree of real estate.

However, performance of real estate should be adjusted by triangular fuzzy number based on customer's demand and customer's economics ability. This point does not consider by past real estate research.

According to chapter 6.2, each kind of traditional multi criterion decision making method choose Λ_1 as the "best" real estate. But, the "best" real estate does not mean "best" real estate is the "fittest" real estate for customer because it will waste and go beyond family's budget.

7 Conclusion

In this research, the integration method to evaluate performance of real estate has been built. The advantage of proposed methods has three points.

(1) Proposed method satisfies consumer's need

In past research, performance of real estate will be analysed and evaluated according to experts' opinion. However, experts' profession opinion is not equivalent to consumer's preference. Proposed method is the minority research to make real estate decision based on consumers' preference and requirement. Consumers' preference and requirement can be easy to adjust by function of fuzzy number.

(2) The execution result of proposed method is steadiness

Based on experiment result of case study, we can know that real estate Λ_2 is the suitable real estate for family when decision parameter has been changed between 0.0 and 0.9. So, proposed method is stable method in execution result.

(3) Proposed method is easy to implement

Each execution step of proposed method is mainly simple mathematics computation. So, proposed method is easy to implement by decision support system for each family to select suitable real estate based on each family's preference.

In the future, some scholars can apply proposed method in relative expensive product fields such as car, motorcycle and oversea tourism. Above product can be very expensive in the top-level. So, car, motorcycle and oversea tourism should be chosen based on consumer's requirement and the requirement should not be over-qualified to avoid high price which cannot afford by consumer.

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