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Risk Factors of Building Apartments for University Talent through the Agent Construction Mode in China: Interrelationship and Prioritization

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Abstract: Apartments for university talent (AUT), are apartments provided to staff at non-market price, in order to attract outstanding scholars from around the world to work in universities and improve educational quality. This has been a critical issue in achieving social sustainability in China during rapid urbanization and industrialization. The agent construction mode has been adopted to build AUT because universities usually lack relevant management experience. The agent construction mode is a type of turnkey engineer construction based on the principal-agent model, project bidding mode, engineering contracting projects, and project supervision system. Risk factors are important considerations for both universities and agent construction companies. Although some studies have investigated the risk factors, only a few studies have identified the hierarchical structure of relevant risk factors. Therefore, the interrelationship and prioritization of the risk factors remain unknown, and this situation presents a barrier to better risk management. This paper investigates the interrelationship of risk factors with interpretative structural modeling (ISM). In addition, fuzzy MICMAC (matric d'impacts croises-multiplication appliqué a un classemen) analysis was conducted to prioritize the risk factors. The findings provide useful references for better risk management of building AUT through the agent construction mode. Although this study focuses on China, the analytical process can also be generalized to other research topics and other countries.

Keywords: agent construction mode; apartments for university talent; social sustainability; risk factor; interrelationship; ISM; fuzzy MICMAC; China

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1. Introduction

Since the termination of national welfare housing allocation in China in 1998, housing prices have soared due to various reasons, including accelerated urbanization, farmland protection, and overinvestment, e.g., [1–3]. The high housing price plus low payment brings certain burdens for university talents to settle down and work well in urban areas, and this situation presents a barrier to improving educational quality and thus achieving social sustainability [4]. Apartments for university talent (AUT), are apartments provided to staff at non-market price, to attract outstanding scholars from around the world to work in universities. In addition, AUT can facilitate in mitigating the housing difficulties faced by young teachers. These apartments are usually located adjacent to the campus, and this location promotes communication between teachers and students. Therefore, building AUT is necessary in the current condition of China, although this practice is against the rule of the housing market.

The agent construction mode (called *dai jian zhi* in Chinese) is adopted to build AUT because universities usually lack management experience in building houses. The agent construction mode is a system in which the owner (usually government agencies) selects a qualified project management company (named as an agent construction company) to build a project by competitive bidding and specified contracts. Under this mode, the agent construction company would be in charge of investment and construction management and should transfer the completed project to the owner [5–7]. Through the agent construction mode, owners (usually non-profit government agencies) can effectively compensate for the lack of relevant construction management experience. Moreover, the agent construction company can expand the market occupation and guarantee profit. This mode partially fits the market competition, effectively curbs corruption, and eliminates enterprises with low competitiveness while enhancing the competitive edge of enterprises [8–10]. In addition, this mode helps to optimize the allocation of social resources to achieve the project objectives by maximizing cost savings and to result in a "win-win" situation [11,12]. In China, the agent construction mode was first launched in Xiamen in 1993, and it aimed to select qualified professional construction companies to conduct project management through bidding. With the acceleration of the urbanization process in the 21st century, the construction market and the agent system have boomed. In 2004, the central government promulgated the "Decision of the State Council on the Reform of Investment System", which proposed "to accelerate implementation of the agent construction mode for the non-profit government investment projects." So far, the agent construction mode has been widely promoted, including in considering the building of AUT in China [13,14].

Risk factors are important considerations for both universities and agent construction companies. Without risk management, the interests of both parties would be eroded. Existing studies have mainly focused on assessing and controlling the risks of implementing the agent construction mode. For example, He and She [15] identified the risks, including low elasticity of duration, project change because of the rapid development of universities, and high functional demands because of university development. In addition, Xiang *et al.* [16] identified organization risk, communication risk, target control risk, and purchase risk in implementing agent construction. Liu and Li [17] assessed the general risks of the agent construction mode using the entropy measurement method. Duan *et al.* [18] assessed the risks of multiple projects under the agent construction mode with the matter–element model. Yan *et al.* [19] introduced risk sharing through contracts to reduce risks in implementing agent construction. Existing studies have provided a good understanding of risk assessment and control in implementing agent construction. However, these studies lack comprehensive investigation on the risk factors from universities, agent construction companies, and government, which are important stakeholders in the agent construction mode. Moreover, only a few studies have investigated the interrelationships of relevant risk factors. Therefore, it remains unknown how to manage the fundamental risk factors, which presents a barrier to better risk management.

This paper aims to investigate the interrelationship of risk factors of building AUT through the agent construction mode in China and prioritize these factors. Section 2 presents the research methods of this study. Interpretative structural modeling (ISM) is adopted to explore the interrelationship. Fuzzy MICMAC (matric d'impacts croises-multiplication appliqué a un classemen) analysis, which is a useful tool to compute the dependence power and driving power of each risk factor, is conducted to prioritize the involved risk factors. Section 3 presents relevant findings and results. Section 4 provides in-depth discussions on the interrelationships and prioritization of the involved risk factors. Section 5 concludes this study and specifies future studies.

2. Research Methods

This study adopts ISM to explore the interrelationship of risk factors of building AUT through the agent construction mode in China. ISM is a useful tool to transform a complex system to well-defined models through matrix and graph theories [20]. Based on quantitative and qualitative information, the interrelationship of elements in a complex system can be mapped by a multi-level structure model [21–23]. In addition, MICMAC is usually used to cluster elements with dependence power and driving power acquired during ISM analysis. Although there are certain disadvantages, ISM has been widely applied in management decision-making, including system thinking [24,25], analyzing the interrelationships of evaluation criteria [26,27], and identifying critical factors [22,28,29].

By following the process of ISM and MICMAC, the research logic of this study is demonstrated in Figure 1. The key points of the five steps are illustrated in the following.

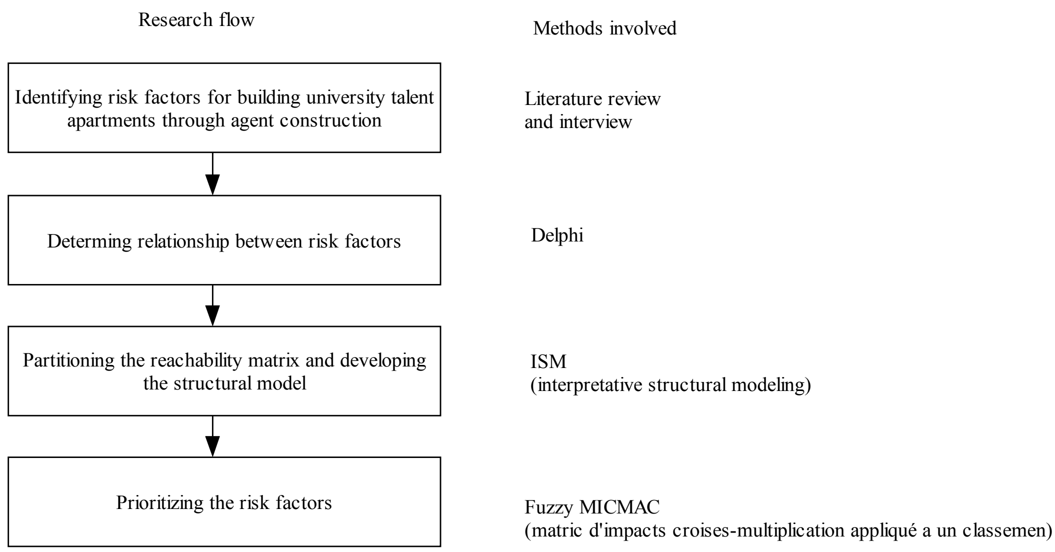

Figure 1. The analytical process.

2.1. Step 1: Identifying the Risk Factors for Building AUT through the Agent Construction Mode

Before mapping the interrelationship, it is necessary to specify the elements in the concerned complex system. In this study, the first step is to identify the risk factors of building AUT through agent construction mode in China. A literature review can be used to select potential factors from existing literatures [30]. In order to distinguish with existing studies, this research summarizes risk factors from the perspectives of universities, agent construction companies, and government. The databases used for searching relevant literature include China National Knowledge Infrastructure (CNKI) and Elsevier, which are two credible databases for construction risk management in Chinese and English respectively. The literature review mainly consists of Chinese studies because of the particularity of the topic. The combined keywords consist of "risk", "agent construction", "university", and "China". After selecting the preliminary risk factors, interviews with experts in the field of agent construction are conducted to verify and supplement the factors. At the end of this step, specific factors for consideration are determined in Equation (1).

$$U = \{U1, U2, \ldots Un\} \tag{1}$$

where U is the set of risk factors of building AUT through the agent construction mode in China, U1, U2, . . . Un is the specific risk factors respectively. n is the total number of identified risk factors.

2.2. Step 2: Determining the Relationship among the Identified Risk Factors

After identifying the concerned elements, the critical step is to determine the correlation between each pair of factors. This is an easy way to find the relationship for a large number of factors. The adjacent matrix A describes the correlation between each pair of factors. In adjacent matrix A, the number 1 or 0 is used to judge whether or not a direct relationship exists [20]. Based on the results in step 1, the n × n adjacent matrix A is developed with the element a_{ij} defined in Equation (2).

$$a_{ij} = \begin{cases} 1, \ there\ is\ a\ direct\ relationship\ between\ Ui\ and\ Uj \\ 2, \ there\ is\ no\ direct\ relationship\ between\ Ui\ and\ Uj \end{cases} \quad (2)$$

It is usually difficult to find whether there is a direct relationship between two factors. The results of relevant empirical studies can be used to determine the correlation. In addition, experts with relevant management experience can also be invited to assess the relationship of two factors. In this study, the experts include university staff in charge of construction, project managers in agent construction companies, and government officials in charge of construction. Delphi is used to finally reach the consensus of value of A.

2.3. Step 3: Partitioning the Reachability Matrix and Developing the Structural Model

The third step is to obtain the system structure by developing and partitioning the reachability matrix. The reachability matrix indicates the impacts of the row element on the column element of the adjacent matrix [31,32]. Sequential power computation of the sum of the n × n adjacent matrix A and n × n unit matrix I can finally generate the reachability matrix R [33]. Suppose that A_1 = A + I, $A_2 = (A + I)^2$, . . . ,$A_i = (A + I)^i$, continuous computation can generate the n × n reachability matrix R until $A_1 \neq A_2 \neq A_3$, . . . , $A_{r\text{-}1} \neq A_r = A_{r+1}$ = R. It should be noticed that Boolean rules (0 + 0 = 0, 0 + 1 = 1, 1 + 1 = 1, 0 × 0 = 0, 0 × 1 = 0, 1 × 1 = 1) are followed during the computation.

On the basis of the reachability matrix R, the hierarchical level of concerned factors can be identified through the reachability set and antecedent set. The reachability set for a specific risk factor consists of the factor itself and other factors influenced by the specific factor [29]. It can be screened from factors with a value of 1 in the horizontal row corresponding to the specific factor in the reachability matrix R [22]. The antecedent set for a specific factor is composed of the factor itself and other factors which influence the specific factor [29]. It can be filtered from factors with a value of 1 in the column corresponding to the specific factor in reachability matrix R [22].

For the first round of determining the reachability set and antecedent set for all factors, if the intersection of the reachability set and the antecedent set equals to that of the reachability set of a particular factor, the particular factor is placed at the first level. After selecting all factors at the first level, relevant factors in the reachability matrix R should be deleted. The factors at the second level can be solicited by following the same principle as the first round. The iterations will be stopped when every factor has been placed at the corresponding level.

After determining all hierarchical levels, a structural model is developed to map the interrelationships of the risk factors [22]. The factors appearing at the first level are placed on highest level of the hierarchy model, and the factors at the second level are located at the second highest level. The iterations is stopped until the factors at the last level are positioned at the bottom level. The interrelationship among various factors can be specified from the reachability matrix R. In the structural model, the interrelationship is illustrated by the arrow, where the factor at the arrow tail has a direct impact on the factor that the arrow points to. The graphic demonstration of the relationship among factors can help decision makers better understand risk management in building AUT through the agent construction mode.

2.4. Step 4: Prioritizing the Risk Factors

MICMAC analysis can be used to compute the dependence power and driving power of each risk factor. The dependence power indicates how much a particular factor has been impacted by other factors, while the driving power reflects how much a particular factor affects other factors. Traditionally, the dependence power of a particular factor is the sum of the values in the relevant column in reachability matrix R. The driving power of a particular factor is the sum of the values in the relevant row in reachability matrix R. This computation is easy but not so practical. The value "1" in the reachability matrix R indicates a direct relationship but maybe with different degrees of impact. Therefore, fuzzy MICMAC is put forward to solve this deficiency by considering the fuzzy nature of thinking in practice [32]. In this step, experts in the field of agent construction are invited to assess the degree of impact between two factors according to the standard as shown in Table 1. Delphi is used to reach consensus.

Table 1. Standard of fuzzy impact degree.

No	Very Weak	Weak	Moderate	Strong	Very Strong	Perfect
0	0.1	0.3	0.5	0.7	0.9	1

Note: the standard is borrowed from [33].

With the help of fuzzy assessment, the reachability matrix R is changed to fuzzy reachability matrix FR with the value as assessed fuzzy impact degree. The dependence power of each factor is the sum of the values in the corresponding column in fuzzy reachability matrix FR. The driving power of each factor is the sum of the values in the relevant row in fuzzy reachability matrix FR. The higher the driving power of a particular factor, the more important the particular factor. Prioritization value is therefore defined by dividing driving power by dependence power as shown in Equation (3).

$$\text{Prioritization value} = \text{driving power}/\text{dependence power} \tag{3}$$

All risk factors can be prioritized by sorting the prioritization value in descending order. Due attention should be paid to the factors with high prioritization when conducting risk management.

3. Results and Findings

By following the step 1 in Section 2, a literature review was conducted to solicit the preliminary list of risk factors. Fifteen factors were selected from mainly four references. To mitigate the deficiency of the literature review, three experts (including researchers and officials) in charge of building AUT were interviewed to validate the preliminary list. Consensus was reached through Delphi. As a result of this step, seventeen risk factors in this study are presented in Table 2.

Table 2. List of risk factors for building AUT through the agent construction mode.

Category	No.	Fisk Factors	Reference
Universities	U1	Lack of knowledge on management of agent construction	[16–19]
	U2	Uncertainty of construction standards	Interview
	U3	Change of building functions	[16–19]
	U4	Irrational interference in construction agency's work	[16–19]
	U5	Delay in payment	[16–19]
Agent Construction Companies	U6	Uncertainty of construction agency's performance	[16–19]
	U7	Uncertainty of construction agency's compensation capacity	[16–19]
	U8	Unreasonable financial management	[16–19]
	U9	Unreasonable selection of stakeholders	[16–19]
	U10	Flaw of the building contracts	[16–19]
Government	U11	Imperfection of law or regulations on construction agency	[16–19]
	U12	Change of technical standards	[16–19]
	U13	Change of macroeconomic control	[16–19]
	U14	Change of investment conditions	[16–19]
	U15	Change of education investment	Interview
	U16	Unreasonable governmental decision and supervision	[16–19]
	U17	Low quality and efficiency of governmental services	[16–19]

A 17 × 17 adjacent matrix A was established to characterize the relationship of the seventeen risk factors by following step 2 in Section 2. Five experts—including university staff in charge of construction, project managers in agent construction companies, and government officials in charge of construction—were invited to obtain the values in adjacent matrix A. Delphi was used to finally reach consensus as shown in Table 3.

Table 3. The adjacent matrix of Fisk factors for building AUT through the agent construction mode.

Factor	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15	U16	U17
U1	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0
U2	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
U3	0	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0
U4	0	0	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0
U5	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
U6	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0
U7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
U8	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
U9	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
U10	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
U11	1	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	1
U12	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	1	0
U13	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0
U14	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
U15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
U16	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
U17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

By following the specified rules in step 2, as introduced in Section 2, the sequential power computation of the sum of the 17 × 17 adjacent matrix A and 17 × 17 unit matrix I is stable after four times. The reachability matrix R was thus obtained as shown in Table 4.

Table 4. The reachability matrix of risk factors for building AUT through the agent construction mode.

Factor	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15	U16	U17
U1	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
U2	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
U3	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
U4	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0
U5	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0
U6	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
U7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
U8	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0
U9	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0
U10	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0
U11	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1
U12	0	1	1	1	1	1	1	1	1	1	0	1	0	0	0	1	1
U13	0	0	0	0	1	0	1	1	0	1	0	0	1	1	1	0	0
U14	0	0	0	0	1	0	1	1	0	1	0	0	0	1	1	0	0
U15	0	0	0	0	1	0	1	1	0	1	0	0	0	0	1	0	0
U16	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	1	1
U17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Based on the reachability matrix R, the first round of identifying the reachability set and antecedent set of seventeen risk factors was conducted. The results were demonstrated in Table 5. As shown in Table 5, for factors U7 and U17, the intersection set equals the corresponding reachability set. Hence, factors U7 and U17 are solicited and placed at level I.

Table 5. The first round of identifying reachability set and antecedent set.

Factor (U_i)	Reachability Set R (U_i)	Antecedent Set A (U_i)	Intersection $R(U_i) \cap A(U_i)$	Level
U1	1,3,4,5,6,7,8,9,10	1,11	1	
U2	2,3,4,5,6,7,8,9,10	2,11,12	2	
U3	3,4,5,6,7,8,9,10	1,2,3,4,11,12	3,4	
U4	3,4,5,6,7,8,9,10	1,2,3,4,11,12	3,4	
U5	5,7,8,10	1,2,3,4,5,6,8,9,10,11,12,13,14,15,16	5,8,10	
U6	5,6,7,8,9,10	1,2,3,4,6,11,12	6	
U7	7	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16	7	I
U8	5,7,8,10	1,2,3,4,5,6, 8,9,10,11,12,13,14,15,16	5,8,10	
U9	5,7,8,9,10	1,2,3,4,6,9,11,12	9	
U10	5,7,8,10	1,2,3,4,5,6, 8,9,10,11,12,13,14,15,16	5,8,10	
U11	1,2,3,4,5,6,7,8,9,10,11,12,16,17	11	11	
U12	2,3,4,5,6,7,8,9,10,12,16,17	11,12	12	
U13	5,7,8,10,13,14,15	13	13	
U14	5,7,8,10,14,15	13,14	14	
U15	5,7,8,10,15	13,14,15	15	
U16	5,7,8,10,16,17	11,12,16	16	
U17	17	11,12,16,17	17	I

The iterations were stopped after eight times. The level of all risk factors can be determined as shown in Table 6.

Table 6. The hierarchical level of risk factors for building AUT through the agent construction mode.

Factor	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17
Level	VI	VI	V	V	II	IV	I	II	III	II	VIII	VII	V	IV	III	III	I

The hierarchical structure model was established on the basis of the identified level in Table 6 and determined relationship in Table 4. For example, for factor U1 (lack of knowledge on management of agent construction) at level VI, the entries corresponding to factors U3 and U4 at level V are 1 and the entry corresponding to U13 is 0. This finding implies that U1 leads to U3 and U4, and that no relationship exists between U1 and U13. Therefore, an arrow with the head pointing to U3 and U4 is used to link U1, U3, and U4. Following the same manner, the interrelationship of risk factors can be graphically illustrated in the structural model as shown in Figure 2.

In the structural model, the factor "imperfection of law or regulations on construction agency" (U11) lies in the bottom level as it affects most factors. The factors "uncertainty of construction agency's compensation capacity" (U7) and "low quality and efficiency of governmental services" (U17) lies in the top level as they are affected by most factors.

In order to better understand the interrelationship of the risk factors, five experts were invited to develop the fuzzy reachability matrix FR according to the methods introduced in Section 2. Delphi was used to reach consensus and the final results are demonstrated in Table 7.

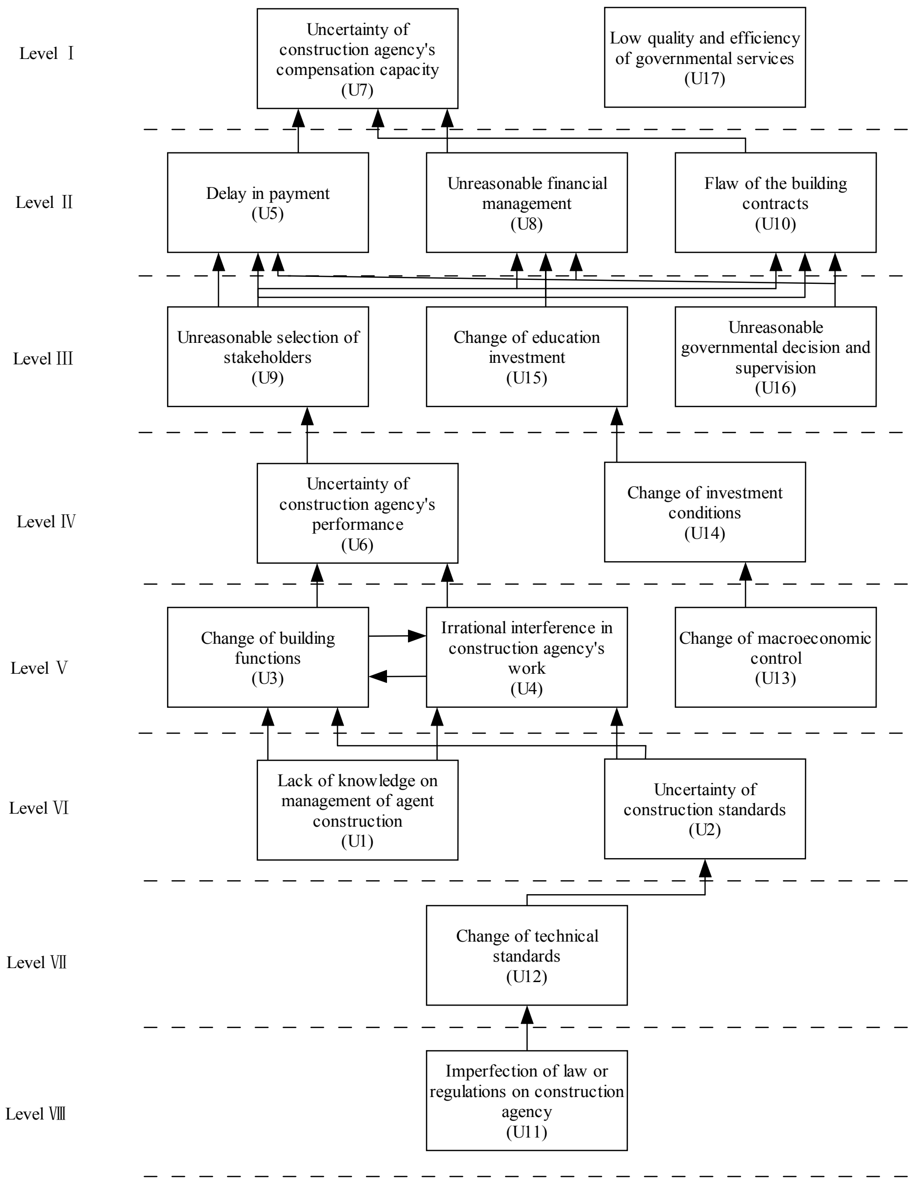

Figure 2. The interrelationship of risk factors for building AUT through the agent construction mode.

Table 7. The fuzzy reachability matrix of risk factors for building AUT through the agent construction mode.

Factor	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15	U16	U17
U1	1	0	0.7	0.9	0.5	0.5	0.5	0.7	0.5	1	0	0	0	0	0	0	0
U2	0	1	1	0.7	0.5	0.5	0.5	0.5	0.5	1	0	0	0	0	0	0	0
U3	0	0	1	0.3	0.7	0.3	0.3	0.3	0.3	1	0	0	0	0	0	0	0
U4	0	0	0.9	1	1	0.3	0.3	0.3	0.3	0.5	0	0	0	0	0	0	0
U5	0	0	0	0	1	0	0.7	0.9	0	0.5	0	0	0	0	0	0	0
U6	0	0	0	0	0.9	1	1	0.9	0.7	0.5	0	0	0	0	0	0	0
U7	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
U8	0	0	0	0	1	0	0.9	1	0	0.5	0	0	0	0	0	0	0
U9	0	0	0	0	0.7	0	0.3	0.5	1	0.3	0	0	0	0	0	0	0
U10	0	0	0	0	1	0	0.7	0.7	0	1	0	0	0	0	0	0	0
U11	0.5	1	0.3	0.7	0.7	0.5	0.5	0.5	0.9	1	1	1	0	0	0	0.9	0.7
U12	0	1	0.7	0.7	0.5	0.7	0.5	0.3	0.5	1	0	1	0	0	0	0.7	0.5
U13	0	0	0	0	0.9	0	0.9	0.7	0	0.3	0	0	1	1	0.7	0	0
U14	0	0	0	0	0.9	0	0.9	0.7	0	0.3	0	0	0	1	0.7	0	0
U15	0	0	0	0	0.9	0	0.5	0.5	0	0.3	0	0	0	0	1	0	0
U16	0	0	0	0	0.9	0	0.5	0.7	0	0.7	0	0	0	0	0	1	0.7
U17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

On the basis of fuzzy reachability matrix FR, the dependence power and driving power for each factor were calculated according to the methods presented in Section 2. According to Equation (3), the prioritization value of each factor can be computed as shown in Table 8. As shown in Table 8, U11 (Imperfection of law or regulations on construction agency), U13 (Change of macroeconomic control), and U1 (Lack of knowledge on management of agent construction) are the three highest priority risk factors.

Table 8. Prioritization of risk factors for building AUT through the agent construction mode.

Factor	Driving Power	Dependence Power	Prioritization Value	Priority Ranking
U1	6.30	1.50	4.20	3
U2	6.20	3.00	2.07	6
U3	4.20	4.60	0.91	11
U4	4.60	4.30	1.07	10
U5	3.10	12.10	0.26	16
U6	5.00	3.80	1.32	9
U7	1.00	10.00	0.10	17
U8	3.40	9.20	0.37	13
U9	2.80	4.70	0.60	12
U10	3.40	9.90	0.34	14
U11	10.20	1.00	10.20	1
U12	8.10	2.00	4.05	4
U13	5.50	1.00	5.50	2
U14	4.50	2.00	2.25	5
U15	3.20	2.40	1.33	8
U16	4.50	2.60	1.73	7
U17	1.00	2.90	0.34	15

Since the results of this study are mainly developed based on qualitative information, a robust check was further conducted to validate the results. An expert's review was adopted to validate the results due to lack of enough data for quantitative analysis [34]. Five experts—including university staff in charge of construction, project managers in agent construction companies, and government officials in charge of construction—were invited to validate the hierarchical level and prioritization of the risk factors. Due attention should be paid to the fact that these experts did not participate in the former research process. The experts were asked a series of questions concerning the rationality of the research process and results. All experts agreed that appropriate methods have been used with a clear logic. The results are useful for their understandings on relevant management work. Most important risk factors identified by the prioritization echoes with their real concerns in practice. Although all experts took a positive attitude on the research process and results, two of them claimed that quantitative analysis would be more useful for them to understand the risk issues. This is due to difficulty in aggregating enough data for quantitative analysis. However, this insufficiency reflects the fact that the management work in practice relies on both qualitative and quantitative information. Future studies should be conducted to develop a quantitative model for investigating the interrelationship of the risk factors. Such series of research can provide support for each other.

4. Discussion

The structural model demonstrates that the factor "imperfection of law or regulations on construction agency" (U11) plays a fundamental role in risk management. This is validated in the interview as experts pointed out "imperfect regulations on agent construction leads to blur boundary between government, universities, and agent construction companies and therefore various uncertainties to avoid risk". The factors "uncertainty of a construction agency's compensation capacity" (U7) and "low quality and efficiency of governmental services" (U17) are also critical risk factors for building AUT through the agent construction mode. If government service is provided with low quality and efficiency, the construction process, such as the beginning and delivery check, will be delayed and will present risks to achieve predetermined objectives. The construction agency's compensation capacity also plays an important role because clearly defining the agent's quality in an imperfect market is slightly difficult.

Besides the three factors identified in the structural model, the priority results remind us that "change of macroeconomic control" (U13) and "lack of knowledge on management of agent construction" (U1) are also important considerations. Among the three highest priority factors, change of macroeconomic control presents barriers for investment on building agent apartments and finance in agent construction. In addition, lack of relevant management knowledge on agent construction hinders the university's effective and efficient monitoring of the whole process. As the university is not assumed to know all required knowledge, experts in agent construction (from inside or outside of the university) can be hired for better implementation of agent construction.

Based on the results of fuzzy MICMAC analysis, a coordinate system can be developed to group the risk factors for better understanding. According to the results in Table 8, the half range for the driving power is 5.5, while for the dependence power it is 6.5. Four Quadrants can therefore be divided according to the half ranges as shown in Figure 3. Quadrant 1 is named as "linkage", where the factors have comparatively high driving power and high dependence power. These factors play a bond function among the risk factors. However, in this study, there is no "linkage" risk factors. Quadrant 2 is nominated as "independent", where the factors have comparatively high driving power but low dependence power. These factors somewhat affect most other factors, but are impacted by few other factors. By referring to the structural model, it can be found that these factors mostly lie in the lower bottom level. In this study, there are five factors in Quadrant 2. Quadrant 3 is called "autonomous", in which the factors have comparatively low driving power and low dependence power. These factors affect few other factors and also are affected by few other factors. By referring to the structural model, it can be found that these factors mostly lie in the middle level. In this study, there are eight factors in Quadrant 3. Quadrant 4 is called "dependent", in which the factors have comparatively low driving power but high dependence power. These factors affect few other factors but are affected by most other factors. By referring to the structural model, it can be found that these factors mostly lie in the upper top level. In this study, there are four factors in Quadrant 4.

Appropriate measures should be made to manage these risk factors. The factors located in Quadrant 2 play a fundamental role in risk management. The government should positively communicate with the industry and respond to the requirements of improving relevant laws and construction standards on agent construction. The university should hire experts of agent construction to monitor the whole process and therefore reduce unreasonable interference. The factors located in Quadrant 3 play an autonomous role in risk management. These factors can be managed by integrating the priority analysis. Due attention should be paid to factors with comparatively high priority. For example, the construction agency can select stakeholders by fully considering the requirements put forward by the university. Hence, risk in delaying payment would be reduced due to unsatisfactory construction works. The factors located in Quadrant 4 play a dependent role in risk management. Measures should be closely paid to other factors that highly affect the "dependent" factors. For example, in order to reduce the risk of "delay in payment", it is necessary to reduce various risks (e.g., "irrational interference in construction agency's work", "uncertainty of construction agency's performance").

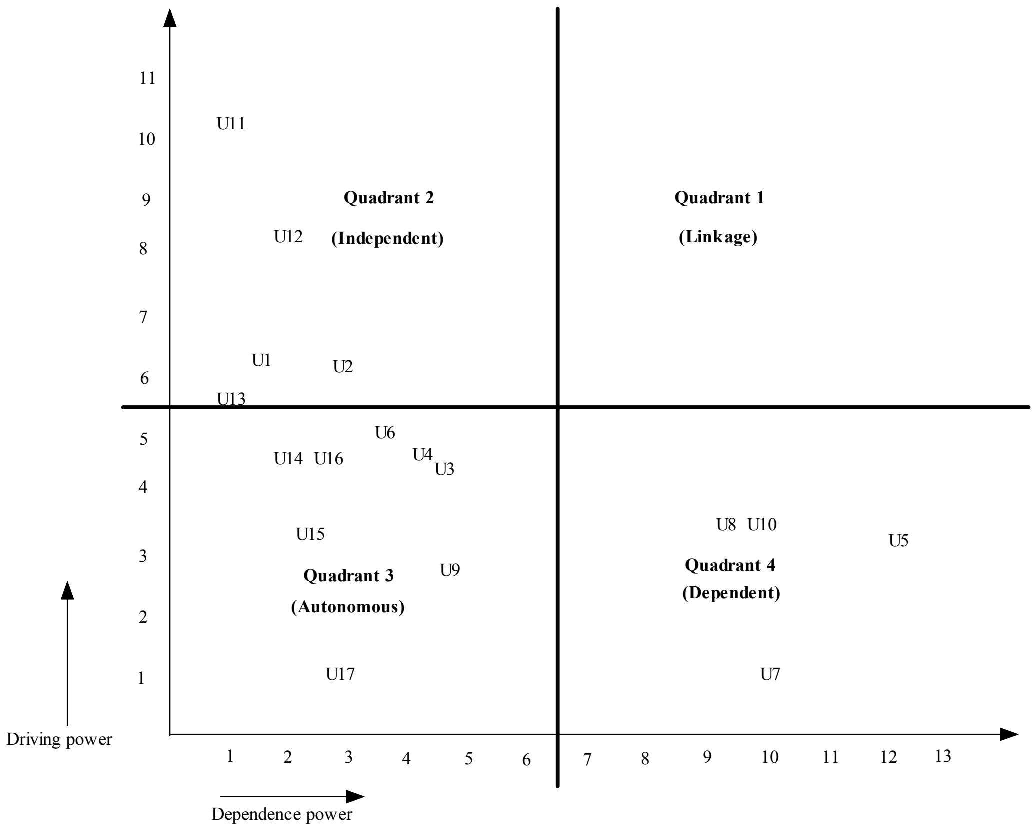

Figure 3. The classification of risk factors for building AUT through the agent construction mode.

5. Conclusions

High quality talents are important for improving educational quality and achieving social sustainability. Within the context of high housing prices in China, AUT are critical for attracting outstanding scholars and settling down staff personnel. However, universities usually lack the required experiences and abilities to build such apartments by themselves. The agent construction mode partially mitigates this problem and is thus promoted in building university talent apartments. For better risk management, this study investigates the interrelationship of risk factors from the perspective of universities, agent construction companies, and the government. The interrelationship and prioritization of the risk factors were examined using ISM and fuzzy MICMAC.

The imperfection of law or regulations on construction agency is considered the fundamental risk factor, and it should be given due attention. Uncertainty of a construction agency's compensation capacity and low quality and efficiency of government services are placed on top of the hierarchical structure, and these factors should also be carefully monitored. In addition, the priority results remind us that "change of macroeconomic control" (F13) and "lack of knowledge on management of agent construction" (F1) should be closely monitored for better risk management. As the university is not assumed to understand all required knowledge, experts in agent construction (from inside or outside of the university) can be hired for better implementation of agent construction. The understanding of the interrelationship among risk factors provides a useful reference for better risk management. However, it should be noticed that there are still some limitations. The interrelationship of risk factors was investigated based on qualitative information. Future studies can use questionnaire surveys and structural equation modeling (SEM) to quantitatively investigate such relationships. Quantitative investigation can further validate this study and provide more in-depth understandings. In addition, as determined by the research objective, measures to mitigate such risks were not thoroughly discussed in this research. Future studies can be conducted to identify effective measures to reduce the risk of agent construction in building AUT in China.

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Abbreviations

The following abbreviations are used in this manuscript:

ISM	interpretative structural modeling
MICMAC	matric d'impacts croises-multiplication appliqué a un classemen
AUT	Apartments for University talent

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