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Market Preferences of Different Operators of Long-Term Rental Apartments in a Fuzzy Environment

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Abstract: The long-term rental apartment market in China is steadily growing to be a trillion-dollar sector, but excessive market growth can lead to several issues. Due to the high demand for long-term rentals, many investors will enter the market. Nevertheless, without direction and supervision, it is simple to overdevelop the supply of long-term rentals, which would have negative effects on the real estate market. Long-term rental apartments involve a variety of companies, and it is vital that we drive their beneficial growth. To provide other operators with a comparison to find flaws, enhance improvements, and prevent irrationally increasing the stock, this paper uses the Pythagorean fuzzy decision-making method to identify the most well-liked long-term rental apartment operators and the most significant rental needs of tenants in the market environment. The results of the study show that real estate developers' flats are the most popular among the four major operators, and that C4: Providing emotional value, C7: Ability to resist risk and C8: Ability to prevent social incidents are aspects that tenants value more than others. The results of the study provide real estate operators with directions for optimization, provide other operators with criteria for improvement, prevent blind increases in rental stock and provide operators with a healthy competitive environment, which is of great significance to the healthy development of long-term rental apartments in China.

Keywords: long-term rental apartments; Pythagorean fuzzy; apartment operators; China

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1. Introduction

The new frontier of global financialization is rental housing [1]. A secure house is a happy home, and housing is a significant concern for livelihood. Due to China's transition to a global market economy during the past three decades, the country's real estate market has seen significant changes. The Chinese central government has recommended to "speed up the construction of a housing system with various major sources of supply, numerous routes of protection, and rent and purchase" in order to better address the fundamental conflict between housing supply and demand. From the stance that "housing is not for speculation" to the creation of a "long-term housing mechanism" to the suggestion of "renting and purchase," the reform direction of housing is "returning to the housing." Future housing construction will generally follow the reform direction of "return to housing properties". China's long-term rental apartment market saw a wave of investment expansion in 2017–2018, promoted by policy, and serving as a significant component of the long-term mechanism of real estate regulation. The institutional framework of China's housing reform and the crucial role that government policies still play are contributing to the expansion of the rental market as well [2]. The increasing mobile population in China, the pursuit of life in big cities by graduates, demographic changes, rising barriers to home ownership, policy support from governments at all levels, capital support from various parties, and the fact that people's perceptions are no longer limited to "must have a home" are all objective and subjective reasons for the increasing demand for long-term rental apartments. Therefore, it is urgent to control the increase in the stock of long-term rental apartments.

In wealthy nations such as the United States, Japan, and Germany, the rental housing system is firmly established. Public and private rental housing are the two main categories used to categorize dwellings for rent. Private institutional rental housing is one of them; it is created and run by professional institutions, and it offers public space, living services, and more fully supporting amenities, among other things. Recent studies in the literature have focused on the examination of market performance in practice and aids in the steady growth of long-term rental apartments, with particular attention paid to risk management, investment choices, business performance, contentment with living, and rentals [3–6]. China's long-term rental apartments have started late and are not yet mature. Studies have focused on the operational model, profitability and catering to customer needs, focusing on how to operate long-term rental flats, making them more profitable and fast-growing, without taking into account the situation in the later stages of the development of long-term rental flats, which may lead to a situation similar to that of the real estate industry, where an "economic bubble" may occur as a result of the rapid increase in stock and the failure to sense market changes.

In this paper, according to the reality of the Chinese market, long-term rental apartments are divided into real estate open house operators, real estate service providers, professional operators and hotel operators according to the different operating entities (Table 1); This paper sets evaluation indicators, invite qualified experts to score the four major operators, calculate the ranking, find the operators that are most popular among tenants and the evaluation indicators that are more important, prevent the operating entities from failing to respond to the rapid changes in the market, and also forewarn investment entities wanting to enter flats and blindly expand their stock.

Table 1. Introduction to Long-term Rental Apartments in China.

Operators	Mode of Operation	Brand Representatives	Advantages	Disadvantages
Real estate open house operators	Development, construction and operation of new or owned stock	Vanke Park Apartments, Longwood Crown Apartments, Landsea Apartments	Ample availability and a mature supply chain	Little offline sales and little experience
Real estate service providers	Receive commissions from homeowners to manage and operate their homes	ZIroom, 5i5j	Understanding of tenant needs and a high volume of clientele	Few financing channels and weak brand influence
Professional operators	Renting from homeowners, then standardizing renovation and remodeling before renting to clients	MoFang Apartment, You+	Flexible business approach, experienced operation and good brand building	High cost investment and high operating costs
Hotel operators	Part of the hotel or a new hotel-style room to be operated as a apartment	Wowqu, Home Inn	Experienced management, strong cost control skills and better control	Low availability of housing and insufficient funding

The paper is organized as follows: Section 1 presents a review of the relevant literature, Section 2 introduces the research methodology, Section 3 carries out the calculations, Section 5 analyses the results, and the final section concludes the article.

1.1. The Development of Long-Term Rental Apartment

Engerstam and Warsame analyzed the long-term dynamics of new housing supply in Sweden's three largest cities over the period 1990–2020 and estimated the impact of market fundamentals on it through new construction and housing conversion. Underlying demand drivers are primarily responsible for changes in the housing mix, with displacement impacts mostly affecting the rental market rather than the owner-occupied segment [3]. Growth in the population and income are the primary factors influencing new building in the rental and cooperative housing sectors. Holtemoeller and Schulz analyzed the behavior of investors in the Berlin rental flat market from 1980–2004. A programmatic structural economic model is used and the impact of shocks on the rationality multiplier is analyzed.

The results show that investors behave irrationally in a very uncertain and unprecedented environment [7]. Kholodilin and Mense compared the energy efficiency capitalization of sales prices and rentals for two types of homes using data from the Berlin housing market and hedonic regressions. According to estimates, the value of future energy cost reductions in the rental industry is 2.5 times more than tenants' implied willingness to pay. The market influence of renters can be used to explain this [8].

Long-term rental apartments have grown dramatically in China's megacities since 2015, encouraged by a number of national policies to promote the development of the private rental sector. As a result, many long-term rental apartment companies have experienced a break in their capital chains and have even gone bankrupt within a short period of time. As a result, many landlords have not been paid and thousands of tenants have been made homeless [9]. Grigsby argues that the housing market is 'uneconomic' and 'inefficient' and requires government intervention [10]. Inflation rates, tax laws, and interest rates all have an impact on people's demand for rental housing, according to DiPasquale and Wheaton [11]. Seko, Sumita, and Economics looked at the cost of renting versus buying housing for Japanese households and concluded that smaller households are more likely to rent due to lower costs [12]. In his investigation of the GRAWEE mortgage system in urban Afghanistan, Feather makes the case that mixed-tenure housing, a middle ground between owned and leased housing, has a great deal of potential to assist more people fulfill their housing requirements [13]. Moreover, it is asserted that rents and demand are positively associated and that continual financial innovation in the rental housing market is followed by regulatory loopholes that ultimately result in higher rentals [14]. According to Maclennan, macroeconomic stability and more labor mobility might boost demand, and the development of the rental housing market has been mostly based on policy direction rather than economic growth and public housing [15]. In their investigation on the link between housing rental rules and poverty, Lee and McNamara discovered that public housing policies may be utilized to disperse poverty [16]. In general, countries are developing long-term rental apartments. The healthy development of long-term rental apartments has important implications for their economies, policies and so on, and measures should be taken to ensure the sustainability of long-term rental apartments.

1.2. The Needs of Long-Term Rental Apartments

In the marketplace, meeting customer wants is a way to encourage consumption, and the long-term rental apartments market is no different. According to Adianto's research, tenants' satisfaction with their rental apartments increases with service quality, and a lack of satisfaction may result from the design of the apartments not reflecting the tenants' sociocultural backgrounds and failing to meet their emotional needs. In light of inhabitants' expectations, it is suggested that current housing rules be reconsidered [17]. Adianto also used an Indonesian rental apartment building's communal products satisfaction survey to discover that poor security, poor cleanliness, and unrepaired plumbing leaks were the main causes of low resident satisfaction. This finding suggests that the design, rules, and management of rental apartments should be adjusted to the tenants' common needs in order to satisfy their unmet needs [18]. The majority of respondents complained about poor building utility maintenance, which forces residents to perform their own maintenance tasks. Sari found that poor building maintenance performance significantly lowers the quality of the structure, which in turn leads to lower satisfaction with housing [19].

To examine the environmental characteristics that influence tenant satisfaction, Byun and Ha chose public rental housing from among several different forms of public rental housing [20]. Tenant satisfaction was shown to be most influenced by safety and civility issues, then by equipment issues, then by physical issues, and finally by transit facilities. He concluded that there is a need to consider plans to prioritize the improvement of living environment factors according to housing type in order to improve tenant satisfaction with living in currently operating and future public rental housing. Milic and Zhou selected eight influencing factors in order to assess residential satisfaction and ultimately

determined that respondents' marital status (single people were more satisfied), home-ownership lease status, independent living arrangements, larger flat size, higher levels of privacy and higher levels of neighborhood attachment significantly predicted higher levels of residential satisfaction [21]. Tenants prefer to reside close to amenities, according to a study on housing satisfaction by Dickson-Gomez and McAuliffe [22]. In order to assess the effect of living location on those seeking long-term rental apartments, Elariane evaluated the usage of location-based service APIs. It was shown that even in densely populated locations, tenants favor well-serviced neighborhoods [23]. Tenants pay more attention to transportation when renting a property, and tenants are willing to pay more for convenient travel, so transportation is the subject of more studies. Boes and Nueesch contend that the cost of long-term rental apartments is influenced by aircraft noise and discover that, in contrast to popular belief, airports' noise pollution does not significantly affect prices. This is because airports, as significant routes of transportation, mitigate the effects of noise on residential life [24]. Breidenbach, Cohen, and Schaffner examined how airport distance (accessibility) and aircraft noise (due to arrival/departure routes) affected rental prices for apartments. They created a joint noise and proximity model, which confirmed that the benefits of proximity and the negative effects of noise externalities largely cancel each other out [25]. This suggests that accessibility has a greater impact on the market for long-stay apartments. In order to evaluate the association between bicycle infrastructure and activity and single-family house values in Tempe, Conrow, Mooney and Wentz employed measures of infrastructure and cycling traffic. They discovered that bicycle infrastructure density was positively correlated with home selling prices [26]. Based on a survey of apartment inhabitants in Perth, Melbourne, and Sydney, De Gruyter, Hooper, and Foster evaluate the sufficiency of off-street parking for flat households and give insights into the factors influencing both an under- and an oversupply of off-street parking. To prevent an under or oversupply of parking spots from leading to tenant discontent, it is advised that planning for new apartment buildings be supported with more specialized residential parking standards [27]. Other scholars have also concluded that transport conditions are important to tenants [28,29].

In addition to paying attention to the above research factors, tenants also have other needs. For instance, in terms of building design, a quantitative study carried out in Semarang by Dewi and Yuliastuti showed that due to a lack of social spaces on each floor of the building, residents have converted the hallways into active public spaces, that the design and facilities of the building do not match the needs of the users on the one hand, and that tenants do not have livable living spaces on the other [30]. In the present day, people are becoming more green-conscious and those who rent properties are taking the concept of green building more seriously. Jang, Kim, and Kim researched whether green building certification enhances prospective tenants' desire to rent space in buildings. They looked at how a building's green building certification affects possible tenants' willingness to rent. The findings demonstrated that potential renters were more inclined to rent space in buildings with green certification and that tenants with greater levels of environmental consciousness were more likely to do so [31]. According to a 2014 study by Zalejska-Jonsson, renters in Sweden may be prepared to pay more for green apartments since they are anticipated to have cheaper running expenses, a better internal atmosphere, and a less environmental effect than traditional structures [32]. A good brand can save tenants time in viewings and trustworthy quality of service. For students to grasp and learn the components of brand value in certain decision-making scenarios, M. Yu, Wang, and Li analyze how Ziroom delivers essential parts of unique services, enhances housing quality, and innovates new business models. Using the power of their own brand, they can draw in more clients [33]. In the US and other countries, the ownership structure of rental housing is changing, as demonstrated by James, as a result of the real estate investment trust (REIT) industry's explosive development. By analysing nearly half a million ratings posted on the largest US flat consumer review website, descriptive statistics and ordered logit analysis show that REITs that follow an aggressive branding strategy have a positive

impact on residential satisfaction, while unbranded REITs have a negative impact [34]. In terms of neighborhoods, Webb and Webber study evaluated cases of anticipated future neighborhood challenges related to primarily condominium-based forms of ownership, interviewing 22 local stakeholders and concluding that neighborhood effects are valued by renters as condominium communities become more common [35]. Of course, there are a number of additional factors that affect rentals. Egner and Grabietz find that housing policy is returning to the political agenda in Germany, although there is no concrete data from the government regarding changes in rental costs. They identified the factors influencing rental costs in German cities using a comparative quantitative method, and they demonstrated that a larger share of students and higher local average salaries were related to higher flat rentals. While building long-term rental apartments, developers deliberately take into account certain demographics [36]. Bamzar conducted a field study on the indoor living environment quality in the Hasselgarden senior housing (rental apartments for older people) in Stockholm, focusing on space use, fall patterns, and perceptions of safety among older people in a targeted study, and suggesting improvement strategies to adapt to their lifestyles, ensure their safety, and improve their well-being [37]. Kwon, Lee, and Beamish utilized a survey to learn more about the upcoming housing choices and lifestyles of the new generation in the US. Based on the study's findings, it is possible to better comprehend how American baby boomers will choose their homes in the future and to make specific suggestions for future home building, administration, and marketing [38]. To determine the many elements that contribute to the long-stay flat industry's success, Z. Yu builds a user perception model based on structural equation modeling and artificial neural networks utilized to fulfill a specific customer's demands (the younger generation) [39].

1.3. Pythagorean Fuzzy Decision-Making

At present, evaluation methods include the fuzzy comprehensive evaluation method, the principal component analysis method, the analytic hierarchy method, the TOPSIS evaluation method, etc. The results of these methods are often too absolute to take into account the complexities of reality and are based on the premise that the decision-maker is fully rational; therefore, the above is full of uncertainty in the process of index selection, data processing, etc. How to use the fuzzy comprehensive evaluation method to achieve reasonable and accurate evaluation in complex and uncertain situations, therefore, has also become the research direction of many scholars. After the authoritative scholar Zadeh introduced the concept of FS in 1965, intensive academic research ensued [40]. The Pythagorean fuzzy set was proposed by Yager in 2013 [41]. The interval value Pythagorean fuzzy sets and decision applications were researched by Peng and Yang in 2016 [42]. A multi-attribute decision-making strategy based on interval value Pythagorean fuzzy cross-entropy was proposed by Hao and other authors [43]. Due to the complexity of objective things, using language terms as evaluation information to make evaluation information closer to people's expression habits has attracted more and more scholars' attention in recent years. Based on Pythagorean fuzzy sets and sets of uncertain languages, Xian and Liu suggest a Pythagorean set of uncertain languages [44]. A binary language fuzzy model made up of linguistic phrases and $[-0.5, 0.5]$ evaluation values was proposed by Herrera and Martínez in 2000 [45]. The fuzzy binary language model successfully prevents information distortion and loss when expressing information. The interval binary language Pythagorean fuzzy set, which Zhang devised, offers some validity and comprehensiveness in conveying information while handling multi-attribute choice issues [46]. Rodriguez, Martínez , and Herrera expanded the ambiguous language terminology set to the hesitant fuzzy language set to achieve the goal of describing hesitant, ambiguous qualitative information [47]. This was done in order to accurately express the evaluation information of hesitation and uncertainty of expert judgment. Several academics have studied the hesitant fuzzy languages' multi-attribute decision-making issue, taking use of the benefits of hesitant fuzzy language sets for expression [48–50]. However, in the real world, it is difficult for decision-makers

to express hesitation with precise values and obscure linguistic information. Therefore, Wang et al. combine hesitant fuzzy language information and interval values and propose a set of interval hesitant fuzzy languages that can accurately and flexibly describe decision information [51]. In recent years, this collection has been widely used in multi-attribute decision-making problems such as risk assessment, enterprise management, and performance evaluation [52–59]. Currently, Pythagorean fuzzy sets are mostly used in the comparison of options, expressing the degree of preference of decision-makers for alternative options. For example, a publisher selects one of four alternative books for publication, establishes three evaluation indicators and invites experts to rank the preferences of the four books [60]. Three experts rank five batches of garments of different quality according to four indicators and select one batch for production [61]. Three experts select one of four alternative information systems based on four indicators to achieve optimal production [62]. Therefore, the Pythagorean fuzzy set can give decision-makers a more quantitative analysis in the case of uncertainty, which is of great significance for decision-making uncertain events. In a study, five alternative houses were ranked by setting up five evaluation indicators to select the best house, similar to the idea of this study [63].

In China, the government and society support the development of long-term rental flats; the trend of expansion of long-term rental flats is inevitable, but blind expansion will lead to an excessive stock of long-term rental flats. In the real estate industry, the excess stock caused by the previous real estate expansion is gradually transformed into long-term rental flats; if the long-term rental apartments are then overstocked, it will affect the stability of the market. With the increased mobility of society, the market in long-term rental apartments is becoming more and more complex and demanding, and everything is in a state of uncertainty. With the ambiguous degree of market preference, this paper draws on Pythagorean fuzzy sets to identify the most preferred operating agents and evaluation indicators to prevent blind market expansion.

Since both the government and the market have expressed support for the growth of long-term rental apartments, this trend is unavoidable. However, if the long-term rental apartment industry can be guided more effectively during its development, this will lead to stable and positive growth. Pythagorean fuzzy sets are a key tool for identifying the evaluation subject in a fuzzy environment.

2. Materials and Methods

In the real estate industry, the traditional decision-making methods are the TOPSIS model, game theory, etc. These methods cannot fully integrate the decision information, and the decision results are too absolute. Pythagorean fuzzy decision-making can make full use of the decision information and can make the decision results more convincing. There is a possibility that the decision-maker will hesitate during the decision-making process, i.e., the probability of supporting is 60%, but the probability of opposing is only 20%, and the remaining 20% is the degree of hesitation, which expresses the uncertainty of that decision-maker about that decision. Pythagorean fuzzy decision-making is frequently used by academics to express the attitude of decision-makers when multiple decision-making objects and multiple evaluation indicators are present at the same time. The opinions of the decision-makers are then aggregated through weighted operators to sort the decision-making objects, indicating the advantages and disadvantages of the decision-making objects in order. The research steps are as follows.

Step 1: Collect expert opinions and normalize to a Pythagorean fuzzy matrix.
Step 2: Aggregate expert opinion fuzzy numbers.
Step 3: Calculate the metric weights.
Step 4: Calculate the market preference value.
Step 5: Sort the scoring function.
Step 6: Make recommendations.

2.1. Collect Expert Opinions and Normalize to a Pythagorean Fuzzy Matrix

After the decision-making objects and evaluation indicators are determined, they are distributed to experts in the form of questionnaires, and expert opinions are collected and sorted out according to the satisfaction evaluation form (Table 2) and standardized as a Pythagorean fuzzy matrix.

1. $e = \{e_1, e_2, \ldots e_m\}$ represents the collection of experts, m is the number of decision-makers team.
2. $C = \{C_1, C_2, \ldots C_j\}$ indicates the evaluation index, and C_j indicates the jth evaluation index.
3. $A = \{A_1, A_2, \ldots A_n\}$ represents the decision-making object and A_n indicates the nth decision-making object.

Table 2. Satisfaction evaluation table.

Evaluation Terminology	Pythagorean Fuzzy Set
Very Good	(0.80, 0.05)
Good	(0.75, 0.10)
Better	(0.70, 0.15)
Medium	(0.55, 0.25)
Relatively Poor	(0.45, 0.40)
Poor	(0.30, 0.55)
Very Poor	(0.20, 0.70)

2.2. Aggregate Expert Opinion Fuzzy Numbers

2.2.1. Define a Pythagorean Fuzzy Set (PFS) [41]

$$P = \left\{ \left\langle x, s(x), o(x) \right\rangle | 0 \le s^2(x) + o^2(x) \le 1, x \in X \right\} \quad (1)$$

where X is the finite domain of discourse, $s(x)$ is the degree of membership, also indicates the degree of support, approval, $s(x) \in [0, 1]$; $o(x)$ is the degree of non-membership, $s(x) \in [0, 1]$, also indicates the degree of opposition; is hesitation, which indicates the degree of hesitation of the decision-maker. The array $(s(x), o(x))$ is called the Pythagorean fuzzy number (PFN), and all PFN combinations are called PFS.

The Pythagorean fuzzy set was created to perfect the Intuitionistic Fuzzy Set (IFS) [64], and the difference between the Intuitionistic Fuzzy Set and the Pythagorean Fuzzy Set is that the condition of the Intuitionistic Fuzzy Set is $s(x) + o(x) \le 1$, while the condition of the Pythagorean Fuzzy Set is $s^2(x) + o^2(x) \le 1$. For example, the fuzzy number (0.6, 0.5) does not meet the conditions if the intuitive fuzzy set is used, but it is in line with the reality, and the Pythagorean fuzzy set is very suitable for avoiding the problem of black and white, and it is obvious that the definition of the Pythagorean fuzzy set has a wider range and is more in line with the uncertainty and unknowingness of current decision-makers in decision-making.

2.2.2. Define the Relationship between Pythagorean Fuzzy Numbers [65]

Assuming $p_1 = (x_1, s_1(x), o_1(x)), p_2 = (x_2, s_2(x), o_2(x)), x_1, x_2 \in X$. The relationships between p_1, p_2 are as follows:

(1) $p_1 \subseteq p_2 \Leftrightarrow \forall x \in X,\ s_1(x) \le s_2(x), o_1(x) \ge o_2(x)$;
(2) $p_1 = p_2 \Leftrightarrow p_1 \subseteq p_2, p_1 \supseteq p_2$;
(3) $p_1 \cap p_2 = \{\langle x,\ \min\{s_1(x), s_2(x)\},\ \max\{o_1(x),\ o_2(x)\}\rangle | x \in X\}$
(4) $p_1 \cup p_2 = \{\langle x,\ \max\{s_1(x), s_2(x)\},\ \min\{o_1(x), o_2(x)\}\rangle x \in X\}$;
(5) $p_1^a = \{\langle x, s_1(x), o_1(x)\rangle | x \in X\}$.

2.2.3. Define the Rules of Operation between Pythagorean Fuzzy Numbers

$p_1(s_1(x), o_1(x)), p_2(s_2(x), o_2(x))$ are two Pythagorean fuzzy numbers, then p_1, p_2 are operated as follows:

(1) $p_1 \oplus p_2 = \left(\sqrt{\frac{s_1^2+s_2^2}{1+s_1^2 s_2^2}}, \sqrt{\frac{o_1^2+o_2^2-o_1^2 o_2^2-o_1^2 s_2^2-s_1^2 o_2^2}{\sqrt{2-\left(o_1^2+o_2^2-o_1^2 o_2^2\right)}}} \right)$

(2) $p_1 \otimes p_2 = \left(\sqrt{\frac{s_1^2+s_2^2-s_1^2 s_2^2-s_1^2 o_2^2-o_1^2 s_2^2}{2-\left(s_1^2+s_2^2-s_1^2 s_2^2\right)}}, \sqrt{\frac{o_1^2+o_2^2}{1+o_1^2 o_2^2}} \right)$

(3) $\lambda p = \left(\sqrt{\frac{(1+s^2)^\lambda-(1-s^2)^\lambda}{(1+s^2)^\lambda+(1-s^2)^\lambda}}, \sqrt{\frac{(1-s^2)^\lambda-[1-(s^2+o^2)]^\lambda}{(2-o^2)^\lambda+o^{2\lambda}}} \right)$

(4) $p^\lambda = \left(\sqrt{\frac{(1-o^2)^\lambda-[1-(s^2+o^2)]^\lambda}{(2-s^2)^\lambda+o^{2\lambda}}}, \sqrt{\frac{(1+o^2)^\lambda-(1-o^2)^\lambda}{(1+o^2)^\lambda+(1-o^2)^\lambda}} \right)$

2.2.4. Define the Weighted Average Aggregation Operator [66]

Pythagorean fuzzy numbers are based on the will of the masses or experts, so there is far more than one fuzzy number. In order to aggregate many fuzzy numbers, scholars propose a variety of willingness aggregation methods suitable for different scenarios; this article is suitable for aggregation operators:

Assuming $\beta_j = p\left(s_{\beta_j}, o_{\beta_j}\right)$, $j = 1, 2 \ldots n$ is a fuzzy number, then the Pythagorean aggregate fuzzy operator:

$$\begin{aligned} PFWA(p_1, p_2, \ldots p_n) &= \omega_1 p_1 \oplus \omega_2 p_2 \oplus \ldots \oplus \omega_n p_n \\ &= p\left(\sqrt{1-\prod_{j=1}^{n}\left(1-\left(s_j\right)^2\right)^{\omega_j}}, \prod_{j=1}^{n}\left(O_j\right)^{\omega_j} \right) \end{aligned} \tag{2}$$

Thereinto, $\omega_j \geq 0, j = 1, 2, \ldots n$ and $\sum_{j=1}^{n} \omega_j = 1$.

2.3. Determination of Indicator Weights Based on the C-OWA Operator

Step 1: Form a collection of expert scores in descending order $(b_0, b_2, \ldots b_{n-1})$, n being the number of experts.

Step 2: Calculate the weighting vector $\alpha_{j+1} = \frac{C_{n-1}^j}{\sum_{n-1}^{j=0} C_{n-1}^k} = \frac{C_{n-1}^j}{2^{n-1}}$, $j = 0, 1, 2, \ldots n-1$ C_{n-1}^j denotes the number of combinations after removing j data from $n-1$ data, and $\sum_{j=0}^{n-1} \alpha_{j+1} = 1$;

Step 3: Calculate absolute weights $\varpi_i = \sum_{j=1}^{n-1} \alpha_{j+1} b_j$, thereinto $i \in [1, m]$, $\alpha_j \in [0, 1]$, $j \in [1, n]$, m indicates the number of indicators;

Step 4: Calculate relative weights $\omega_i = \frac{\varpi_i}{\sum_{i=1}^{m} \varpi_i}, i = 1, 2, 3, \ldots m$.

2.4. Calculate the Market Preference Value

The combined market preferences for each option are calculated as

$$A_m = {P_1}^{w_1} \otimes {P_2}^{w_2} \otimes \ldots \otimes {P_j}^{w_m} \tag{3}$$

2.5. Sort the Scoring Function

Arbitrary Pythagorean fuzzy numbers $p = (s, o)$; Hesitation $\pi = \sqrt{1-s^2-o^2}$; Defining the scorekeeping function $\varsigma = \frac{s^2-o^2}{1+\pi^2}$, $\varsigma \in [-1, 1]$. Accuracy functions $A = \frac{s^2+o^2}{1+\pi^2}$, $A \in [0, 1]$.

Sequencing principles:

(1) If $\varsigma_1 \succ \varsigma_2$, then $p_1 \succ p_2$;
(2) If $\varsigma_1 = \varsigma_2$, then:

① If $A_1 \succ A_2$, then $p_1 \succ p_2$
② If $A_1 = A_2$, then $p_1 \equiv p_2$

3. Results

3.1. Identification of Decision Options and Decision Indicators

The development of cities is inseparable from talent, and all major cities are striving to attract talent. Housing is a problem that must be solved for talent to develop off-site, and in 2010, long-term rental flats began to appear in the market for specific groups. According to the Seventh Population Census Report, the floating population is about 376 million, and the cross-provincial floating population is about 123 million, representing an increase of about 70% compared to the sixth census report, and the future trend of population mobility is rising year by year. The large population movement and the low willingness to purchase a home have led to the gradual expansion of the rental market in China, and it is only by catering to the needs of the majority of tenants that we can gain a firm foothold in the rental market. At present, China's long-term rental flats can be divided into real estate developers, real estate service providers, professional operators and hotel operators in terms of operating bodies, and centralized and decentralized flats in terms of distribution. This study determines which operating body operates the long-term rental flats that are more attractive to tenants' interests, which is conducive to the development of positive competition In the long-term rental flat industry and makes the long-term rental flat industry move steadily upwards. This paper classifies long-stay flats into four types of long-stay flats according to their operating entities: A1: Real estate developers, A2: Real estate service providers, A3: Professional operators and A4: Hotel operators. Eight indicators are selected to evaluate the popularity of the four types of long-stay flats among tenants. These are: C1, Housing quality. C2, Supporting facilities. C3, Property management. C4, Emotional value. C5, Decoration style. C6, Leasing convenience. C7, Risk resistance. C8, Ability to prevent social risk events, which are more important to tenants today. Table 3 explains the relevant concepts.

Table 3. Evaluation indicators.

Indicators	Explanation
C1: Housing quality	Soundproofing, light and ventilation, structural safety, privacy, and other basic conditions are the primary considerations of tenants
C2: Supporting facilities	While more conventional facilities such as hospitals, shopping malls and transport are important for tenants to consider, younger tenants are also looking for relaxation facilities such as sports and recreational areas
C3: Property management	Tenants who develop off-site are mostly there because they work, so there are high demands in terms of public health management, speed of problem solving, housekeeping and especially security
C4: Emotional value	Long-term flat tenants are mostly one-person households, so the relationship between neighbors, the attitude of logistical services and the humanistic care of the community are also points that should be considered, and the main body of the operation will be extended as a soft power
C5: Decoration style	The major operating entities have their own designs, such as the design of beds, chairs, cabinets, and moreover the division of the functional areas of the rooms. Nowadays, people are busy at work and do not have high requirements for the kitchen, but have higher requirements for the functional areas, such as the bedroom, with a high utilization rate; in addition, the tenants have more trendy requirements for the decoration materials, colors, etc.
C6: Leasing convenience	The rental process and the handling of deposits and the fulfilment of contracts are passed on by word of mouth, and the tenants' impressions of the operator influence second rentals or recommendations.
C7: Risk resistance	The frequent occurrence of "rental loans" and "lightning" incidents is due to the uncontrolled expansion of the operators, resulting in companies with low financial resilience and loss of market trust
C8: Ability to prevent social risk events	One-person tenants have higher requirements for safety, and negative incidents in the community affect tenants' trust in the operator

3.2. Regulating Expert Opinion to Form an Initial Decision Matrix

The development of long-stay flats is in a stage of rapid development, and there is no decision on the evaluation of long-stay flats operated by various operators today. The market for long-term rental flats is promising, and perceiving the market preference as soon as possible will allow the operators to adjust their strategies and prevent too many investment entities from blindly entering the long-term rental flat circuit, resulting in a waste of resources. In this paper, a decision-making team of five experts who are experienced in renting apartments, have a desire to rent for a long time and fit into the research group of this paper is selected, and the specific information of the team is shown in the table. The decision-makers are of comparable professional level, and all fit the research object of this paper, so the decision weights are assigned the same value. The personal rental experience of the decision-making team gives the satisfaction assessment terminology in the table, which converts the satisfaction assessment language into a Pythagorean fuzzy matrix (Table 4). Expert opinion is then aggregated according to Equation (2) (Table 5).

Table 4. Converts the satisfaction assessment language into a Pythagorean fuzzy matrix.

		C1	C2	C3	C4	C5	C6	C7	C8
e1	A1	(0.75, 0.10)	(0.75, 0.10)	(0.70, 0.15)	(0.55, 0.25)	(0.70, 0.15)	(0.75, 0.10)	(0.75, 0.10)	(0.80, 0.05)
	A2	(0.75, 0.10)	(0.70, 0.15)	(0.75, 0.10)	(0.75, 0.10)	(0.80, 0.05)	(0.75, 0.10)	(0.75, 0.10)	(0.75, 0.10)
	A3	(0.75, 0.10)	(0.70, 0.15)	(0.55, 0.25)	(0.80, 0.05)	(0.75, 0.10)	(0.75, 0.10)	(0.45, 0.40)	(0.55, 0.25)
	A4	(0.55, 0.25)	(0.45, 0.40)	(0.70, 0.15)	(0.30, 0.55)	(0.45, 0.40)	(0.80, 0.05)	(0.55, 0.25)	(0.70, 0.15)
e2	A1	(0.75, 0.10)	(0.80, 0.05)	(0.70, 0.15)	(0.55, 0.25)	(0.55, 0.25)	(0.75, 0.10)	(0.80, 0.05)	(0.70, 0.15)
	A2	(0.75, 0.10)	(0.70, 0.15)	(0.75, 0.10)	(0.80, 0.05)	(0.80, 0.05)	(0.75, 0.10)	(0.55, 0.25)	(0.55, 0.25)
	A3	(0.70, 0.15)	(0.75, 0.10)	(0.70, 0.15)	(0.70, 0.15)	(0.70, 0.15)	(0.75, 0.10)	(0.55, 0.25)	(0.70, 0.15)
	A4	(0.55, 0.25)	(0.70, 0.15)	(0.75, 0.10)	(0.55, 0.25)	(0.55, 0.25)	(0.75, 0.10)	(0.30, 0.55)	(0.75, 0.10)
e3	A1	(0.70, 0.15)	(0.70, 0.15)	(0.70, 0.15)	(0.70, 0.15)	(0.75, 0.10)	(0.75, 0.10)	(0.55, 0.25)	(0.70, 0.15)
	A2	(0.75, 0.10)	(0.70, 0.15)	(0.55, 0.25)	(0.75, 0.10)	(0.55, 0.25)	(0.55, 0.25)	(0.55, 0.25)	(0.70, 0.15)
	A3	(0.75, 0.10)	(0.70, 0.15)	(0.75, 0.10)	(0.75, 0.10)	(0.55, 0.25)	(0.75, 0.10)	(0.70, 0.15)	(0.55, 0.25)
	A4	(0.45, 0.40)	(0.55, 0.25)	(0.55, 0.25)	(0.45, 0.40)	(0.55, 0.25)	(0.30, 0.55)	(0.55, 0.25)	(0.75, 0.10)
e4	A1	(0.70, 0.15)	(0.70, 0.15)	(0.45, 0.40)	(0.55, 0.25)	(0.70, 0.15)	(0.75, 0.10)	(0.45, 0.40)	(0.45, 0.40)
	A2	(0.55, 0.25)	(0.55, 0.25)	(0.45, 0.40)	(0.55, 0.25)	(0.70, 0.15)	(0.70, 0.15)	(0.45, 0.40)	(0.70, 0.15)
	A3	(0.70, 0.15)	(0.70, 0.15)	(0.45, 0.40)	(0.55, 0.25)	(0.70, 0.15)	(0.70, 0.15)	(0.55, 0.25)	(0.70, 0.15)
	A4	(0.75, 0.10)	(0.70, 0.15)	(0.75, 0.10)	(0.70, 0.15)	(0.70, 0.15)	(0.75, 0.10)	(0.70, 0.15)	(0.70, 0.15)
e5	A1	(0.75, 0.10)	(0.75, 0.10)	(0.75, 0.10)	(0.70, 0.15)	(0.75, 0.10)	(0.70, 0.15)	(0.45, 0.40)	(0.70, 0.15)
	A2	(0.75, 0.10)	(0.70, 0.15)	(0.75, 0.10)	(0.70, 0.15)	(0.70, 0.15)	(0.75, 0.10)	(0.30, 0.55)	(0.75, 0.10)
	A3	(0.70, 0.15)	(0.70, 0.15)	(0.75, 0.10)	(0.70, 0.15)	(0.75, 0.10)	(0.75, 0.10)	(0.45, 0.40)	(0.70, 0.15)
	A4	(0.75, 0.10)	(0.70, 0.15)	(0.75, 0.10)	(0.70, 0.15)	(0.75, 0.10)	(0.75, 0.10)	(0.45, 0.40)	(0.75, 0.10)

Table 5. Aggregated expert opinion decision matrix.

	C1	C2	C3	C4	C5	C6	C7	C8
A1	(0.731318375, 0.117607902)	(0.743381917, 0.102383626)	(0.677599628, 0.168293272)	(0.620164576, 0.203798277)	(0.699531527, 0.141261725)	(0.740861276, 0.108447177)	(0.642420225, 0.18205642)	(0.692694649, 0.146507803)
A2	(0.720918549, 0.120112443	(0.676049974, 0.166134951	(0.677086362, 0.158489319)	(0.723675728, 0.113396658)	(0.726399706, 0.107056368)	(0.710469454, 0.130258554)	(0.558315268, 0.267707501)	(0.699531527, 0.141261725)
A3	(0.721346098, 0.12754245	(0.710916794, 0.138316187)	(0.664515562, 0.171877193)	(0.713353972, 0.122975474)	(0.699531527, 0.141261725)	(0.740861276, 0.108447177)	(0.555668735, 0.272406993)	(0.649582538, 0.184005481)
A4	(0.636785393, 0.190365394	(0.637384449, 0.202141161	(0.710469454, 0.130258554)	(0.577373415, 0.262125361)	(0.622078498, 0.206445896)	(0.716141018, 0.122423993)	(0.538777767, 0.290321228)	(0.731318375, 0.117607902)

Examples of calculations:

$$0.731318375 = \sqrt{1 - \prod_{j=1}^{n}\left(1 - (s_j)^2\right)^{\omega_j}} =$$
$$\sqrt{1 - [(1 - 0.75^2) * (1 - 0.75^2) * (1 - 0.75^2) * (1 - 0.7^2) * (1 - 0.75^2)]^{1/5}}$$
$$0.117607902 = \prod_{j=1}^{n}(O_j)^{\omega_j} = (0.1 * 0.1 * 0.15 * 0.15 * 0.1)^{1/5}$$

3.3. Calculation of Guideline Weights

The eight indicators in this paper were selected to determine what tenants want from a flat, but there are high and low requirements. Eight experienced tenants were selected to evaluate the importance of the indicators in this paper. The eight scoring positions are ranked in Table 6 and the relevant weights are calculated in Table 7.

Table 6. Criteria weighting scoring table (Sorted).

	Score 1	Score 2	Score 3	Score 4	Score 5	Score 6	Score 7	Score 8
c1	9.5	9	9	9	8.5	8	8	8
c2	9	8	8	8	8	8	7	7
c3	9.5	9.5	9	8.5	8	7.5	7	7
c4	10	9.5	9.5	9	8.5	8.5	8	8
c5	9.5	9	9	9	8.5	8	8	8
c6	8.5	8	8	8	7	7	7	7
c7	10	10	9	9	8.5	8.5	8.5	8
c8	10	10	9.5	9	9	8.5	8.5	8

Table 7. Calculation of weighting vectors, absolute weights, and relative weights.

	C1	C2	C3	C4	C5	C6	C7	C8
Weighted vectors	0.008	0.055	0.164	0.273	0.273	0.164	0.055	0.008
Absolute weights	8.641	7.945	8.250	8.836	8.641	7.504	8.809	9.027
Relative weights	0.147	0.136	0.141	0.151	0.147	0.128	0.150	0.154

Examples of calculations:

$$0.008 = C_{8-1}^{0}/2^{8-1}$$
$$8.641 = (1 * 9.5 * 7 * 9 + 21 * 9 + 35 * 8.5 + 21 * 8 + 7 * 8 + 1 * 8)/128$$
$$0.147 = 8.641/(8.641 + 7.945 + 8.250 + 8.836 + 8.641 + 7.504 + 8.809 + 9.027)$$

3.4. Calculation of Combined Preference Values and Scoring Function Ranking

Calculation of combined preference values and scoring function ranking based on Equation (3) (Table 8).

Table 8. Combined preference values and scoring functions.

	Combined Preference Values	Scorekeeping Functions
A1	(0.736, 0.044)	0.371
A2	(0.732, 0.048)	0.364
A3	(0.726, 0.053)	0.357
A4	(0.692, 0.053)	0.314

Examples of calculations:

$$(0.736,\ 0.044) = (0.731,\ 0.118)^{0.147} \otimes (0.743,\ 0.102)^{0.136} \otimes \ldots \otimes (0.639,\ 0.147)^{0.154}$$
$$0.371 = \frac{0.736^2 - 0.044^2}{1 + 1 - 0.736^2 + 0.044^2}$$

The results of the scoring function show that A1 > A2 > A3 > A4. This indicates that the long-term rental market run by property developers is more trusted by tenants in the current market.

4. Discussion

In the 2022 ranking of the influence of long-term rental flat brands, Loogwood Crown Apartments brand ranked first, and Vanke Pork Apartments brand ranked second; they are all part of the long-stay flat brands run by property developers. As real estate development enters the era of stock, market demand and policy guidance coupled with the changing perceptions of the tenant base make long-term rental flats the next windfall, as evidenced by the actions of major companies expanding into the long-term rental apartment sector; whoever takes the lead in capturing the market will have more potential for stable layout development. In this era of unhindered information transmission, the operating entity will be immediately informed of whether it does a good or bad job, so the operating entity should reasonably design long-term rental flats for the main customer groups. From the scoring of guideline weights, local youth rentals look more at the anti-risk ability of the operating entity, the quality of the housing, the ability to prevent social risks, and the ability to provide part of the emotional value of long-term rental flats. In these aspects, real estate long-term rental flats operated by real estate developers have the advantage of centralized management, centralized design and dedicated housekeepers, which put tenants' needs into practice and therefore are more preferred by tenants. Other operators should improve the quality of their flats in line with tenants' needs and cater to the needs of today's tenants so that their own brands are not eliminated.

The mindset of the tenant group is constantly changing as society progresses, and they are no longer satisfied with the simple need for shelter from the elements when renting. In addition to the conventional indicators of housing quality, supporting facilities, property management and the convenience of the rental procedure, this paper newly adds the provision of emotional value, the ability of the operating body to guard against economic risks, the ability to guard against social risks and the style of decoration, which have emerged in recent years as indicators for determining the demand for rental housing and divide the existing long-term rental flats in the market according to the operating body into real estate developers, real estate service providers, professional operators and hotel operators. The results of this study show that long-stay flats operated by real estate developers are more popular in the market, which gives real estate developers a reason to continue to expand their long-stay flat business, gives all operators a direction to work towards, and gives tenants confidence in their rental properties. The shortcomings of this paper are that the number of participants in the study of market perceptions is small and the indicators are not sufficiently detailed. Subsequent studies will be refined to examine changes in rental demand by looking at the strengths of each operating entity.

5. Conclusions

This paper examines the popularity of long-term rental operators in the Chinese market. The findings show that long-term rental apartments run by real estate developers are the most popular, followed by real estate service providers, then professional operators and hotel operators. In evaluating popularity, eight indicators were created and scored by tenants to identify the points that are more important to tenants today, such as the ability to prevent risk, resilience and the ability to provide emotional value, in addition to the quality of the property and the style of decoration. Operators can use the results to improve the competitiveness of their brands in the market, while other investors who want to enter the long-term rental market should consider whether they are able to meet the eight evaluation criteria, and if not, there is no need to increase the number of long-term rental apartments blindly.

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