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Establishing a Legal Risk Prevention System for Housing Lease Contracts in the Digital Age

Yu Xiong[1,*]
[1] Guangdong Institute for International Strategies, Guangdong University of Foreign Studies, Guangzhou, Guangdong, 510420, China
Corresponding authors: (e-mail: xiongyu19952025@126.com).

Abstract Under the wave of digitization, the legal risks of housing lease contracts are characterized by complexity and high frequency. Based on the data analysis of national housing lease dispute cases, it is found that the proportion of disputes in economically developed regions reaches 67.14%, and 89.18% of the cases are directly related to the loopholes of contract terms. Through the Delphi method and questionnaire survey, 21 risk assessment indicators of 6 categories are established, and the ISM model is used to determine the weights of the indicators. The cloud model is further integrated to quantitatively evaluate the risk of a contract instance, and the risk is characterized by three-dimensional parameters of expected value (Ex), entropy (En) and hyperentropy (He). The system reliability and validity test shows that the Cronbach's α coefficient is 0.876, and the KMO values are all > 0.8. Among them, B3 contract subject risk is the core, B1 policy and legal risk and B4 core clause risk are next, and B2 market and financial risk has the lowest weight of only 0.120. The finalized comprehensive evaluation cloud parameter of the project is (2.172,0.737,0.065), and cloud similarity calculation shows that the overall risk level is medium-low risk, with similarity 0.7137. Among them, C33 housing legality risk is medium risk (Ex=4.028, En=1.121). Finally, based on the four aspects of strengthening the qualification of the subject and the verification of the legality of the house, dynamically monitoring the policies and regulations and optimizing the core terms, constructing a full-process digital performance management system, and establishing a collaborative risk warning and response mechanism, a corresponding risk prevention strategy for housing leasing is established.

Index Terms housing lease contract, legal risk assessment, ISM, cloud model, indicator weights

I. Introduction

With the deepening of reform and opening up and the continuous improvement of the economic level, in order to supplement the urban labor resources, the Chinese government has been deeply promoting the construction of urbanization level, and by the end of 2024, China's urbanization level has been close to 65%, and it is expected that by the middle of this century, China's urbanization level will reach about 70% [1]. By then, China's urbanization level will reach the urbanization level of developed countries. The increasing level of China's urbanization has promoted the flow of rural human resources to cities [2]. The large gathering of urban population will inevitably lead to the emergence of urbanization clusters on a large scale, and since not all people who move from rural to urban areas have enough capital to own their own houses or own their own business when they first enter the city, these people have the demand for leasing houses [3]-[5]. Market demand guides consumer behavior, the housing rental market is bound to expand with the increasing demand, which leads to the imbalance of housing as a social resource, people who do not have the economic strength to own the property rights of the house can only solve the related living and business housing needs by means of leasing, urbanization promotes the development of the social economy, and at the same time expands the scale of the housing rental market and demand [6]-[9].

Housing lease as a contractual economic behavior, under normal circumstances, the signing of the housing lease contract is the lessee and the lessor of housing in the principle of equality and voluntariness, fairness and reasonableness of the form of oral agreement or written contract to fix the rights and obligations of both parties [10]-[12]. Then, each abide by and fulfill the terms of the contract until the end of the contract period, as long as the lease contract parties in their respective rights and obligations within the scope of consciously exercising the corresponding rights and responsibilities, the lease contract parties generally will not be due to the reasons of the lease contract legal disputes [13]-[15]. However, in the seemingly simple and actually very complex housing lease this behavior process not only exists due to the lessor and the lessee to fulfill the housing lease contract to the lessor to bring the legal risk, but also exists due to a variety of other uncertainties to the lessor's rental behavior to bring the legal risk [16]-[18].

In terms of understanding the dynamics of residential tenancy relationships, scholars generally agree that tenants are the weaker party in such relationships. This is primarily because landlords are perceived to exploit their advantageous position to restrict tenants' rights, impose additional obligations on them, and create an imbalance in the rights and obligations outlined in lease agreements [19]-[21]. Literature [22] conducted an in-depth examination of Australia's housing lease regulations and found that current regulations fail to adequately address risks related to finance, eviction, and disputes, thereby leaving tenants in a disadvantaged position in housing lease relationships. It recommends revising the consumer protection framework to improve housing equity. Literature [23] conducts an in-depth study of Pakistan's current housing rental regulations, pointing out the potential of rental housing as an alternative to homeownership. The government should strengthen legal protections for tenants and establish safety nets to make rental housing a viable option. Literature [24] examines the increasing number of temporary rental contracts in the Netherlands, a trend similar to the Anglo-American model where tenants' rights are weakened, and proposes a research agenda to address the instability and legal risks associated with such forms in the housing market. Literature [25] analyzes the legal risk factors in Malaysia's current “rent-to-own” (RTO) policy, pointing out that uncertainty and the presence or absence of guarantors are important legal risk factors in RTO programs. In cases where tenants decide not to purchase the property, this may lead to an oversupply of housing and vacant properties. Literature [26] found in a study of Ghana's housing market that landlords engage in illegal practices of collecting advance rent during the rental process. However, due to transaction costs, tenants and landlords can still reach mutually beneficial agreements outside the legal framework. This, however, also leads to a significant increase in legal risks for both parties.

Although both legislation and public awareness have traditionally focused on protecting tenants' rights, in the actual rental market, landlords—as the primary participants in the housing rental market and providers of housing resources—face risks of rights infringement that are no less significant than those faced by tenants. If a landlord's rights are infringed upon, the resulting losses often exceed those incurred by tenants [27]-[29]. For example, if a tenant causes the destruction of a property due to improper use, or if a landlord's business operations result in the landlord being held liable for compensation to a third party, such situations can lead to losses for the landlord that far exceed the rental income they receive from the property. While the law grants landlords corresponding rights to seek compensation [30], in judicial practice, the effectiveness of such compensation claims is often poor [31], [32]. As such, research on the legal risks associated with residential lease agreements holds significant practical significance for protecting the rights of both landlords and tenants. It not only guides tenants in self-protecting their rights but also promotes the further development of the residential lease market.

The study forms a set of risk prevention and control closed loop by integrating the construction of indicator system, ISM weight determination and cloud model evaluation to provide scientific decision-making support for lessors, lessees, regulatory agencies and digital platforms in contract formation, performance, dispute prevention and resolution. Firstly, based on the in-depth analysis of the lessor's legal risk, combined with the empirical analysis of the geographical distribution and case distribution of the national housing lease dispute cases, we systematically sort out the root causes and characteristics of the risk. On this basis, a legal risk assessment index system of housing lease contract is constructed, which contains 6 first-level indicators (policy and legal environment risk, market and financial risk, contract subject risk, core clause risk, performance management risk, and external environment risk) and 21 second-level indicators, and its applicability and reliability are verified through a questionnaire survey. The Interpretive Structural Model (ISM) method is then introduced to explain its principle of analyzing the hierarchical dependency relationship among risk factors through the steps of establishing the adjacency matrix, calculating the reachability matrix, and dividing the priority of elements. The established indicator system is processed to scientifically determine the relative weights of risk indicators at all levels in the overall risk structure. Finally, the cloud model theory is introduced to elaborate the method of constructing the evaluation level cloud scale, using the inverse cloud generator to transform the expert scores into the numerical features (expectation, entropy, and superentropy) of the indicator layer cloud, and synthesizing the evaluation cloud of the guideline layer based on the weights. The forward cloud generator generates the evaluation cloud map and compares it with the cloud scale to realize the intuitive and dynamic visual evaluation of the risk state and effectively deal with the ambiguity and randomness in the evaluation process.

II. Construction of a system for identifying and evaluating legal risks in housing lease contracts

II. A. Overview of legal risks in housing leases

II. A. 1) Legal risks for housing tenants

In people's general consciousness, the lessor's legal risk is relatively low, the risk lies only in the lessee can not pay rent on time, the risk of lease income can not be realized, but the actual situation of the lessor's risk is far from

people imagine so simple, because the lessor's behavior is not seemingly on the surface of a way of exchange, behind the scenes also involved in many other aspects of the reason, it is the existence of a variety of factors, resulting in the lessor's legal risk is also various. The lessor's legal risk is also various, through the analysis of the lessor's legal risk, the lessor's legal risk is roughly summarized as follows: the legitimacy of the leased premises risk, the legal risk caused by incomplete lease contract agreement, the lessor's breach of contract risk, the lessee's breach of contract risk, the lessor's special risk of the different leasing modes.

II. A. 2) Basic information on housing lease contract dispute cases

From the geographical distribution of housing lease disputes and the distribution of cases to summarize the basic situation of housing lease disputes, a deeper analysis of the sources of disputes arising from the lease contract, in order to better articulate the legal risks of the lessor's lease contract.

(1) Geographical Distribution

The statistical table of case data of the top ten regional provinces of housing lease cases is shown in Figure 1.

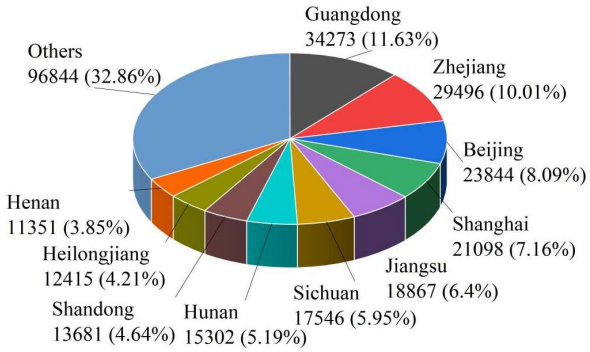

Figure 1: Top 10 regions for housing lease disputes cases

It can be seen that the geographical distribution of the number of cases of housing lease disputes in China is extremely uneven, and the high incidence of cases related to housing lease contracts is positively correlated to the degree of economic development of its region, i.e., the more economically developed it is, the higher the number of cases of disputes over housing lease contracts tends to be, and the top ten cases of cases of disputes over housing lease contracts accounted for 67.14% of the overall number of cases relating to all disputes over housing lease disputes, among which the traditionally Economically developed regions (top five: Guangdong Province, Zhejiang Province, Beijing Municipality, Shanghai Municipality, Jiangsu Province) accounted for 43.29% of the total number of housing lease disputes. It can be seen that the more economically developed provinces and cities (densely populated areas), the more prominent the contradiction between supply and demand for housing, the more prosperous the housing lease transactions, the higher the frequency of leasing occurs, and often produce disputes may be more.

(2) Distribution of cases

The types and numbers of case distribution are shown in Figure 2.

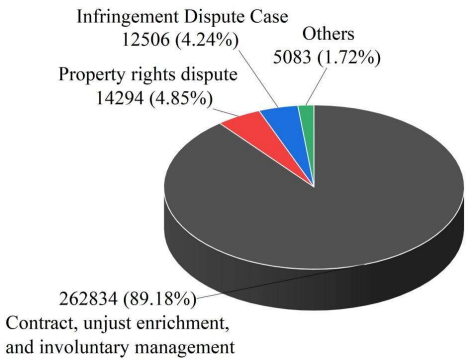

Figure 2: DistriCution of case causes Cy type and quantity

From the distribution of the cause of the case, due to “contract, unjust enrichment, causeless management” occupies the proportion is absolute, the number of cases amounted to 262834, accounting for 89.18%, which can be seen that the lease contract type of litigation cases accounted for the bulk of the lease disputes, in addition to other related to the lease of the housing related tort disputes and property rights disputes In addition, there are also tort disputes and property disputes related to housing leases, the number of cases for both of which are 14,294 and 12,506 respectively, accounting for 4.85% and 4.24% of the total cases. Tort disputes and property disputes may extend to the right to use the house in the lease contract and the right of first refusal of the house and other matters, which are stipulated and constrained by the lease contract, in short, in the case of disputes over the lease of the house, the cause of the case is directly pointing to the lease contract or indirectly involved in the contents of the lease contract, most of them are related to the lease contract.

II. B. Construction of the Legal Risk Assessment Indicator System for Housing Lease Contracts

After systematically sorting out the main types of risks faced by lessors, and through the geographical and case distribution data of dispute cases nationwide, the actual root causes and characteristics of the risks are deeply analyzed. On this basis, in order to effectively quantify and manage these risks, the article will focus on the whole life cycle of the contract, construct a set of scientific and systematic legal risk assessment index system of housing lease contract, and use the questionnaire survey method to verify and analyze the index system more deeply.

II. B. 1) Initial construction of the legal risk assessment index system for housing lease contracts

From focusing on the legal effect of the contract itself, the legitimacy of the terms, obstacles to fulfillment and dispute resolution and other key dimensions to start the construction of the legal risk assessment system of the housing lease contract, the legal risk assessment system of the housing lease contract as shown in Table 1.

Table 1: Housing Lease Contract Legal Risk Assessment System

Target Layer	Risk Classification (Primary Indicators)	Risk Factors (Secondary Indicators)
Legal Risk Assessment of House Rental Contracts	B1: Policy and Legal Environment Risks	C11: Adjustment of local leasing management policies
		C12: Changes in tax policies
		C13: Risks associated with changes in the relevant legal framework
	B2: Market and Financial Risks	C21: Interest rate risk
		C22: Liquidity risk
		C23: Inflation risk
		C24: Market supply and demand risk
		C25: Risk from industry competitors
	B3: Contract Subject Risk	C31: Risk of the landlord's qualifications
		C32: Risk of the tenant's creditworthiness
		C33: Risk of the legality of the property
		C34: Risk of the property condition
	B4: Key Clause Risks	C41: Risk of rent and deposit terms
		C42: Risk of maintenance responsibility
		C43: Risk of termination and breach of contract
		C44: Risk of special terms
	B5: Contract Execution Management Risks	C51: Risk of contract modification
		C52: Risk of evidence preservation
		C53: Risk of agency and delegation
	B6: External Environmental Risks	C61: Risk of force majeure
		C62: Risk of third-party infringement

Table 1 has established a systematic legal risk assessment system for housing lease contracts, which includes 6 first-level indicators and 21 second-level indicators, covering the key risk dimensions throughout the entire contract life cycle. B1 policy and legal environment risks cover local policy adjustments, changes in tax policies, and alterations in the legal system. B2 market and financial risks include interest rate risk, liquidity risk, inflation risk, market supply and demand risk, and industry competition risk. The subject risks of Contract B3 focus on the qualifications of the lessor, the credit of the lessee, the legality of the house and the condition of the house. The

core terms of B4 involve risks related to rent and deposit terms, maintenance liability, termination and breach of contract liability, and special terms. B5 performance management risks include contract modification, evidence preservation and principal-agent risks. B6 External environmental risks cover force majeure and third-party infringement.

This system, through a hierarchical structure, provides a logically clear framework for risk assessment, with particular emphasis on the control of policies, subject qualifications, and core terms.

II. B. 2) Validation of the risk assessment indicator system based on the questionnaire method

In order to ensure the objectivity and scientificity of the indicator system, the questionnaire survey method will be used to verify the constructed risk assessment indicators again. Based on the legal risk assessment system of housing lease contract constructed in Table 1, a questionnaire is designed and a survey is conducted on the practitioners in the field involved to verify the degree of acceptance of the risk indicators. The questionnaire adopts Likert scale and sets up 1-5 scoring method (5-very important; 4-quite important; 3-generally important; 2-unimportant; 1-very unimportant), and the respondents are asked to score the importance of each of the 21 indicators in the system of risk assessment indicators.

Taking the practitioners who have certain working experience in the fields of real estate, housing leasing, contract law, etc., and have certain understanding of housing leasing contract law as the survey object, the survey was conducted by issuing questionnaires online on Questionnaire Star platform, supplemented by emails and telephone communication, etc. A total of 200 questionnaires were issued, and 187 questionnaires were recovered, with the recovery rate of 93.5%.

Descriptive statistical analysis of the scoring results of the 21 indicators in the valid questionnaire, respectively, the mean, standard deviation, minimum and maximum values of the indicators were calculated, and the results are shown in Table 2, so as to analyze the degree of acceptance of the interviewees for the risk assessment indicators.

Table 2: Mean score, standard deviation, minimum and maximum value of indicators

Indicators	M	SD	MIN	MAX
C11	4.46	1.36	2	5
C12	4.28	1.03	1	5
C13	4.40	1.13	1	5
C21	3.61	0.94	1	5
C22	3.78	1.05	1	5
C23	3.48	1.01	1	5
C24	3.77	1.14	1	5
C25	3.58	1.12	1	5
C31	4.39	1.29	1	5
C32	4.34	0.91	1	5
C33	4.11	0.92	1	5
C34	4.29	1.15	1	5
C41	4.56	1.04	2	5
C42	4.17	0.94	1	5
C43	4.19	1.19	1	5
C44	4.02	1.26	1	5
C51	4.37	1.34	2	5
C52	3.85	1.44	1	5
C53	3.80	1.32	1	5
C61	4.04	1.25	1	5
C62	3.68	1.12	1	5

It can be found through Table 2 that the mean value of the scores given by the respondents to the indicators in the risk assessment indicator system constructed in this paper is above 3.5, and it can be assumed that the six categories of risks and 21 risk indicators in the indicator system can reflect the risks that may be encountered in the law of housing lease contract to a certain extent.

Among them, the risk of core terms is most emphasized, with the highest mean value of 4.56 for C41 Rent and deposit terms, indicating that practitioners regard it as the most critical risk. Meanwhile, C11 Local Policy Adjustment has a mean value of 4.46, indicating that policy and subject risks are highly sensitive; C31 Lessor Qualification and

C32 Lessee Credit both exceed 4.3 points, highlighting the importance of subject review. Market risk is less recognized, with C23 Inflation having the lowest mean value of 3.48 and C25 Industry Competition scoring only 3.58, reflecting that the risk of market fluctuation is relatively weakened.

In general, practitioners are most concerned about the risks directly related to contract validity such as rent terms, policy changes and subject qualification, and are less sensitive to macro market risks. The applicability of the legal risk indicator system for housing lease contracts constructed in the article is verified, i.e., the risk assessment indicator system is considered to be relatively scientific.

II. B. 3) Reliability and validity analysis

Reliability analysis and validity analysis, as the first part of questionnaire analysis, can better test the data quality to ensure that the results of the questionnaire survey have good reliability and validity. Reliability analysis refers to the reliability of the questionnaire itself, which is used to assess whether the same measurement tool can produce similar results at different times, on different occasions, by different evaluators or between different versions.

(1) Reliability Analysis

In order to assess the reliability level of the questionnaire, the subjective questions are screened, and descriptive statistics such as age, gender, and education level are deleted from the questionnaire; then the organized questionnaire data are uploaded to SPSSAU, and “Questionnaire Research - Reliability” is selected; then the questionnaire indexes are selected from the items and analyzed by Cronbach's alpha coefficient method, and finally the results are obtained. Then the indexes of the questionnaire were selected from the items and analyzed by Cronbach's coefficient method, and finally the results of the questionnaire reliability analysis are shown in Table 3.

Table 3: The results of the questionnaire reliability analysis

Primary indicator	Secondary indicator	CITC	The deleted α coefficient	Cronbach α	Overall Cronbach's α coefficient
B1	C11	0.696	0.878	0.814	0.876
	C12	0.527	0.832		
	C13	0.583	0.808		
B2	C21	0.467	0.775	0.785	
	C22	0.579	0.765		
	C23	0.424	0.885		
	C24	0.488	0.826		
	C25	0.475	0.858		
B3	C31	0.721	0.829	0.833	
	C32	0.684	0.765		
	C33	0.569	0.698		
	C34	0.594	0.775		
B4	C41	0.729	0.876	0.842	
	C42	0.694	0.862		
	C43	0.455	0.822		
	C44	0.626	0.812		
B5	C51	0.717	0.859	0.825	
	C52	0.516	0.816		
	C53	0.620	0.857		
B6	C61	0.569	0.835	0.806	
	C62	0.494	0.756		

From the results of reliability analysis, it can be seen that the questionnaire contains 21 items, the alpha Cronbach's coefficient of the six dimensions is above 0.7, and the overall alpha Cronbach's coefficient is 0.876. Meanwhile, for the “alpha coefficient of the deleted items”, the reliability coefficient does not increase significantly after deletion of any item, which suggests that there is no need to delete the items in the questionnaire. This indicates that there is no need to delete any of the items. Therefore, the reliability coefficient value of the questionnaire is reliable, which indicates that the data collected in this study have strong reliability and consistency, and can provide reliable data support for the next study.

(2) Validity analysis

Validity is validity, is the degree to which the measurement results can respond to the actual results, the higher the value of validity, that is, the more the measurement results can reflect the true performance of the object under

test. In this paper, the structural validity test of the questionnaire will use the Bartlett's test of sphericity and the KMO test, respectively, to test the indicators of each variable.In the KMO test, the KMO statistic takes the value of the range of (0,1).The closer the value of KMO is to 1, it means that the correlation between the variables is stronger, and the weaker the biocorrelation is, and the more suitable for doing the factor analysis of the original variables.

The validity of the questionnaire was tested through the validity analysis function of SPSS software, and the test results are shown in Table 4.

Table 4: The validity test results of the questionnaire

Variable	KMO	Bartlett's spherical test approximate chi-square value	P
B1	0.983	3612.052	0.000
B2	0.858	384.669	0.000
B3	0.933	682.096	0.000
B4	0.957	1107.358	0.000
B5	0.922	516.452	0.000
B6	0.904	468.759	0.000

The results of the KMO test show that the overall KMO value of the questionnaire and each classified risk element are all greater than 0.8, and the overall KMO test of the questionnaire is qualified. Meanwhile, the results of the Bartlett's sphericity test show that the significance P-values of the questionnaire as a whole and each classification element are all 0.000<0.05, demonstrating significance at the level and rejecting the null hypothesis. This indicates that there is a correlation among the variables of each risk category, and the entire questionnaire has good structural validity.

III. Determination of the weights of the ISM-based legal risk indicator system for housing lease contracts

Chapter 2 verifies the applicability of the legal risk assessment indicator system of housing lease contract through questionnaire survey and confirms the reliability of the data. In order to more deeply understand the internal logical relationship between these risk factors and scientifically determine the relative importance (i.e., weight) of each indicator in the overall risk structure, this chapter introduces the Interpretative Structural Model (ISM) method. Firstly, the basic principles and operational steps of ISM will be elaborated, and then the method will be applied to calculate the weights of risk indicators at all levels, which will provide a quantitative basis for the subsequent construction of risk evaluation models and the formulation of prevention and control strategies.

III. A. Principles and Steps of the Interpretative Structural Modeling (ISM) Approach

Interpretive Structural Modeling (ISM) is a structured technical model, which is one of the very commonly used methods in modern systems engineering. Through the use of computer technology, combined with the rich experience accumulated by people in the process of practice, it splits a more complex system and constructs an intuitive ladder-type structural model, so as to derive the interrelationships between the basic elements in the element set.

By utilizing the interrelationships between elements, ISM can sort out and explain the internal structure of many static systems with messy and discrete relationships, and can deal with the problems of many variables and complex structural relationships, with a wide range of applications. In this paper, in the risk assessment process of the REITs financing project of real estate enterprise type long term rental apartments, due to the large number of risk factors, the interrelationship between them needs to be sorted out and interpreted, so the interdependence between the risk factors can be obtained through the ISM method.

The steps of ISM method work as follows: determine the relationship between the factors and construct the factor relationship adjacency matrix; establish the reachability matrix and relationship matrix according to the factor relationship table; process the reachability matrix and get the hierarchical structure relationship between the factors based on the processed sub-matrix; finally, the ISM hierarchical structure model is constructed based on the hierarchical structure relationship. The specific calculation formula is as follows

III. A. 1) Creating an adjacency matrix

Neighborhood matrix represents the direct influence between the elements, mainly through the elements of two by two comparison, to determine whether there is a mutual relationship between the elements, the construction of the neighbor matrix $A=[a_{ij}]_{n\times n}$, a_{ij} is defined as follows: if F_i has an influence on the case of F_j, the matrix element

a_{ij} is 1; element F_i has no influence on the case of F_j, the matrix element a_{ij} is 0 (the element's influence on its own is recorded as 1) that is:

$$a_{ij} = \begin{cases} 1 & F_i \text{ has an impact on } F_j \\ 0 & F_i \text{ has no impact on } F_j \end{cases} \tag{1}$$

III. A. 2) Computing the reachability matrix

Since the adjacency matrix will be affected by subjective factors in the process of establishment, it is also necessary to carry out arithmetic operations on the adjacency matrix A to obtain the reachability matrix and reflect the relationship existing between the indicators through the elements in the reachability matrix. After the adjacency matrix A is determined, according to the logic of Boolean algebra operation, the n power operation of $(A+I)$ is carried out until M can satisfy the following formula:

$$\begin{aligned} M &\equiv (A+I)^{n+1} = (A+I)^n \\ &\neq \ldots \neq (A+I)^3 \neq (A+I)^2 \neq A+I \end{aligned} \tag{2}$$

The reachability matrix M can be expressed as:

$$M = \begin{bmatrix} m_{11} & m_{12} & \ldots & m_{1n} \\ m_{21} & m_{22} & \ldots & m_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ m_{n1} & m_{n2} & \ldots & m_{nn} \end{bmatrix} \tag{3}$$

III. A. 3) Prioritization of elements

Through the reachability matrix M, the elements that can be reached in F_i are grouped into the same set, which is called reachable set $P(F_i)$; and all the elements that can be reached in F_i are grouped into the same set, which is called prior set $Q(F_i)$, and the specific formula is as follows:

$$P(F_i) = \left\{ F_j \middle| m_{ij} = 1 \right\} \tag{4}$$

$$Q(F_i) = \left\{ F_j \middle| m_{ij} = 1 \right\} \tag{5}$$

When $P(F_i) \cap Q(F_i) = P(F_i)$, the corresponding elements are selected, which are the first level elements, and the rows and columns where the first level elements are located are deleted from the reachability matrix M to obtain the new reachability matrix M^*, and then the above operation is repeated for the reachability matrix M^* to obtain the elements of each level in turn.

III. B. Determination of indicator weights

Based on the explanatory structural model ISM to derive the interrelationship between the basic elements in the legal risk assessment system of the housing lease contract, after a series of calculations to establish the weight of the indicators as shown in Table 5.

Table 5: The weight of the legal risk assessment system for housing lease contracts

Primary indicator	Weight	Secondary indicator	Weight	Composite weight	Sort
B1	0.223	C11	0.336	0.075	3
		C12	0.341	0.076	2
		C13	0.323	0.072	5
B2	0.120	C21	0.250	0.030	17
		C22	0.175	0.021	20
		C23	0.150	0.018	21
		C24	0.233	0.028	18
		C25	0.192	0.023	19
B3	0.236	C31	0.331	0.078	1
		C32	0.267	0.063	6
		C33	0.186	0.044	11
		C34	0.216	0.051	10
B4	0.191	C41	0.387	0.074	4
		C42	0.220	0.042	12
		C43	0.215	0.041	13
		C44	0.178	0.034	15
B5	0.121	C51	0.430	0.052	8

		C52	0.281	0.034	16
		C53	0.289	0.035	14
B6	0.109	C61	0.523	0.057	7
		C62	0.477	0.052	9

Among the first-level indicators, B3 Contract Counterparty Risk has the highest weighting at 0.236, making it the most critical component in overall risk management. Next are B1 Policy and Legal Environment Risk (0.223) and B4 Core Terms Risk (0.191). B2 Market and Financial Risk (0.120) and B5 Performance Management Risk (B5, 0.121) have similar and relatively low weights, while B6 External Environment Risk has the lowest weight, at just 0.109. This indicates that in the digital age, the focus of risk management lies in the qualifications and creditworthiness of contract participants, policy compliance, and the rigor of the contract terms themselves.

The most critical factor in the secondary indicators is the C31 lessor qualification risk, with a combined weight of 0.078, highlighting the centrality of the legitimacy of the lessor's subject. This is closely followed by C12 local lease management policy adjustment risk (0.076) and C11 tax policy change risk (0.075), highlighting the significant impact of changes in the policy environment on leasing contracts. Indicators under Market and Financial Risk generally ranked low, with C23 Inflation Risk (0.018) and C25 Industry Competitor Risk (0.023) as well as C22 Liquidity Risk (0.021) being the three indicators with the lowest combined weights. This suggests that practitioners are relatively less sensitive to the risk of macroeconomic fluctuations than to risks directly related to contract validity and subject qualification.

This weighting system clearly reveals that subject qualification, policy changes and core rent terms are absolute priority risk points in the prevention and control of legal risks in housing lease contracts. And although the market financial risk category contains multiple factors, its overall and individual factors are significantly less influential than the first three categories of risk.

IV. Research on legal risk evaluation of housing lease contracts based on cloud modeling

The weights of each risk indicator have been scientifically quantified through the ISM model. In order to transform this weighting system into an operational risk evaluation tool, Chapter 4 introduces the ISM-Cloud model coupling method to construct a dynamic risk assessment framework, realizing the accurate grading and visualization of the risk of housing lease contracts.

IV. A. Modeling the Cloud

IV. A. 1) Constructing a cloud scale of evaluation levels

Set five evaluation levels as the evaluation of the legal risk of housing lease contracts, specifically low risk, low risk, medium risk, high risk, high risk, corresponding to the range of values of the domain were $[0,2]$, $[2,4]$, $[4,6]$, $[6,8]$, $[8,10]$. According to the range of values of the evaluation levels, the data will be converted to the corresponding cloud digital features parameters through the formula, respectively, the expected value Ex, entropy En and super entropy He, the specific formula is as follows:

$$E_x = \left(V_{\max} + V_{\min}\right)/2 \tag{6}$$

$$E_n = \left(V_{\max} - V_{\min}\right)/6 \tag{7}$$

$$H_e = k \tag{8}$$

Note: k is a constant, superentropy He is generally taken to be 0.1.

IV. A. 2) Determination of the evaluation cloud for indicator layer indicators

Based on the above constructed evaluation index cloud scale, after obtaining the experts' scores on the evaluation indexes, they are transformed into three cloud numerical eigenvalues of the cloud model according to the inverse cloud generator, and the calculation formulas are shown below:

(1) Calculate the sample expectation value:

$$Ex = \bar{X} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{9}$$

Note: x_i is the rating of each expert and Ex is the sample expectation.

(2) Calculate the sample variance:

$$S^2 = \frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \bar{X}\right) \tag{10}$$

Note: S^2 is the sample variance.

(3) Calculate the entropy of the cloud droplet:

$$En = \sqrt{\frac{\pi}{2}} \times \frac{1}{n} \sum_{i=1}^{n} \left| x_i - Ex \right| \tag{11}$$

Note: En is the entropy of the cloud droplet.

(4) Calculate the superentropy of the cloud droplet:

$$He = \sqrt{\left| S^2 - En^2 \right|} \tag{12}$$

Note: He is the superentropy of the cloud droplet.

IV. A. 3) Determination of evaluation clouds for normative level indicators

On the basis of calculating the cloud digital eigenvalues of the indicators of the indicator layer, the cloud digital eigenvalues of the indicators of each criterion layer are calculated sequentially based on the following formula:

$$\begin{cases} Ex = \dfrac{W_1}{W_1 + W_2 + \cdots + W_n} Ex_1 + \dfrac{W_1}{W_1 + W_2 + \cdots + W_n} Ex_2 + \cdots + \dfrac{W_1}{W_1 + W_2 + \cdots + W_n} Ex_n \\ En = \dfrac{W_1^2}{W_1^2 + W_2^2 + \cdots + W_n^2} En_1 + \dfrac{W_2^2}{W_1^2 + W_2^2 + \cdots + W_n^2} En_2 + \cdots + \dfrac{W_n^2}{W_1^2 + W_2^2 + \cdots + W_n^2} En_n \\ He = \dfrac{W_1^2}{W_1^2 + W_2^2 + \cdots + W_n^2} He_1 + \dfrac{W_2^2}{W_1^2 + W_2^2 + \cdots + W_n^2} He_2 + \cdots + \dfrac{W_n^2}{W_1^2 + W_2^2 + \cdots + W_n^2} He_n \end{cases} \tag{13}$$

The cloud digital eigenvalues of the guideline layer indicators are sequentially input into the forward cloud generator, programmed using MATLAB software, and the evaluated cloud diagrams of the guideline layer indicators are generated, which are plotted one by one in the cloud scale diagrams, and compared with the cloud scale diagrams, respectively, and the generated cloud diagrams.

IV. B. Evaluation of Example Risks of Housing Lease Contracts Based on Cloud Modeling

Based on the constructed cloud model evaluation system, a real house lease contract is further taken as the research object, and its legal risk is evaluated and researched by example through expert scoring and cloud parameter calculation to empirically verify the model applicability.

IV. B. 1) Determination of the standard cloud

Experts are invited to divide the risk level of legal risks of housing lease contracts and their corresponding intervals according to the specifics of the contract as follows: low risk [0, 2), with the standard cloud parameter of (1,0.851,0.1); medium-low risk [2, 4), with the standard cloud parameter of (3,0.851,0.1); medium risk [4, 6), with the standard cloud parameter of (5,0.851,0.1); medium high risk [6, 8), the standard cloud parameter is (7,0.851,0.1); high risk [8, 10], the standard cloud parameter is (9,0.851,0.1). After a number of value experiments based on the combination of interval fuzziness, k is taken as 0.1. The standard cloud of legal risk of housing lease contract is shown in Figure 3.

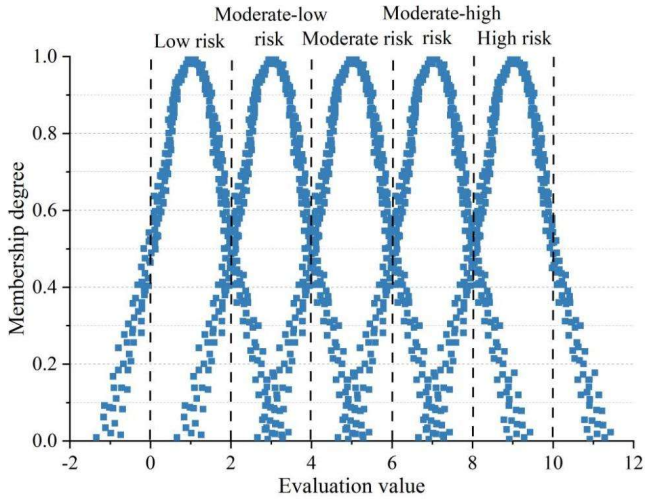

Figure 3: The standard of legal risks in housing lease contracts

IV. B. 2) Determination of the evaluation cloud for each project indicator and the comprehensive evaluation cloud

Based on the legal risk evaluation index system of the housing lease contract constructed in this paper, the above experts were invited to score the risk rating of the secondary indicators of the project in accordance with the risk level interval. The expert rating scoring results are organized. Then calculate the parameter eigenvalues of the evaluation cloud of each secondary risk indicator of the project according to the specific formula. The parameters of the evaluation cloud for the first-level indicators are then calculated from the combined weights of the second-level indicators and the evaluation cloud. Then the comprehensive evaluation cloud parameters of the project are calculated from the comprehensive weights and evaluation clouds of the first-level indicators as C(Ex,En,He)=(2.172,0.737,0.065). The evaluation cloud parameters of the indicators at all levels are shown in Table 6.

Table 6: Evaluation cloud parameters of various indicators

Target level	Evaluation of cloud parameter	Primary indicator	Evaluation of cloud parameter	Secondary indicator	Evaluation of cloud parameter
The overall legal risks of the housing lease contracts for the project	(2.172,0.737,0.065)	B1	(2.334, 0.754, 0.066)	C11	(1.842, 0.783, 0.143)
				C12	(2.916, 0.715, 0.087)
				C13	(3.158, 0.802, 0.112)
		B2	(1.945, 0.656, 0.053)	C21	(3.724, 0.862, 0.136)
				C22	(2.359, 0.791, 0.124)
				C23	(2.215, 0.738, 0.092)
				C24	(1.987, 0.813, 0.105)
				C25	(3.576, 0.769, 0.148)
		B3	(2.490, 0.844, 0.079)	C31	(1.263, 0.652, 0.119)
				C32	(3.817, 0.794, 0.142)
				C33	(4.028, 1.121, 0.285)
				C34	(2.935, 0.863, 0.107)
		B4	(2.178, 0.703, 0.059)	C41	(1.842, 0.735, 0.098)
				C42	(3.254, 0.816, 0.132)
				C43	(3.719, 0.782, 0.206)
				C44	(2.467, 0.857, 0.143)
		B5	(2.023, 0.797, 0.073)	C51	(1.386, 0.643, 0.121)
				C52	(3.972, 0.765, 0.094)
				C53	(2.815, 0.798, 0.137)
		B6	(1.556, 0.563, 0.046)	C61	(3.128, 0.712, 0.089)
				C62	(2.275, 0.631, 0.114)

Table 6 shows the cloud model parameters (expected value Ex, entropy En, hyperentropy He) for each level of indicators in the evaluation of an example of legal risk of a house lease contract. The expected value of the overall risk level Ex=2.172 is in the [2,4) range, indicating that the overall risk level is low to medium risk. The entropy En=0.737 reflects moderate risk ambiguity, and the hyperentropy He=0.065He=0.065 shows high consistency of expert assessment.

In terms of the first-level indicator risk, B3 contract subject risk (Ex=2.490) has the highest risk and is close to the medium risk threshold, mainly dragged down by the C33 housing legality risk (Ex=4.028).B1 policy and legal environment risk (Ex=2.334) and B4 core clause risk (Ex=2.178) are both of medium-low risk, but the entropy value of B1 is higher (En= 0.754), indicating higher uncertainty about policy changes.B6 External environment risk (Ex=1.556) is the least risky and has the least ambiguity (En=0.563).

At the level of secondary indicators, C33 housing legality risk (Ex=4.028,En=1.121) is a medium risk, and the ambiguity is significantly higher than other indicators (En>1), so it needs to be prioritized for prevention and control.C32 lessee credit risk (Ex=3.817), C43 termination and default liability risk (Ex=3.719) are close to medium risk.C31 lessor qualification risk (Ex = 1.263) and C51 Contract Change Risk (Ex=1.386) have an expectation value below 2.0, which is in the low risk category.

IV. B. 3) Determination of risk evaluation level

Firstly, the comparison cloud diagram is drawn by MATLAB software according to the standard cloud parameters, the evaluation cloud parameters of each level of indicators and the comprehensive evaluation cloud parameters of

the project. Then calculate the similarity of each level of indicators and the project as a whole according to the calculation steps of similarity, and organize into a similarity comparison table. Finally, the risk level is determined by comparing the position of the evaluation cloud with the standard cloud within the same cloud diagram and the similarity between the evaluation cloud parameters and the standard cloud parameters.

The evaluation cloud parameters of the risk of the law of housing lease contract of the studied project are (2.172,0.737,0.065), and the generated comparison cloud diagram is shown in Figure 4.

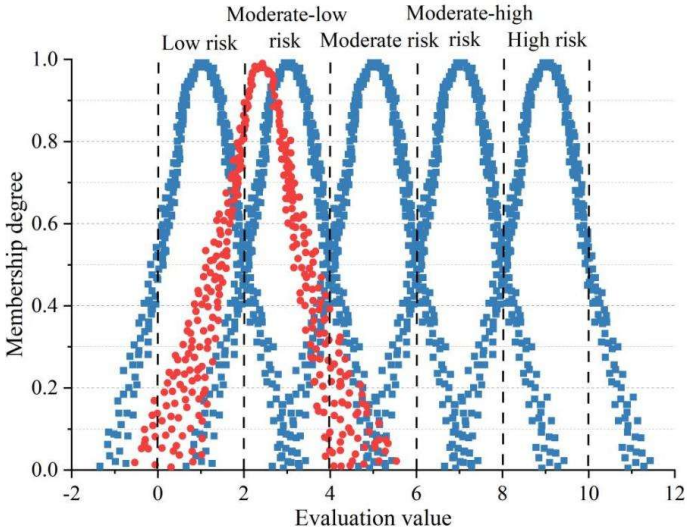

Figure 4: Project Comprehensive Evaluation Cloud

The expected value Ex = 2.172 is close to the center value of the low and medium risk standard cloud, and Figure 4 shows that its cloud map has the highest overlap with the low and medium risk standard cloud. The comprehensive evaluation of cloud and standard cloud similarity is shown in Table 7.

Table 7: The similarity between the comprehensive evaluation and the standard cloud

Risk level	Similarity
Low level	0.2064
Moderately low level	0.7137
Moderate level	0.0763
Moderately high level	0.0036
High level	0

It can be seen that the project's risk level was determined to be 71.37% similarity to medium-low risk and 20.64% similarity to low risk, which together accounted for more than 92% of the total. This indicates that the overall risk of the project is clearly categorized as medium-low.

V. Housing rental risk prevention strategies

Based on the aforementioned legal risk assessment system for housing lease contracts and the quantitative evaluation results of the cloud model of actual cases, the following systematic prevention and control strategies are proposed for the core risk points of housing lease contracts in the digital era.

V. A. Strengthening the qualification of subjects and verification of the legality of housing

(1) Digital verification front

Digital tools such as government open data interfaces and third-party credit platforms are utilized to conduct online real-time verification of the lessor's property rights/operating qualifications and the lessee's credit history. Focus on ensuring that the property rights of the housing are clear, free of rights defects and in compliance with the leasing conditions, such as non-prohibited types of leasing and meeting safety standards, to avoid C31, C32 and C33 high-risk points from the source.

(2) Blockchain deposit application

Adopt blockchain and other technologies for the deposit of key qualification documents (property rights certificates, identity certificates, business licenses) to ensure that the chain of evidence is complete and untamperable and to cope with potential risks of evidence preservation.

V. B. Dynamic monitoring of policies and regulations and optimization of core provisions

(1) Intelligent tracking of policy compliance

Establish a digital monitoring and early warning mechanism for local leasing policies, tax regulations, and timely identification of B1-type risks. The contract management system can be embedded with policy update alerts and compliance checking modules.

(2) Standardization and Intelligence of Core Terms

Based on high-frequency risk points, develop and promote standardized, non-ambiguous core clause templates. Utilize smart contract technology to explore functions such as automatic transfer of rents and reminders of default conditions in compliance with the legal framework, so as to reduce disputes arising from loopholes in the terms and conditions. Conduct a special legal review of “special clauses”.

V. C. Build a full-process digital performance management system

(1) Electronic Signing and Deposit

A reliable electronic signature platform is fully adopted for signing contracts and automatically archived to the cloud to ensure the uniqueness of the contract version and the traceability of the signing process, and to reduce the risk of contract change and proxy.

(2) Dynamic monitoring of fulfillment process

Utilize IOT equipment or regular online inspection records to digitally manage the status of housing, equipment and facilities maintenance responsibilities. Establish online communication and evidence tracing channels to facilitate the restoration of facts in case of disputes.

(3) Risk data-driven decision-making

Integrate contract performance data and use data analysis to identify unusual patterns, such as frequent delayed payments and maintenance disputes, to support proactive intervention and risk management decisions.

V. D. Establishment of a synergized risk early warning and response mechanism

(1) Integration of external risk factors

Integrate external environmental risks such as force majeure and third-party infringement into the risk assessment model and establish contingency plans.

(2) Multi-party collaborative governance

Promote the safe sharing of data among government regulatory platforms, leasing service platforms, and financial institutions to form a risk joint defense and control network. For example, associating leasing contract filing information with credit system and market supervision data to enhance overall market transparency and risk warning capability.

(3) Intelligent Dispute Prevention and Resolution

Explore digital dispute resolution mechanisms such as online mediation and electronic evidence through arbitration/litigation to reduce the cost of defending rights and enhance the efficiency of dispute handling.

VI. Conclusion

This study provides a scientific basis for the legal risk management of housing lease contracts in the digital era by constructing a closed loop of risk prevention and control of “indicator system - weight allocation - cloud model evaluation”.

Disputes in economically developed regions accounted for 67.14% (top five provinces: Guangdong, Zhejiang, Beijing, Shanghai and Jiangsu accounted for 43.29%), highlighting the positive correlation between leasing activity and risk. 89.18% of the cases were directly related to loopholes in contractual terms (e.g., rents, termination liabilities), which confirms that the rigor of terms and conditions is the core of risk prevention and control.

The risk assessment system of 21 indicators in 6 categories was validated by Delphi method and questionnaire, with Cronbach's alpha coefficient of 0.876 and KMO values of >0.8, which is reliable in terms of reliability and validity. Practitioners' scores showed that C41 rent and deposit terms had the highest level of concern (mean value 4.56), and market financial risks (e.g., C23 inflation, mean value 3.48) were less sensitive.

The ISM weight allocation shows that B3 contract subject risk has the highest weight (0.236), of which C31 lessor qualification is a key subcomponent, with a combined weight of 0.078. B1 policy and legal risk (0.223) and B4 core clause risk (0.191) are next in importance, and B2 market and financial risk has the lowest weight (0.120).

In the cloud model risk quantification example evaluation, the overall risk cloud parameters are (Ex=2.172, En=0.737, He=0.065), and the cloud similarity calculation shows 71.37% probability of low to medium risk. The core risk point is the C33 housing legality risk, which reaches a medium risk (Ex=4.028), and the entropy value En=1.121 reflects a high level of assessment ambiguity, which needs to be prioritized for prevention and control.

References

[1] Lu, Q., Wang, X., Sha, H., Chen, J., Luo, J., & Xu, G. (2025). Temporally Decelerated and Spatially Balanced Urbanization in China during 1996–2022. Journal of Urban Planning and Development, 151(2), 04025017.

[2] Cheng, M., & Duan, C. (2021). The changing trends of internal migration and urbanization in China: new evidence from the seventh National Population Census. China Population and Development Studies, 5(3), 275-295.

[3] Zhang, C., Jia, S., & Yang, R. (2016). Housing affordability and housing vacancy in China: The role of income inequality. Journal of housing Economics, 33, 4-14.

[4] Bajari, P., Chan, P., Krueger, D., & Miller, D. (2013). A dynamic model of housing demand: Estimation and policy implications. International Economic Review, 54(2), 409-442.

[5] Czerniak, A., & Rubaszek, M. (2018). The size of the rental market and housing market fluctuations. Open Economies Review, 29, 261-281.

[6] Liu, Y., Wang, P., He, Z., & Dong, J. (2021). Real estate rental market: a 10-year bibliometricbased review. Economic research-Ekonomska istraživanja, 34(1), 1752-1788.

[7] Boeing, G. (2020). Online rental housing market representation and the digital reproduction of urban inequality. Environment and Planning A: Economy and Space, 52(2), 449-468.

[8] Raess, P., & von Ungern-Sternberg, T. (2002). A model of regulation in the rental housing market. Regional Science and Urban Economics, 32(4), 475-500.

[9] Van Ommeren, J., & Graaf-de Zijl, M. (2013). Estimating household demand for housing attributes in rent-controlled markets. Journal of housing economics, 22(1), 11-19.

[10] Shen, C. Y., & Zhang, L. Y. (2016, August). On the protection of the lease contract of the house. In 2016 International Conference on Management Science and Management Innovation (pp. 91-93). Atlantis Press.

[11] Ariyanti, H., Navisa, F. D., & Sunardi, S. (2023). Legal Protection for Lessees for Lease Agreements for Buildings on Land with Third Party Ownership (Study of Lease Agreements for Hasaka Villa Canggu). International Significance of Notary, 3(2), 18-28.

[12] Hussar, A., & Kull, I. (2016). The Landlord's Limited Right to Terminate a Residential Lease Contract. Juridica Int'l, 24, 71.

[13] Chifor, D. C. (2024). RISK ISSUES IN THE LEASE CONTRACT. Analele Universităţii Titu Maiorescu, 23(XXIII), 65-76.

[14] Semakov, D. V. (2016). On the legal risk allocation when entering into an commercial lease agreement. Russian Journal of Legal Studies, 5(1), 29-36.

[15] Mohammadi, S., & Birgonul, M. T. (2016). Preventing claims in green construction projects through investigating the components of contractual and legal risks. Journal of cleaner production, 139, 1078-1084.

[16] Byoun, S., & Xu, Z. (2014). Contracts, governance, and country risk in project finance: Theory and evidence. Journal of Corporate Finance, 26, 124-144.

[17] Giner, B., & Pardo, F. (2018). The value relevance of operating lease liabilities: Economic effects of IFRS 16. Australian accounting review, 28(4), 496-511.

[18] Triki, O., & Abid, F. (2022). Contingent convertible lease modeling and credit risk management. Financial Innovation, 8(1), 89.

[19] Kukoba, Y. (2024). Protection of the rights of commercial property lessees amidst economic instability. Law. Human. Environment, 4(15), 31-46.

[20] Pugacheva, A., Romanova, A., & Lunev, A. (2021, March). Leasing Services as a Type of Investment Activity: Russian Experience of Legal Regulation. In VIII International Scientific and Practical Conference'Current problems of social and labour relations'(ISPC-CPSLR 2020) (pp. 530-534). Atlantis Press.

[21] Tomescu, R. A. (2022). The financial leasing market from the perspective of current legal realities. Perspectives of Law and Public Administration, 11(2), 246-251.

[22] Goodall, Z., & Stone, W. (2024). Sharing risk in shared housing: rental regulations and housing justice in Australia. International Journal of Housing Policy, 1-21.

[23] Ahmed, S., & Salam, M. (2022). Rental housing policies and associated legal covers: Case of middle income formal housing in Karachi. Journal of Urban Management, 11(4), 488-499.

[24] Huisman, C. J. (2016). A silent shift? The precarisation of the Dutch rental housing market. Journal of Housing and the Built Environment, 31, 93-106.

[25] Nei, P. G. P., Tobi, S. U. M., & Jasimin, T. H. (2023). REVIEW OF RISK MANAGEMENT IN RENT TO OWN (RTO) SCHEME IN MALAYSIA. PLANNING MALAYSIA, 21.

[26] Kufuor, K. O. (2018). Let's break the law: Transaction costs and advance rent deposits in Ghana's housing market. Global Journal of Comparative Law, 7(2), 333-354.

[27] Brydolf-Horwitz, M. (2020). Risk, property rights, and antidiscrimination law in rental housing: Toward a property-in-action framework. Law & Social Inquiry, 45(4), 871-901.

[28] Sun, X. (2018, December). Analyzing the Implementation of "Rental with Right" And Relevant Legislation and Institutionalization. In IOP Conference Series: Materials Science and Engineering (Vol. 452, No. 3, p. 032128). IOP Publishing.

[29] Hulse, K., & Haffner, M. (2014). Security and rental housing: New perspectives. Housing Studies, 29(5), 573-578.

[30] Papke, D. R., & Papke, M. E. (2023). Rights and Remedies: Rental Housing for Low-Income Households in the United States. Marq. Benefits & Soc. Welfare L. Rev., 25, 1.

[31] Aminikhah, R. (2020). Option in House Lease Contracts. International Journal of Management, Accounting & Economics, 7(9).

[32] Rizky, M. C., & Darmawan, D. (2024). Legal Aspects and Implementation of an Effective and Fair House Lease Agreement. Jurnal Hukum Lex Generalis, 5(10).