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Research Article

The Impact of Risk Preference in Decision Behavior on Urban Expansion Morphology

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With the rapid development of urbanization, the urban expansion morphology has been changing with complex driving mechanisms behind the urban evolution process. This article simulates the results of urban land development contingent upon decision-makers' risk preferences and reveals the inherent law of the effect of risk preferences on urban expansion morphology. Results show that cautious decision-makers lead to the urban expansion morphology being relatively compact, and the reckless decision-makers lead the urban expansion to sprawl. Moreover, there are obvious differences in strengths of planning constraints on the decision-makers with different risk preferences. The reckless decision-makers, driven by the economic interests, are more likely to break through the planning, especially when the planning is not reasonable. It is also found that enhancing executive ability of planning for the reckless decision-makers can promote compactness of the urban expansion morphology. However, the effect of enhancing executive ability of planning on the cautious decision-makers is limited. Thus, in the case of unreasonable planning, the executive ability of planning to the reckless decision-makers should be enhanced so as to avoid urban sprawl.

1. Introduction

China has witnessed a rapid economic growth in the past decades with a continuous expansion of urban areas. For example, the percent of urban population increased from 18% in 1978 to 56.1% in 2015 and the urban built-up areas extended from 6,000 square kilometers to 52,100 square kilometers during the same time period [1]. In the process of urban development, urban growth morphology is featured by extensive expansion, with dramatic morphological changes in the outline of the city. This leads to unordered and rapid expansion of land use for construction, increase of traffic pressure, and increasing encroachment of open space (i.e., farmland and green space). Therefore, an analysis of the factors influencing urban expansion morphology has important practical implications for promoting the compact development of urban expansion, which can help to save land resources and protect the ecological environment.

Morphologically, urban expansion patterns can be spatially identified as sprawl, satellite city, filling, corridor, traffic axle, concentric circles, and sectors [2–5]. In terms of the impact of urban expansion morphology on urban compactness, two types of urban expansion morphologies can be subdivided: filling and extension [6], with the former making a city more compact and the latter making a city to sprawl. Studies on the influencing factors of urban expansion morphology mainly focus on understanding the driving forces (i.e., economic development, population increase, and planning guidance) behind the morphological changes of a city [7–9]. Differences in a city's natural environment conditions tend to cause the city to expand in different directions [10]. In addition, traffic development drives the development of urban space forms and can determine the directions of the spatial expansion of a city [11, 12]. The emergence of new space elements, suburban sprawl, and the polycentric structure of a city affect the characteristics of urban spatial morphology changes [13, 14]. Given the land

use cost, the principle of keeping the development cost minimum is followed in urban expansion, leading to the periodic changes between "extending outside and filling inside" [15]. Urban development ideas, such as low carbon city and environmental protection, are helpful to the compact development of cities [16]. However, much of current research has seldom went further to explain the mechanism of what factors drive urban expansion to either "fill inside" or "extend outside." Moreover, of the existing studies on urban expansion factors, more focused on the macro aspects and few examined the expansion factors from the micro perspective.

Urban sprawl is an important form of urban expansion morphology, which was a phenomenon that occurred in the developed world, and was becoming an international issue because of global urbanization and rapid population growth [17]. China has undergone unprecedented urbanization since the country adopted the opening-policy in 1978 [18]. Urban sprawl is prevalent across the country, especially in the economically developed cities, such as Beijing, Shanghai, Guangzhou, Shenzhen, and Hangzhou, just to name a few [19–23]. In these cities, urban construction land is growing rapidly, with dramatic urban morphology changes, leading to rapid urban sprawl [24]. Li et al. found that, in the stage of rapid economic development, urban sprawl tended to be intensified [25]. In the economically developed areas, the housing price is usually higher, resulting in developer's responses being largely focused on housing demands, which has been the main reason for urban sprawl in most of China's cities [26]. High housing price leads to fierce competition of urban land, with the increase of speculations, and the housing market is full of risks [27]. On the government's part, the goals of the central government and the local government are not always consistent. For example, the goal of the central government is to protect cultivated land, while that of the local government is to develop economy by converting the cultivated land into the construction land [28]. During the period of industrialization, attempts were made to attract investment with a low industrial land price strategy, resulting in a disproportionally large amount of industrial land within the total urban land use structure at the expense of the urban sprawl [29]. Many local governments focus on the development of high-tech industries that have vitality and adventurous spirits and were worth of being supported with favorable policies of government including land supply [30]. For example, Alibaba (a famous Internet company in China), supported by the Hangzhou government, drove the land development and urban economic development in the west of Hangzhou. In many cities of China, the shortage of the construction land quota has limited the land use for economic development. However, local governments in the southeast coast of China are more audacious and innovative and dare to take risks. Some new policies were well used to promote urban land development, such as hook of urban construction land increase and rural residential land decrease policy and transaction of quotas of construction land [31, 32]. On the other hand, the government-led investment model also leads to urban sprawl [33].

In addition, it is widely recognized that the development and formation process of a city is a complex system, and the evolution process has a high degree of self-organizing law [34, 35]. The urban expansion simulation technology, such as cellular automata and multiagent model, is appropriate to study the self-organizing law of urban development [36, 37]. The multiagent model usually simulates urban evolution process based on the local decision and interaction between micro subjects, so it can solve the problem with the cellular automata model, which is hard to reflect the influence of the micro subjects [38]. Meanwhile, there are lots of uncertainties in the process of urban development, because decision-makers' preferences are fuzzy, the choices are multiple, and the decisions are based on bounded rationality [39]. On the other hand, the risk is closely related to the uncertainty [40], and decision-makers of the complex space system perceive risk differently in the process of urban land use, which has a great effect on the land use patterns [41]. Current research on the simulation of the urban expansion using the multiagent model tended to quantify the behavior rules of decision-makers on the utility of land development, distance, infrastructure, land supply, and so on, based on the perfect rationality [42–44]. In the decision of real urban development, the risk preferences of decision-makers will inevitably affect the decision-making of urban development and then affect the urban expansion morphology. Therefore, more studies are needed to examine how risk preferences of micro decision behavior affect the macro urban expansion morphology. In this study, we simulated the outcomes of urban land development at different levels of risk preferences, explored the inherent law on how risk preferences of the micro decision behavior affect the macro urban expansion morphology, constructed the interaction relationship between micro behavior and macro pattern, and enriched the related research on urban expansion morphology. Results of this study can be used to guide the future urban land development, promote city compact development, and increase the use efficiency of land resources.

2. The Analysis of Risk Preference in the Process of Urban Development

A city is the result of the interactions among individuals whose decision-makings in space affect the process and formation of the city's morphology. In other words, the dynamic evolution of a city's morphology depends on the individual behaviors associated with land development and the interaction modes between them [45]. More often than not, unhappiness or pain caused by losing an existing wealth tends to outweigh happiness from gaining a wealth [46]. This so-called endowment effect applies to everybody and will not decrease with the increase of age, experience, and other factors [47]. Kahneman's prospect theory explains the endowment effect in a way that the value function curve is concave in the gain area and convex in the loss area, with the value function curve of the loss area being steeper than that of the gain area. Thus, decision-makers are risk-seeking when faced with losses and risk-averse when faced with gains [48].

Meanwhile, risk and uncertainty are closely linked. Considering probability problems, people tend to overestimate the small probability events and underestimate the big probability events [48]. In the process of development, a city will inevitably follow some common objective laws, namely, big probability events, which are easier to grasp. In this case, decision-makers often underestimate the big probability events for gains or losses and tend to be risk-aversion investors for gains or the risk-seekers for losses. On the other hand, under the background of rapid urbanization, there are many uncertainties in urban development, and various small probability events occur day by day. All kinds of small probability events lead to the overestimation of gains in the decision-making, expressed as the risk-seeking for gains and the risk-aversion for losses. From the perspective of location, there are also differences in the uncertain factors at different urban locations. For example, in the center of a city with good urban infrastructure, the location maturity is high, and the uncertain factors are few. In contrast, the factors such as infrastructure and population change rapidly in the suburbs, and the location maturity is low with many uncertainties. Therefore, the risk preferences of decision-makers will be different in urban land development at different locations. In general, when faced with gains, if the possibility of gains is small, people are risk-seeking, and if the gain possibility is big, they are risk-averse. When faced with losses, if the loss possibility is small, people are risk-averse. Otherwise, they are risk-seeking [49].

It should be noted that people as the behavioral decision-makers are not always rational and may have different risk preferences for risk-seeking or risk-aversion. Moreover, behavioral decision-makers also have different cognitive preferences and value orientations; therefore they have different value pursuits [50]. For example, when government decision-makers determine the planning scheme, they will inevitably place priority on political achievement and may ignore some other socioeconomic factors, which can be seen as risk-seeking or risk-aversion. At the same time, past experience of failure or success may also affect the risk preferences of decision-makers. That is, decision-makers may be more likely to be risk-seekers if they had plenty of successful experiences, while the opposite is true if they have experienced too much failure. Therefore, past experience, be it failure or success, will affect the risk preferences of decision-makers.

Empirically, in studying location preferences of developers, Han et al. [51] found that they are risk-seeking for gains and risk-averse for losses when the return or loss is relatively small or large. However, they are risk-averse for gains and risk-seeking for losses when the return or loss is medium. Thus, developers are sensitive to small or large returns or losses, while they are not sensitive to medium returns or losses. In addition, some developers do not feel strong risk-aversion and still seek risk even in the face of loss, due to the reputation utility, which means one would bear the loss with earning reputation. For developers of different scales, large developers tend to have a higher level of risk-tolerance than small- and medium-sized developers, and thus they are more inclined to pursue a risk. In examining the impact of urban construction land boundary on the developer's risk preferences, Wang and Lai [45] found that, after the delimitation of the land boundary, developers tended to have a higher risk-tolerance for land development outside the boundary and behaved as risk-seekers. This may increase the possibility for land development outside of the boundary and significantly decrease their ability to bear risk within the boundary, making them more worried about the sense of loss within the boundary. Fainstein interviewed real estate developers and found they are overconfident in the decision-making process as risk-seekers [52].

In summary, in the process of urban development, different decision-makers such as government and developers will have different risk preferences for risk-aversion or risk-seeking, when analyzing various gains or losses associated with urban development, due to their own cognitive preferences, value orientations, and other factors.

3. Method

The method here follows Ligmann-Zielinska's research [53], but there are some differences. First, the risk preferences are divided into three types: risk-averse (cautious), risk-neutral (neutral), and risk-seeking (reckless), removing the types of poor and rich, which have opposite risk preferences when faced with gain and loss. The influences of different risk preferences would offset each other and prevent us from separating the effects of different risk preferences. Second, in the real world, the development of urban land is restricted by external factors, such as planning, which is the most important. The planning helps to promote urban compact development by considering the ecological value and social value. As a result, the planning should be considered when researching the impact of risk preference on urban expansion morphology under the situation of planning. Meanwhile, how the planning is carried out will affect the results of urban land development; therefore, the execution ability of planning is also an important variable. Third, with the development of a city, the value of urban land in different areas will change, and the surrounding areas of developed land have higher potential, making it easier to develop. Therefore, neighborhood attraction will also affect the urban expansion morphology and is added to the simulation. The method is closer to reality by considering the planning, neighborhood attraction, and other factors.

3.1. Influencing Factors of Urban Land Development. The urban space is not homogeneous in that urban development usually concentrates in areas with location advantages, such as downtown or the city fringe. In addition, urban land price usually decreases from downtown to the fringe, indicating that economic values vary by locations. Thus, two factors, attractiveness and land price, are considered in this research. Attractiveness is a layer featuring spatial autocorrelation. A linear form of distance decaying Euclidean function is used to create the land price with the grid center having the highest value [53].

The artificial landscape is made up of 40,000 raster cells (200 rows by 200 columns. The cells have two states of

development: developed and undeveloped. Figure 1 presents the two decision criteria maps. In order to express spatial heterogeneity, this study assumes that eastern and western areas of a city are more attractive, and the land price decreases faster toward the south and north directions.

3.2. Urban Development Decision-Making Based on Risk Preferences. According to the risk theory, risk is typically conceptualized as a bipolar continuum from unacceptable to acceptable, from intolerable to tolerable, or from insignificant to significant [54]. Figure 2 presents the risk preferences with a bipolar continuum: from negative to positive with neutrality as the reference point [55].

The attitude templates used in this paper are simplified nonlinear approximation of utility functions shown in Figure 3. These attitude approximations consist of different concave and convex transformations that direct the information processing. For the utility of an option characterized by performance (criterion), the two nonlinear attitudes bend the "fair" linear relationship between the criterion value and option utility [53, 56]. In this paper, the attitude utility functions (AUFs) are numerically approximated as follows [53]:

$$\begin{aligned} &\text{neutral:} \quad y = x, \\ &\text{reckless:} \quad y = \frac{(e^{\alpha x} - 1)}{\alpha}, \\ &\text{cautious:} \quad y = \frac{\ln(\alpha x - 1)}{\alpha}, \end{aligned} \tag{1}$$

where α is a curving coefficient defining the shape of the AUF. It equals 3 in the aforementioned approximation. $x = p(c)$ refers to the standardized original value of criterion c for option p, and y refers to the recalculated value of criterion c for option p in relation to the attitude toward risk.

In the computer simulation, site utilities are based on the ideal decision rule. IP is derived using the "Technique for Order Preference by Similarity to the Ideal Solution" developed by Hwang and Yoon [57]. The locations are judged based on the algorithm of the research of Ligmann-Zielinska [53].

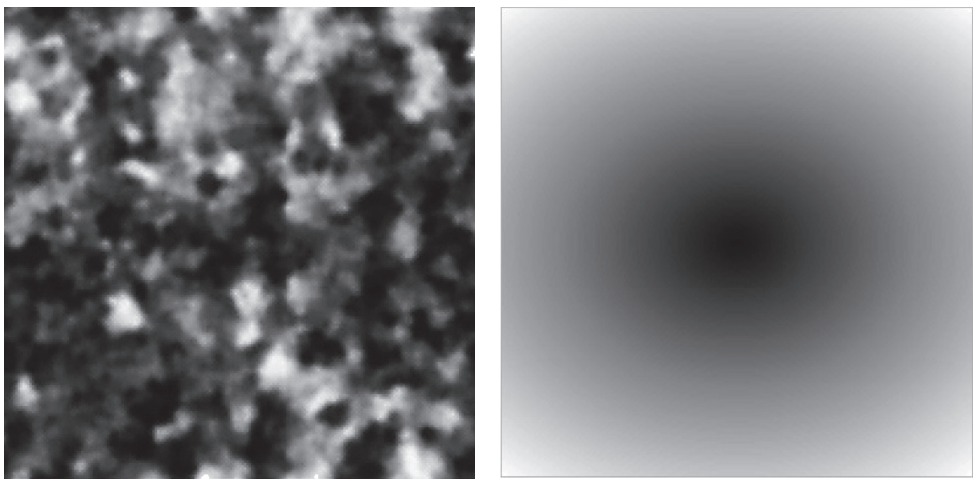
3.3. Quantization in Computer Simulation

3.3.1. Contiguous Relationship. In the adjacent relation model, the Moore neighborhood is defined as a two-dimension lattice composed of a central cell and the surrounding eight cells. Applying the Moore neighborhood to land development, it is assumed that when the decision-maker develops land, the adjacent relation between the land development unit and the surrounding eight cells is the only consideration. In the initial state, the development probability of each cell in the region is only related to the two factors of attractiveness and land price. When there are developed cells in the region, the development potential of the adjacent eight cells will increase by a specific value N, the aggregate strength coefficient. At the same time, the increase in development potential value can be accumulated continuously. That is, when a certain location is located around two developed cells at the same time, its development potential will increase $2N$. Moreover, when the undeveloped location is surrounded by eight developed cells, its development potential will increase $8N$, which is the maximum possible situation of development potential value increase (Figure 4). In addition, if a cell is developed, its development potential is reduced to zero, which means that the location will not be exploited repeatedly in the subsequent stage.

3.3.2. The Impact of Planning. Usually, in a planning area, the government will be responsible for the construction of urban infrastructure (i.e., roads) and other supporting facilities (i.e., safety, health, education, and medical treatment) to ensure the smooth operation of the city and promote its sustainable development. The government will also provide the industrial land, residential land, and commercial land that are required for urban growth [58]. Therefore, the development value of land in the planning area is often increased. In addition, "the Land Management Law" and "the Regulations on the Implementation of the Land Management Law" clearly stipulate that any violations of the overall land use planning will be penalized. As a result, the illegal development of land outside the planning area may be punished.

It can be seen that the land in the planning area will have greater development potential; for the cells in the planning area, the development potential will be increased by f (plan). However, the illegal development of land outside the planning area will bear the illegal risk. That is, for the cells outside the planning area, if developed, the developer will be punished by f (unplanned). But not all illegal land will be punished, depending on the local government's implementation of the planning, assuming that the probability of punishment is p.

3.3.3. The Representation of Urban Expansion Morphology. In this study, the number of patches, aggregation index, and area weighted contiguity index are used to characterize urban expansion morphology. The urban expansion morphology with few numbers of patches and high agglomeration index and area weighted contiguity index is relatively compact, and it is conducive to curbing the sprawl of the city, improving the efficiency of the use of public facilities, reducing environmental pollution and demand of traffic and energy, and reducing the occupation of cultivated land. At the same time, compact urban layout can provide localized services and facilities, which are conducive to making the allocation of urban resources more just and reasonable, avoiding social space isolation caused by poverty gap, and contributing to social integration and social equity [59, 60]. Also, it can easily provide more job opportunities, daily necessities, services, and leisure entertainment within the commuting distance as well as more opportunities for social interactions with friends around [61]. As a result, the compact urban expansion morphology has higher social and



(a) (b)

Figure 1: Influencing factors of urban land development (darker color means higher value). (a) Attractiveness. (b) Land price.

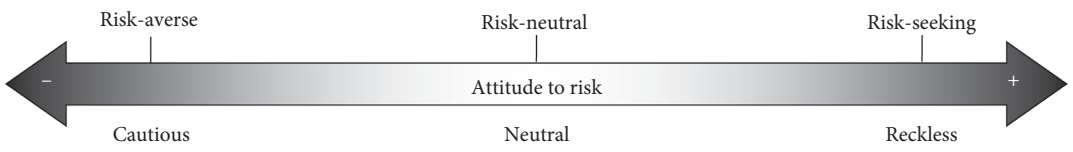


Figure 2: Bipolar continuum of attitudes to risk.

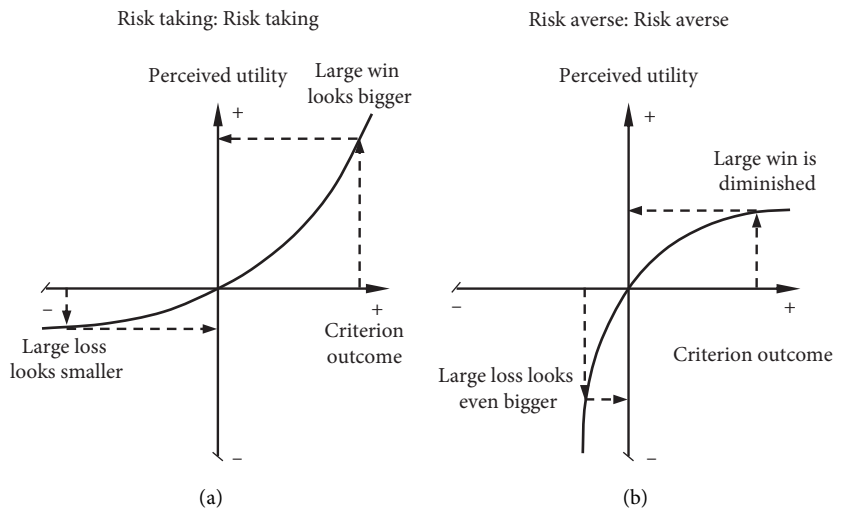


Figure 3: Gain and loss curve of different attitudes to risk. (a) Reckless. (b) Cautious.

ecological benefits. In addition, the location with high attractiveness and land price in the study area often has higher economic benefits. Thus, it is appropriate to use the attractiveness and land price representing the economic benefits of urban development.

4. Results and Discussion

There are two types of organization mechanisms in the process of urban development: one is to form and develop spontaneously through the self-organization law, and the other is to form and develop under the control of heteroorganization (i.e., planning). Heteroorganization and self-organization are the two aspects of the urban system and are a pair of contradictions, which are both mutually exclusive and interdependent. Specifically, in the process of interactions between the two mechanisms of self-organization and heteroorganization, the system will generate a positive feedback when the two mechanisms coordinate well (i.e., reasonable planning). Under this circumstance, changes will occur according to the planning, which will accelerate the benign development of urban space. Otherwise, the system

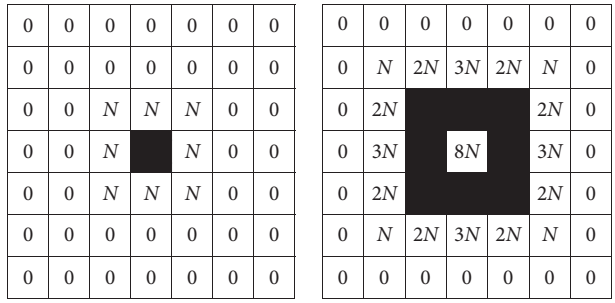


Figure 4: Development potential in the neighboring attraction.

will generate a negative feedback and hinder the healthy development of urban space. This study explores three specific issues.

The first is to study the influence of risk preferences of urban decision-makers on urban expansion morphology under the self-organization law, based on the situation of no planning.

The second is to study the influence of risk preferences of decision-makers on urban expansion morphology when the planning and the self-organization law of urban development are violated or coordinated. Assuming that the planning layout is an ellipse, when the planning and the self-organization law of urban development are violated, the long axis of the ellipse is located in the north-south direction; when the planning and the self-organization law of urban development are coordinated, the long axis of the ellipse is located in the east-west direction.

The third is to study the influence of risk preferences of decision-makers on urban expansion morphology under different execution ability of planning when planning and self-organization law of urban development are violated or coordinated. Planning execution ability shows the probability of illegal land being investigated and dealt with by the relevant departments of the government. In this study, the probability is divided into three levels, namely, weak level, medium level, and strong level, which are 20%, 50%, and 80%, respectively.

4.1. Situation with No Planning. At the beginning of the simulation, the whole study area is undeveloped. The simulation will finish until 30% of the cells are developed, and then the urban spatial morphology is clear and can explain the results better.

Under the situation with no planning, the city is free to develop under the control of the law of self-organization; decision-makers usually give priority to the development of location with high attractiveness and high land price. Results are shown in Table 1.

The results show that the urban land development outcomes caused by cautious decision-makers have less patches and higher aggregation index and area weighted contiguity index, with the urban expansion morphology being relatively compact. On the contrary, the reckless decision-makers cause the aggregation index and area weighted contiguity index to decrease and the number of urban patches to increase, making the city tend to sprawl.

Reckless decision-makers tend to give priority to the development of attractive areas in the city. The attractive value that reckless decision-makers obtain is 33.59, higher than the attractive value of 32.25 for the cautious decision-makers. Meanwhile, the land price value that reckless decision-makers obtain is 25.78, lower than the value of 26.67 for the cautious decision-makers. As can be seen from Figure 1, land price is high inside and low outside, leading the city to develop circularly from inside to outside. Attractive values are irregularly distributed, patterned bits and pieces like a chessboard, tending to guide the development of the city blossoming everywhere. The reckless decision-makers are greatly influenced by the attraction of the city, which makes the development of the city tend to sprawl and leap. It can also be clearly found that the urban pattern lacks a sense of compactness. At the same time, it is found that the economic benefit that reckless decision-makers obtain is 59.37, higher than that of cautious decision-makers, which is 58.92. It can be seen that the reckless decision-makers are inclined to pursue economic benefits, while placing less priority on ecological benefits and social benefits which will be low under such circumstance.

4.2. Situation with Planning. Under the guidance and control of the planning, urban development will basically follow the planning. With different risk preferences and different planning execution, about an average of 80% of the land will be developed in accordance with the planning (Tables 2 and 3 and Figures 5 and 6). Whether the planning and urban self-organization law of development is coordinated or not, for different risk preferences, attractiveness values increase with increasing risk preferences of decision-makers. In the meantime, the value of land price will generally decline; thus land attractiveness and land price often cannot complement each other, but the sum of attractiveness value and land price value still increases with the increasing risk preference of decision-makers. Therefore, whether there is planning or not, the risk-seeking decision-makers always have a strong preference for economic benefits. In addition, the binding strength of the planning to decision-makers with different risk preferences is different. The reckless decision-makers are more likely to go beyond

Table 1: Results of land development.

Attitude	Result	A	P	NP	AI	AWCI	A + P
Cautious		32.25	26.67	8	0.9551	96.89	58.92
Neutral		32.88	26.34	12	0.9494	96.36	59.22
Reckless		33.59	25.78	18	0.9415	95.65	59.37

Notes: "A" represents attractiveness value, "P" represents land price value, "NP" represents number of patches, "AI" represents aggregation index, "AWCI" represents area weighted contiguity index, "■" represents developed area, and "■" represents undeveloped area.

Table 2: Results of land development in the situation of planning coordinating with the city's self-organizing laws.

Attitude	Executive ability (%)	Result	A	P	Plan (%)	NP	AI	AWCI	A + P
Cautious	20		29.18	27.18	83.9	4	0.9689	98.10	56.36
	50		28.69	27.17	86.1	6	0.9714	98.30	55.86
	80		28.45	27.16	87.1	8	0.9721	98.39	55.61
Neutral	20		29.89	27.27	80.1	13	0.9636	97.62	57.16
	50		29.41	27.27	82.6	9	0.9660	97.85	56.68
	80		29.08	27.27	84.2	6	0.9684	98.07	56.35

Table 2: Continued.

Attitude	Executive ability (%)	Result	A	P	Plan (%)	NP	AI	AWCI	A + P
Reckless	20		30.65	27.04	76.8	22	0.9543	96.80	57.69
	50		30.14	27.12	79.4	20	0.9583	97.18	57.26
	80		29.84	27.16	80.9	21	0.9604	97.35	57.00

Notes: "plan" represents the proportion of developed cells in the planning area to the total developed cells and "◯" represents the planning area.

Table 3: Results of land development in the situation of planning coordinating with the city's self-organizing laws.

Attitude	Executive ability (%)	Result	A	P	Plan (%)	NP	AI	AWCI	A + P
Cautious	20		30.04	27.56	87.4	12	0.9714	98.33	57.60
	50		29.87	27.60	88.1	11	0.9732	98.50	57.47
	80		29.75	27.62	88.6	10	0.9739	98.56	57.37
Neutral	20		30.19	27.50	87.1	18	0.9675	97.96	57.69
	50		29.94	27.56	88.2	17	0.9702	98.22	57.50
	80		29.81	27.59	88.7	15	0.9716	98.35	57.40
Reckless	20		30.73	27.25	85.4	14	0.9601	97.33	57.98
	50		30.32	27.38	87.1	18	0.9631	97.59	57.70
	80		30.11	27.43	88.0	18	0.9655	97.82	57.54

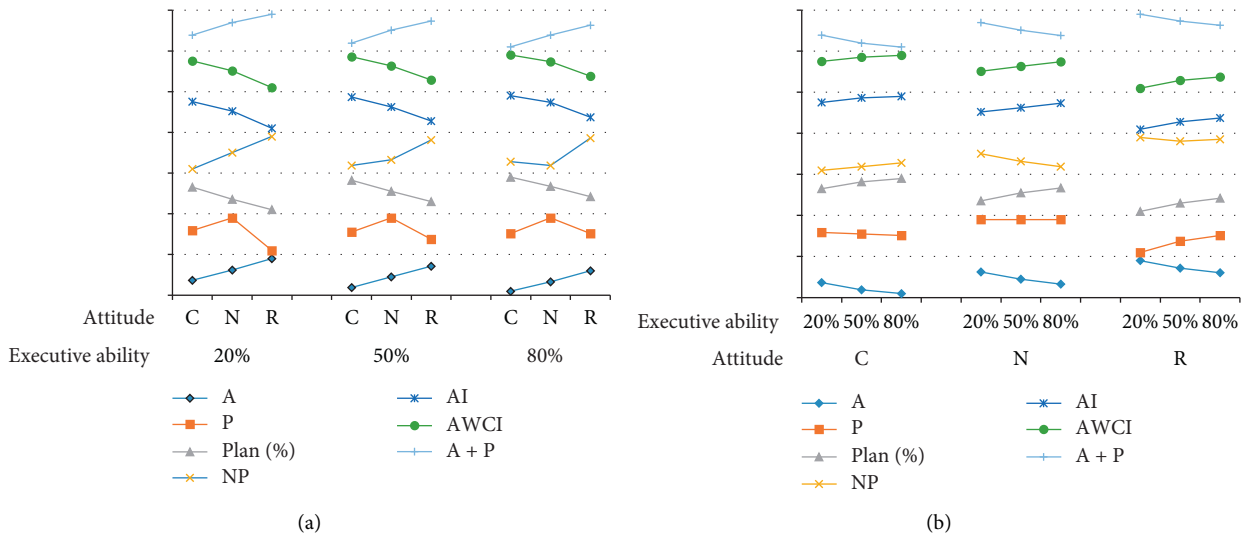


Figure 5: Index comparison under different risk preferences and executive ability of planning (in the situation of unreasonable planning). Notes: the downward broken line indicates decrease; otherwise, it indicates increase.

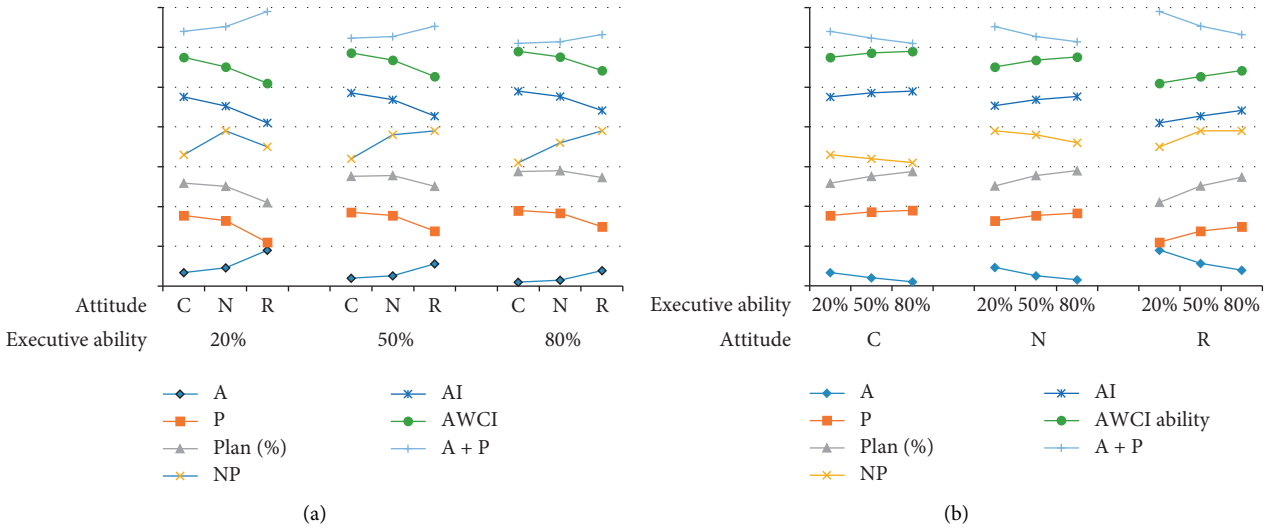


Figure 6: Index comparison under different risk preferences and executive ability of planning (in the situation of reasonable planning).

the planning. When the planning is unreasonable, on average, more than 6.7% of land will be developed without following the planning by reckless decision-makers than by cautious decision-makers. However, this difference will be reduced to 1.2% when the planning is reasonable. Meanwhile, the city, if developed by reckless decision-makers, will have more patches and lower aggregation and proximity degree, with a sprawling and leaping development pattern.

4.2.1. A Comparative Analysis between Unreasonable Planning Scenario and No-Planning Scenario. Under different planning executions, the difference in attractiveness values between the two scenarios, unreasonable planning and no planning, is not sensitive to different risk preferences. However, the difference in land price values enlarges obviously with the increase of risk preferences, making the difference between sums of attractiveness values and land price values smaller with increasing risk preferences (Table 4 and Figure 7). It can be said that the loss of economic benefits due to unreasonable planning is compensated by the reckless decision-makers. For the number of patches, if the decision-maker is cautious, planning can also play a role in reducing the number of patches. On the other hand, if the decision-maker is reckless, planning can even lead to the sprawl of land outside the planning area, increasing the number of patches after planning. At the same time, it is found that the difference of aggregation and proximity degree is not

Table 4: Comparison between results of urban development in unreasonable planning scenario and no-planning scenario.

Attitude	Situation		A	P	Plan (%)	NP	AI	AWCI	A + P
Cautious	No planning		32.25	26.67		8	0.9551	96.89	58.92
	Unreasonable planning	20%	29.18	27.18	83.9	4	0.9689	98.10	56.36
		50%	28.69	27.17	86.1	6	0.9714	98.30	55.86
		80%	28.45	27.16	87.1	8	0.9721	98.39	55.61
	Difference	20%	−3.07	0.51		−4	0.0138	1.21	−2.56
		50%	−3.56	0.50		−2	0.0163	1.41	−3.06
		80%	−3.80	0.49		0	0.017	1.50	−3.31
Neutral	No planning		32.88	26.34		12	0.9494	96.36	59.22
	Unreasonable planning	20%	29.89	27.27	80.1	13	0.9636	97.62	57.16
		50%	29.41	27.27	82.6	9	0.966	97.85	56.68
		80%	29.08	27.27	84.2	6	0.9684	98.07	56.35
	Difference	20%	−2.99	0.93		1	0.0142	1.26	−2.06
		50%	−3.47	0.93		−3	0.0166	1.49	−2.54
		80%	−3.80	0.93		−6	0.019	1.71	−2.87
Reckless	No planning		33.59	25.78		18	0.9415	95.65	59.37
	Unreasonable planning	20%	30.65	27.04	76.8	22	0.9543	96.8	57.69
		50%	30.14	27.12	79.4	20	0.9583	97.18	57.26
		80%	29.84	27.16	80.9	21	0.9604	97.35	57.00
	Difference	20%	−2.94	1.26		4	0.0128	1.15	−1.68
		50%	−3.45	1.34		2	0.0168	1.53	−2.11
		80%	−3.75	1.38		3	0.0189	1.70	−2.37

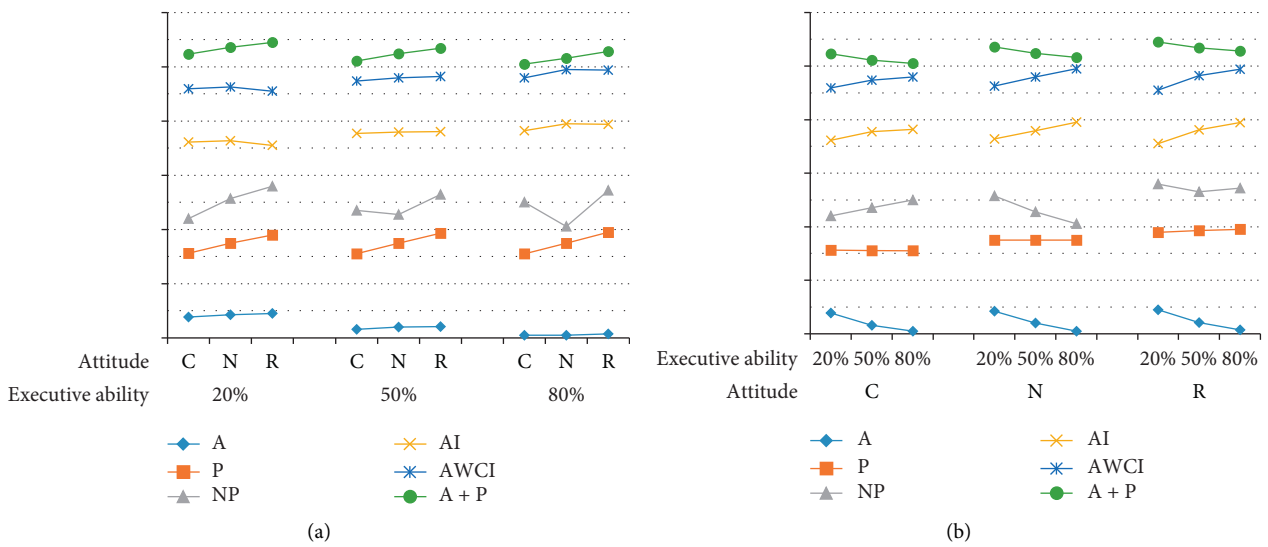


Figure 7: Index comparison between the situations of unreasonable planning and no planning. Notes: dotted line represents 0 value line, underneath the line indicates that the value in the situation of unreasonable planning is smaller than that in the situation of no planning, and otherwise represents bigger.

sensitive to different risk preferences. When the planning is unreasonable, its effect on improving the compactness of urban expansion morphology is limited.

4.2.2. A Comparative Analysis between Reasonable Planning Scenario and Unreasonable Planning Scenario. When the planning and the urban development self-organization law are well coordinated, all indicators, except patch numbers, are better than the violated situation, implying that when the planning is reasonable, both economic benefits and compactness of urban expansion morphology will be improved (Table 5 and Figure 8).

Under different planning executions, for the attractiveness value and land price value, if the urban developer is a reckless decision-maker and is highly motivated to pursue economic interests, the increase of economic benefits under reasonable planning would be limited, with an increase by 0.42 on average. On the contrary, cautious decision-makers, who are easily controlled and guided by the planning, can play a greater role in enhancing the economic values of urban development by 1.54 when the planning is reasonable.

Table 5: Comparison between results of urban development in the situations of reasonable planning and unreasonable planning.

Attitude	Situation		A	P	Plan (%)	NP	AI	AWCI	A + P
Cautious	Unreasonable planning	20%	29.18	27.18	83.9	4	0.9689	98.10	56.36
		50%	28.69	27.17	86.1	6	0.9714	98.30	55.86
		80%	28.45	27.16	87.1	8	0.9721	98.39	55.61
	Reasonable planning	20%	30.04	27.56	87.4	12	0.9714	98.33	57.60
		50%	29.87	27.6	88.1	11	0.9732	98.50	57.47
		80%	29.75	27.62	88.6	10	0.9739	98.56	57.37
	Difference	20%	0.86	0.38	3.5	8	0.0025	0.23	1.24
		50%	1.18	0.43	2.0	5	0.0018	0.20	1.61
		80%	1.30	0.46	1.5	2	0.0018	0.17	1.76
Neutral	Unreasonable planning	20%	29.89	27.27	80.1	13	0.9636	97.62	57.16
		50%	29.41	27.27	82.6	9	0.966	97.85	56.68
		80%	29.08	27.27	84.2	6	0.9684	98.07	56.35
	Reasonable planning	20%	30.19	27.50	87.1	18	0.9675	97.96	57.69
		50%	29.94	27.56	88.2	17	0.9702	98.22	57.50
		80%	29.81	27.59	88.7	15	0.9716	98.35	57.40
	Difference	20%	0.30	0.23	7.0	5	0.0039	0.34	0.53
		50%	0.53	0.29	5.5	8	0.0042	0.37	0.82
		80%	0.73	0.32	4.5	9	0.0032	0.28	1.05
Reckless	Unreasonable planning	20%	30.65	27.04	76.8	22	0.9543	96.80	57.69
		50%	30.14	27.12	79.4	20	0.9583	97.18	57.26
		80%	29.84	27.16	80.9	21	0.9604	97.35	57.00
	Reasonable planning	20%	30.73	27.25	85.4	14	0.9601	97.33	57.98
		50%	30.32	27.38	87.1	18	0.9631	97.59	57.70
		80%	30.11	27.43	88.0	18	0.9655	97.82	57.54
	Difference	20%	0.08	0.21	8.6	−8	0.0058	0.53	0.29
		50%	0.18	0.26	7.7	−2	0.0048	0.41	0.44
		80%	0.27	0.27	7.1	−3	0.0051	0.47	0.54

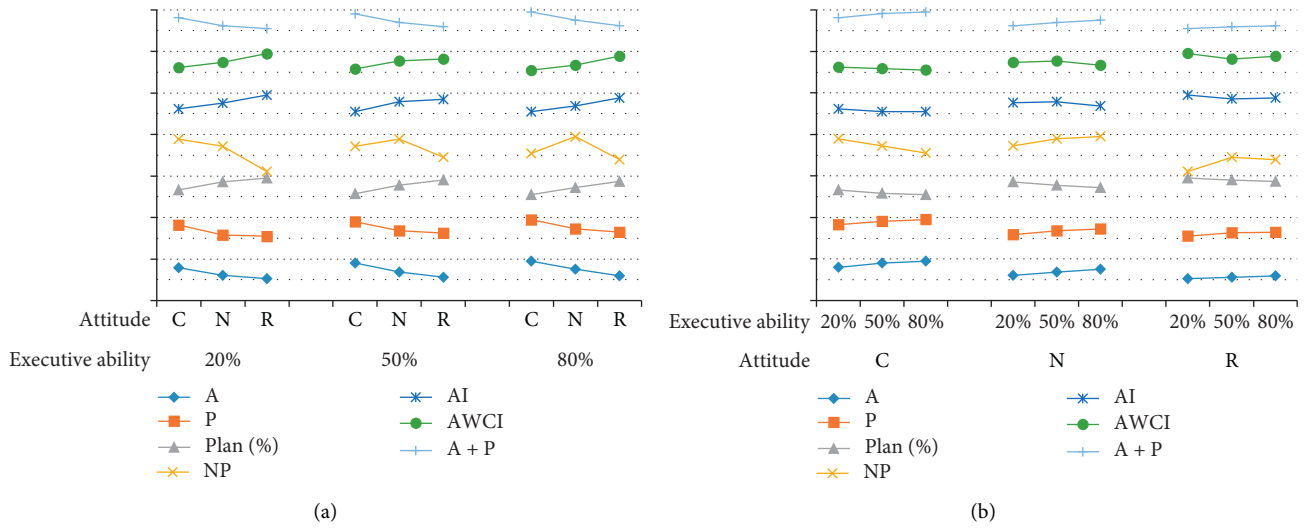


Figure 8: Index comparison between the situations of reasonable planning and unreasonable planning.

In terms of planning implementation, if the urban developer is a cautious decision-maker, whether the planning is reasonable or not, its development behavior tends to conform to the planning. The proportion of land development which conforms to the planning under the situation of reasonable planning is 2% higher than that under the situation of unreasonable planning. However, for a reckless decision-maker, only when the planning is reasonable will the land development be better in line with the planning, and the proportion of land development which conforms to the planning will be increased by 7.8%. For the aggregation and proximity degree, if the developer is a cautious decision-

Table 6: Comparison of utility when enhancing executive ability of planning under different risk preferences.

Situation	Attitude	Executive ability	Plan	AI	AWCI	A + P
Reasonable planning	Cautious	20%	10487	0.9714	98.33	57.60
		80%	10634	0.9739	98.56	57.37
		Difference	147	0.0025	0.23	−0.23
	Reckless	20%	10245	0.9601	97.33	57.98
		80%	10555	0.9655	97.82	57.54
		Difference	310	0.0054	0.49	−0.44
	R		1.10	1.13	1.11	
Unreasonable planning	Cautious	20%	10070	0.9689	98.10	56.36
		80%	10455	0.9721	98.39	55.61
		Difference	385	0.0032	0.29	−0.75
	Reckless	20%	9218	0.9543	96.80	57.69
		80%	9710	0.9604	97.35	57.00
		Difference	492	0.0061	0.55	−0.69
	R		1.4	2.07	2.06	

maker, the planning will control the morphology of the city very well. Under the situation of reasonable planning, agglomeration and proximity index can only be increased by 0.002 and 0.20, respectively. For the reckless decision-maker, only when the planning is reasonable can it avoid the sprawling and leaping development, and the agglomeration and proximity index will be increased by 0.005 and 0.47, respectively.

The analysis above shows that when the executive ability of planning is improved, the economic benefits will be reduced, but the compactness of urban expansion morphology will be improved. If the reduction of economic benefits is considered to be the cost of urban expansion morphology being compact, then the ratio of the compactness enhancement of urban expansion morphology to economic benefits reduction can be regarded as the output-input ratio. Then the output-input ratio can be used to evaluate the performance of the improvement of planning execution ability. If the executive ability of planning is improved, the output-input ratio under the reckless decision-making scenario over that under the cautious decision-making scenario (formula (2)) is greater than 1; then improving the executive ability of planning will have a better effect for the reckless decision-makers:

$$R_i = \frac{\left(\Delta X_{i,\text{Reckless, 20\%}\longrightarrow\text{80\%}}/\Delta(\text{A}+\text{P})_{\text{Reckless, 20\%}\longrightarrow\text{80\%}}\right)}{\left(\Delta X_{i,\text{Cautious, 20\%}\longrightarrow\text{80\%}}/\Delta(\text{A}+\text{P})_{\text{Cautiou, 20\%}\longrightarrow\text{80\%}}\right)} \cdot (i = \text{Plan, AI, AWCI}). \tag{2}$$

As shown in Table 6, the R values are greater than 1, indicating that if the risk preference of the urban development decision-makers is reckless, improving the executive ability of planning is beneficial to the improvement of the compactness of the urban expansion morphology. Also, if the planning is unreasonable, improving the executive ability of planning is more beneficial to improve the compactness of urban space. Otherwise, it will lead to urban sprawling development because reckless decision-makers tend to not stick to the planning. Of course, the most effective way to promote the compact development of the city is still to make a scientific and reasonable planning in order to avoid reckless decision-makers from breaking through planning and leading to the urban sprawling development when the planning is unreasonable.

5. Conclusion and Prospect

With the rapid development of urbanization in China, the urban spatial morphology is undergoing drastic changes, and its evolution process has a complex driving mechanism. At present, the relevant researches still focus on macro factors and did not reveal the influence mechanism from the micro perspective. However, in the process of urban development, different micro decision-makers have different risk preferences, which will inevitably have an impact on the urban expansion morphology. Therefore, it is worth studying how risk preference affects the macro urban expansion morphology, which has important implications for the construction of the internal mechanism between the micro level and macro level in the process of urban expansion. In this study, the computer simulation technology is used to simulate the urban land development outcomes of decision-makers under different risk preferences and to reveal the internal law of the risk preference of micro decision-making behavior on macro urban expansion morphology.

(1) Cautious decision-makers lead to a relatively compact morphology of urban expansion, while reckless decision-makers increase the number of urban patches and decrease aggregation index and area weighted contiguity index, making the urban expansion sprawl. Specifically, the reckless decision-makers, which are greatly affected by the attraction of the city, tend to give priority to the development of attractive areas in the city, resulting in a sprawling and leaping pattern of urban development. Therefore, reckless decision-makers are inclined to pursue maximum economic benefits and are less likely to

take into account the ecological benefits and social benefits, which would be low.

(2) Planning has different binding forces to decision-makers of different risk preferences. Reckless decision-makers are easier to break through the planning. Moreover, when the planning is unreasonable, an average of 6.7% more land will be developed without conforming to the planning under the reckless decision scenario than under the cautious decision-making scenario. When the planning is reasonable, this difference will be reduced to 1.2%. In addition, reckless decision-makers compensate the loss of economic benefits due to unreasonable planning and also lead to the sprawl of land outside the planning area. Therefore, for reckless decision-makers, only when the planning layout follows the self-organization law of urban development will its land development better conform to the planning, avoiding the sprawling and leaping development.

(3) When the execution ability of planning improves, the economic benefits will be reduced, but the compactness of urban expansion morphology will be improved. If the risk preference of urban development decision-makers is reckless, it is favorable for improving the compactness of urban expansion morphology through the improvement of execution ability of planning. If its risk preference is cautious, the role of improving the execution ability of planning is relatively limited. Moreover, if the planning is unreasonable, for reckless decision-makers, it is more favorable for improving the urban space compactness by improving execution ability of planning.

(4) In general, the decision-makers in the process of urban land development, like governments, developers, and residents, have different risk preferences in different areas. These decision-makers are more prone to be reckless in developed areas (i.e., Southeast Coastal Area in China). Meanwhile, the urban development in developed areas is more complicated, and it is hard to predict the urban development in the future. In order to make the urban morphology more compact in developed areas, two recommendations are provided for the planners to follow. First, the planning should consider the law and any influencing factors of urban development as much as possible, prohibiting the reckless decision-makers from breaking through the planning to gain economic benefits. Second, the government should assess the risk preferences of the stakeholders in the process of urban land development and improve the execution ability of planning, especially for the reckless ones, by strengthening supervision, punishment, and other relevant measures. The implementation of the planning should be evaluated regularly to find out whether there is violation of the planning. In addition, the performance of government agencies and personnel in charge should be assessed based on the planning evaluation. Meanwhile, the illegal land developments should be monitored by remote sensing, and the illegal buildings should be demolished and fined. It is necessary to change the rigid planning to flexible planning to deal with the uncertainty of urban development and make the planning more reasonable to conform to the actual situation of future development.

(5) Compared with Ligmann-Zielinska's research [53], there are some similarities. The cautious decision-makers have a positive correlation with a compact landscape, and the reckless decision-makers produce the less clustered development. With that being said, there are some new findings. First, decision-makers of different risk preferences have different responses to the planning. The planning has the function of promoting the urban development compact, but the binding force of planning on the reckless decision-makers is relatively weak, especially when the planning is unreasonable. In addition, once the land development breaks through the planning area, it is usually scattered. Second, the mechanism of how risk preferences of the decision behavior affect the urban expansion morphology was revealed. Decision-makers of different risk preferences have different motivations to pursue economic value, leading to the urban land development outside the planning area. Third, how the planning is strictly implemented depends on how the economic interests and the compactness of the city development are balanced and how risky the decision-makers are. Governments at different levels play an essential role in regulating the planning process and implementation outcomes.

This study explored the internal law of the influence of risk preferences of micro decision-makers on the macro urban expansion morphology in an ideal situation but did not study the risk preferences of different decision-makers in the real urban development process and the function form of risk preference through the method of behavioral economics. In order to formulate specific policies according to the decision-makers with different risk preferences, reasonably guide the coordinated development of urban economic system, social system, and natural system, and improve the compactness of the city, further research is needed in the future.

Data Availability

Data were curated by the authors and are available upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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