

Risk path identification and factor analysis of project capital operation of small and medium-sized real estate enterprises based on the DEMATEL-ISM model

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Abstract. To investigate the risk path identification and factor analysis of project capital operation of small and medium-sized real estate enterprises, this paper compiles 18 risk indicators affecting engineering finance of small and medium-sized real estate enterprises in China based on literature research, and analyzes them based on the Decision-making Trial and Evaluation Laboratory (DEMATEL) method combined with the explanatory structural model (ISM) model, calculate the interrelationship and importance of each risk factor, and systematically stratify them according to their logical structure. The results show that the three indicators of "uncontrolled development progress, inadequate financing channels, and insufficient funds" have the greatest influence on the capital risk of small and medium-sized real estate enterprises, while the three indicators of "lack of an independent capital budgeting system, the imbalance between market supply and demand, and national macro policy restrictions" are the most influential factors. The three indicators of "lack of independent capital budgeting system, unbalanced market supply and demand, and national macro policy restrictions" are the underlying factors affecting the capital risk of small and medium-sized real estate enterprises. The analysis of risk transmission paths and underlying factors conducted in this paper has important warning implications for the project capital management of small and medium-sized real estate enterprises.

Keywords: DEMATEL; ISM; engineering finance; capital risk; real estate projects.

1. Introduction

Due to the characteristics of the real estate industry which requires a large amount of capital and slow capital recovery, the development project capital management of small and medium-sized real estate enterprises faces greater risks and challenges. In the process of investment, operation, and return of engineering funds, they are affected by numerous risk factors. To make small and medium-sized real estate enterprises develop steadily, it is essential to research the financial risk of their real estate engineering funds. Many experts and scholars have already carried out relevant studies.

Wu et al [1] explored the working capital management of real estate enterprises and discussed the measures to improve the working capital management performance of real estate enterprises from a practical perspective. While LIU et al [2] took a specific project as an example and explored the capital flow management of real estate development projects around indicators such as project net cash flow and balance point of own funds. WANG et al [3] established a risk management operation mechanism system around the capital chain of real estate enterprises to actively control and manage the possible risks of project development. ZHANG et al [4] selected eight representative OU, WU, and ZHU et al [5] selected 10 early warning indicators of financial risk of real estate enterprises from the perspective of system science and constructed an early warning model of financial risk of real estate enterprises based on factor analysis method for quantitative research and analysis. WANG et

al [6] introduced the value at risk into the financial risk monitoring index system and constructed a financial risk monitoring model for small and medium-sized real estate enterprises to evaluate the financial risk. WANG and HAN et al [7] improved the entropy assignment method, combined it with the superiority-disadvantage solution distance method and the rank and ratio method, increased the objectivity of the assignment, and further extended the model to make the financial risk evaluation of real estate. The model is further extended to make the financial risk evaluation of real estate listed companies more objective and reasonable, and the risk level is reasonably graded.

Most of the existing studies are directly based on the real estate industry as a whole, without taking into account the difference in the tolerance and sensitivity of large and small enterprises to project capital risk and the difference in the impact factors of risk factors due to the different sizes of enterprises. In this paper, we use a combination of decision laboratory analysis (DEMATEL) and explanatory structural model (ISM) model to study the project financial risk of small and medium-sized real estate enterprises, divide each risk factor, construct a direct influence matrix based on weight calculation, calculate with the DEMATEL method, derive the overall influence matrix to construct the reachable matrix, and finally obtain the hierarchy of each risk factor structure diagram. The DEMATEL-ISM method is proposed to study the capital risk of development projects of small and medium-sized real estate enterprises and to provide decision reference and theoretical support for the capital management.

2. Engineering financial risk factors of small and medium-sized real estate enterprises

2.1 Risk of capital investment

In the development project capital investment of small and medium-sized real estate enterprises, excessive reliance on exogenous financing will lead to too large exogenous debt; builders advance funds, increasing the cycle and risk of subsequent payments; enterprise debt ratio is too high, exceeding the industry average, weak debt servicing capacity, debt risk increases; insufficient financing channels, mainly relying on financial institutions loans, a single channel of financing will further increase the risk of capital; project preliminary feasibility. Insufficient research, resulting in poor decision-making, blindly put into the project funds will also bring unpredictable risks to the project finance.

2.2 Risk of capital operation

In the capital operation of development projects of small and medium-sized real estate enterprises, the lack of cost control measures and monitoring may lead to budget overruns; the lack of an independent capital budget system, and the prediction of capital planning, input, and expenditure without dedicated implementation feedback, which may lead to the problem that the capital input does not match with the actual situation, resulting in the risk of project capital shortage or idle capital; blind investment and expansion of enterprises will lead to a sharp increase in project capital demand, resulting in a large amount of liquidity. Inadequate working capital management will directly lead to low inventory turnover, high inventory in current assets, poor liquidity, and slow capital turnover; out-of-control development progress, the pursuit of speed will lead to an imbalance between input and revenue, and failure to set expenditure based on revenue and production based on sales in the case of tight capital, resulting in. The impact of other uncertain or unexpected factors may also bring capital risk to the project.

2.3 Risk of capital return

In the capital return of the development projects of small and medium-sized real estate enterprises, the unqualified quality of the main project will directly lead to the failure to sell the property and the inability of the enterprise to obtain the returned capital; the national macro policy affects the market,

which may slow down the sales progress of the project and slow down the capital return; the slow recovery of the housing receivables will affect the debt solvency and capital turnover of the enterprise and directly lead to the slowdown of the capital return; the imbalance between supply and demand in the market and the large proportion of the market inventory. A short credit period will lead to loss of consumers and failure to achieve corresponding sales, thus affecting capital recovery; a long credit period will increase financial expenses and cannot guarantee recovery, thus increasing the risk of crash recovery.

In summary, the engineering financial capital risk index system of small and medium-sized real estate enterprises constructed in this paper is shown in Table 1.

Table 1. Project financial capital risk index of small and medium-sized real estate enterprises.

Level indicators	The secondary indicators	Reference
Capital investment risk	Excessive reliance on exogenous financing S_1	[8]
	The builder advances the money S_2	[8]
	The enterprise's capital is insufficient S_3	[5]
	The corporate debt ratio is higher than the industry average S_4	[5]
	Insufficient financing channels S_5	[9]
	The early stage of the project is not feasible enough S_6	[3]
Risk of capital operation	Inadequate cost control measures S_7	[8]
	Lack of independent budget system S_8	[9]
	Companies invested blindly in expansion S_9	[9]
	Inadequate working capital management S_{10}	[10]
	Development schedule out of control S_{11}	[11]
	Influence of uncertainty and unexpected factors S_{12}	[6]
Risk of capital return	The quality of the project is not up to standard S_{13}	[8]
	National macro policy restrictions S_{14}	[8]
	Collection of housing receivables is slow S_{15}	[8]
	The market imbalance between supply and demand S_{16}	[11]
	The market inventory room proportion is large S_{17}	[1]
	Improper credit period S_{18}	[2]

3. DEMATEL Method

Decision-making Trial and Evaluation Laboratory, DEMATEL was a systematic analysis method proposed by scholars A. Gabus and E. Fontela of Battelle Laboratory in 1971 at a conference in Geneva. [12] The advantage of this method is that it can quantify the influence degree and importance of each element in the system, which is helpful to find out the key elements and reduce the complexity of the research problem. It is intuitive, practical, and convenient, and more and more applied to various research fields. Many factors cause the risk of project capital operation of small and medium-sized real estate enterprises, and there is a certain correlation between them. DEMATEL can be used to quantify and analyze the importance of various risk indicators. DEMATEL algorithm steps are as follows:

STEP1 the establishment of direct impact matrix: through the literature survey method to establish a project financial capital risk index system, each index can be marked as $X_1, X_2, \dots, X_n$. Then, experts are asked to score the impact between indicator X_i and indicator X_j , denoted as d_{ij} , therein $d_{ij} = 0, 1, 2, 3, 4$. If the factor X_i has no direct impact X_j , then let $d_{ij} = 0$. If a factor X_i has a direct impact X_j , the evaluation value of the degree of influence is $d_{ij}(d_{ij} = 1, 2, 3, 4)$, and the value d_{ij} increases from 1 to 4 in turn, indicating the deepening of the degree of influence. The degree of influence is respectively expressed as small, general, large, and large. On this basis, the direct impact matrix A is established:

$$A = \begin{bmatrix} 0 & d_{12} & \cdots & d_{1n} \\ d_{21} & 0 & \cdots & d_{2n} \\ \vdots & \vdots & & \vdots \\ d_{m1} & d_{m2} & \cdots & 0 \end{bmatrix} \quad (1)$$

STEP2 Calculation of normalized direct impact matrix F : The row sum maximum method is used to normalize the original matrix A , and the normalized direct impact matrix F is obtained. The calculation formula is as follows:

$$F = \frac{d_{ij}}{\max \left(\sum_{j=1}^n d_{ij} \right)} \quad (2)$$

STEP3 the establishment of comprehensive influence matrix T : Based on a standardized direct influence matrix, the comprehensive influence matrix T is obtained after further calculation, where I is the unit matrix. The calculation formula is as follows:

$$T = (t_{ij})_{n \times n} = F(I - F)^{-1} \quad (3)$$

STEP4 the influence degree and the affected degree are calculated: the influence degree is the sum of the index values of each row in the comprehensive influence matrix T , denoted as P_i ; the influence degree is the sum of the index values of each column in the comprehensive influence matrix T , denoted as C_i . The calculation formula is as follows:

$$P_i = \sum_{j=1}^n t_{ij}, (i = 1, 2, \dots, n) \quad (4)$$

$$C_i = \sum_{j=1}^n t_{ji} \quad (5)$$

STEP5 Calculation centrality and cause degree: centrality is the sum of influence degree and affected degree, denoted as M_i ; the reason is to calculate Q_i by subtracting the influence degree and the affected degree. The calculation formula is as follows:

$$M_i = P_i + C_i \quad (6)$$

$$Q_i = P_i - C_i \quad (7)$$

4. ISM Method

Interpretative Structural Modeling (ISM) is a systematic engineering research method first proposed by Professor Warfield of the United States in 1973. This method reflects the logical relationship among the elements of the system more intuitively by constructing a multi-level ladder model. The advantage of this approach is that it can effectively stratify a complex system, and the logical relationship between the elements can be demonstrated, with intuitive and universal applicability. The factors that cause the risk of engineering financial funds are not completely independent. The ISM method can show the hierarchical structure and the logical relationship between the various risk indicators. It is conducive to discovering the path transmission mechanism of risks and discovering the root causes of risks. ISM algorithm steps are as follows:

STEP1 the establishment of adjacency matrix: experts are asked to score the impact between indicator X_i and indicator X_j , and if the indicator X_i has no direct impact on the indicator X_j , let $d_{ij} = 0$. If the index X_i has a direct impact X_j , then $d_{ij} = 1$. Specifically, we can use the direct influence matrix in the previous DEMATEL analysis method to obtain the adjacency matrix, denoted as S , by re-assigning the values of 1, 2, 3, and 4 to 1, and the others remain unchanged.

STEP2 the reachability matrix is calculated as follows: the reachability matrix is calculated according to the law of passage and Boolean operation, which is used to represent the reachability of certain two indicators after a certain path. Where I is the unit matrix, and the order of the adjacency matrix S is n . Let $S_1 = S + I$, $S_2 = (S + I)^2$, ..., $S_n = (S + I)^n$, the calculation formula is as follows:

$$R = S_{n-1} = (S + I)^{n-1} \quad (8)$$

STEP3 The reachable matrix is decomposed to determine the reachable set, the antecedent set, and the intersection set: let the reachable set corresponding to each index be R , which is the index set containing '1' in the corresponding row; let the leading set of each index be Y , which is the index set of its corresponding column containing '1'; let the intersection be Z , then $Z = R \cap Y$.

STEP4 Hierarchical decomposition is carried out to draw a multilevel hierarchical directed graph. The reachable set antecedently set an intersection set corresponding to each index, it is verified by the formula $R_i \cap Z_i = R_i$. If the equation is established, it means that the corresponding index i R_i can find the antecedent Z_i . This index is a high-level index, and then the corresponding rows and columns are divided from the reachable matrix, and the highest-level index is extracted from the residual matrix. This process is repeated until all rows and columns are divided, the hierarchical decomposition graph is obtained, and it is drawn into a multilevel hierarchical directed graph.

5. Analysis of factors affecting the capital risk of development projects of small and medium-sized real estate enterprises

5.1 DEMATEL analysis

We invited ten experts from the industry to rate the impact indicators and assign values to the mutual influence relationships among the indicators, and the five levels of extra strong, strong, average, weak, and none were assigned as 4, 3, 2, 1, and 0, to obtain the impact matrix of the capital risk evaluation indicators of the development projects of small and medium-sized real estate enterprises as shown in Table 2.

The combined influence matrix is calculated on the basis of the direct influence matrix, and the influence degree (D), the influenced degree (C), the centrality degree (D+C) and the cause degree (D-C) are obtained. The results are shown in Table 3.

The value of the cause index obtained by subtracting the degree of influence and the degree of being influenced reflects the degree of correlation among the influencing factors. In table 4, there are

11 causal factors, including S_3 insufficient capital, S_6 insufficient pre-project feasibility, S_8 lack of independent capital budgeting system, S_9 blind investment expansion, S_{10} insufficient working capital management, S_{12} uncertain and unexpected factors, S_{14} national macro policy restrictions, S_{15} slow recovery of housing receivables, S_{16} the imbalance between market supply and demand, S_{17} large proportion of market inventory, and S_{18} inappropriate credit period. Among them, national macro policy restrictions (1.255), lack of independent capital.

Table 2. Matrix of direct effects among the factors.

	S_1	S_2	S_3	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	S_{18}
s_1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
s_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
s_3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
s_4	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
s_5	0	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
s_6	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0
s_7	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
s_8	0	0	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0
s_9	0	1	0	0	0	0	0	0	0	3	0	2	0	0	0	0	0
s_{10}	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
s_{11}	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
s_{12}	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
s_{13}	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
s_{14}	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0
s_{15}	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
s_{16}	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0
s_{17}	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
s_{18}	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Table 3. DEMATEL calculated index values.

	Impact degree D	Influenced degree C	Centrality D+C	Reason degree D-C
s_1	0.630	0.846	1.475	-0.216
s_2	0	1.950	1.950	-1.950
s_3	1.296	0.691	1.988	0.605
s_4	0.889	0.897	1.786	-0.008
s_5	0.778	1.282	2.060	-0.504
s_6	0.778	0	0.778	0.778
s_7	0.167	0.500	0.667	-0.333
s_8	0.806	0	0.806	0.806
s_9	1.167	0.444	1.611	0.722
s_{10}	0.167	0	0.167	0.167
s_{11}	0.333	2.150	2.483	-1.816
s_{12}	0.389	0	0.389	0.389
s_{13}	0	0.981	0.981	-0.981
s_{14}	1.255	0	1.255	1.255
s_{15}	0.765	0.574	1.340	0.191
s_{16}	0.987	0.333	1.320	0.654
s_{17}	0.588	0.222	0.811	0.366
s_{18}	0.677	0	0.677	0.677

Budgeting system (0.806), and insufficient pre-project feasibility (0.778) ranked in the top three, showing that the factors affecting the capital risk of development projects are most likely to be affected by these three factors. There are seven outcome factors, including s_1 over-reliance on exogenous financing, s_2 advances from builders, s_4 corporate debt ratio higher than the industry average, s_5 insufficient financing channels, s_7 insufficient cost control measures, s_{11} uncontrolled development progress, and s_{13} substandard project quality. The top three factors are advances from builders (-1.950), uncontrolled development progress (-1.816), and substandard construction quality (-0.981), indicating that among the factors influencing the capital risk, these three factors are most vulnerable to other factors.

The centrality obtained by adding the influence degree and the influenced degree reflects the degree of influence of each influence factor on the financial risk, and the higher the centrality indicates the greater the influence of the influence factor. As shown in Table 3, the three factors with the highest centrality are s_{11} uncontrolled development progress (2.483), s_5 insufficient financing channels (2.060), and s_3 insufficient funds (1.988), which indicate that these three factors have a great influence on the financial risk, and enterprises need to pay more attention to them.

5.2 ISM Analysis

Based on the inability of DEMATEL to delineate the structural level of the system of factors influencing the capital risk of the development projects, as well as the inability to identify their fundamental elements of them, the ISM method is used to remedy the above-mentioned shortcomings. In the following paper, the ISM method is used to establish the structural hierarchy model of the financial risk impact factor system. Firstly, the adjacency matrix is obtained according to the direct influence matrix, and then the adjacency matrix is summed up with the unit matrix and calculated to obtain the reachable matrix as Table 4.

The reachability matrix is constructed based on the ISM model. The reachable matrix shows whether there is a connecting path between elements. Number 1 means there is a path from one element to another, and number 0 means there is no path from one element to another, as in Table 4. Construct the reachable set and prior set of factors from the correlation of the influencing factors in the reachable matrix, and draw the hierarchical structure of the influencing factors, as in Figure 1.

Table 4. Reachable matrix.

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}	S_{18}
s_1	1	1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	0	1
s_2	1	1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	0	1
s_3	1	1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	0	1
s_4	1	1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	0	1
s_5	1	1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	0	1
s_6	1	1	1	1	1	1	0	0	0	0	1	0	1	0	1	0	0	1
s_7	1	1	1	1	1	0	1	0	0	0	1	0	1	0	1	0	0	1
s_8	1	1	1	1	1	0	1	1	0	0	1	0	1	0	1	0	0	1
s_9	1	1	1	1	1	0	0	0	1	0	1	0	1	0	1	0	0	1
s_{10}	1	1	1	1	1	0	0	0	0	1	1	0	1	0	1	0	0	1
s_{11}	1	1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	0	1
s_{12}	1	1	1	1	1	0	0	0	0	0	1	1	1	0	1	0	0	1
s_{13}	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
s_{14}	1	1	1	1	1	0	0	0	1	0	1	0	1	1	1	1	1	1
s_{15}	1	1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	0	1
s_{16}	1	1	1	1	1	0	0	0	1	0	1	0	1	0	1	1	1	1
s_{17}	1	1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	1	1
s_{18}	1	1	1	1	1	0	0	0	0	0	1	0	1	0	1	0	0	1

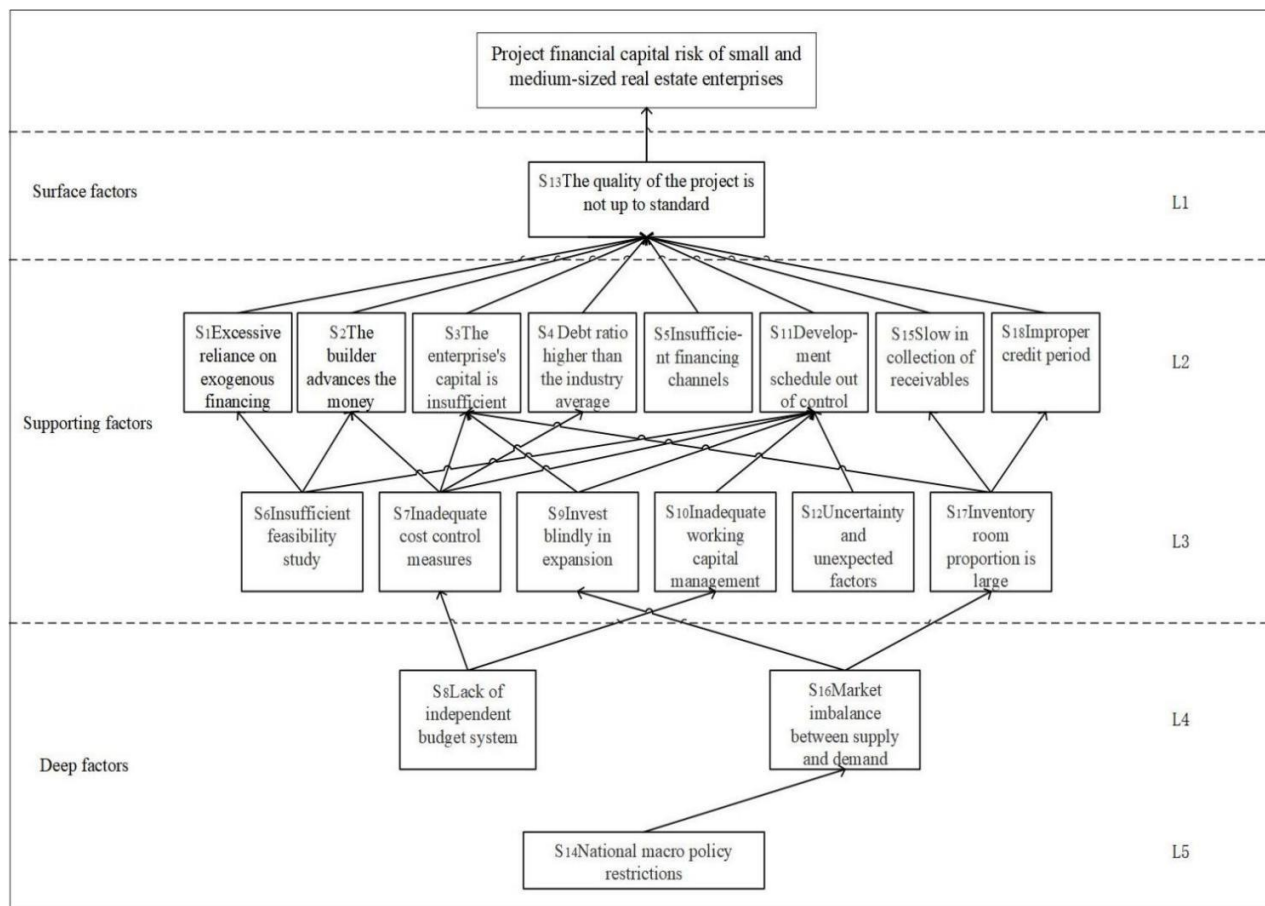


Figure 1. Hierarchical structure of influencing factors.

From the figure 1, it can be seen that the influencing factors of financial risks of development projects of small and medium-sized real estate enterprises are a multi-level hierarchical structure with five levels.

The first layer of factors is the surface layer, S_{13} engineering quality failure, which has the most direct impact on the capital risk of development projects. Since all the influencing factors from the second to the fifth layer ultimately point to the first layer of engineering quality failure factor through different paths and ways, it also shows that engineering quality failure is the most direct cause of the capital risk of the development projects.

The second and third tiers of influencing factors, as intermediate tiers, are those that affect the capital risk of development projects of small and medium-sized real estate enterprises through direct factors. Among them, the influencing factors in the second layer include S_1 over-reliance on exogenous financing, S_2 the advance of funds by builders, S_3 insufficient enterprise capital, S_4 enterprise's debt ratio higher than the industry average, S_5 insufficient financing channels, S_{11} uncontrolled development progress, S_{15} slow recovery of property receivables, and S_{18} inappropriate credit period.

The third layer of influencing factors includes S_6 insufficient pre-project feasibility, S_7 insufficient cost control measures, S_9 blind investment expansion, S_{10} insufficient working capital management, S_{12} uncertainty and unexpected factors, S_{17} large proportion of market inventory. These factors act on the surface factors through different paths and indirectly affect the capital risk of development projects.

The fourth and fifth-tier factors are also the most basic factors and deep-rooted causes of capital risk for development projects of small and medium-sized real estate enterprises, including S_8 lack of

independent capital budgeting system, S_{16} market supply and demand imbalance, and S_{14} national macro policy restrictions. Among them, national macro policy restrictions as the underlying factor affect all the remaining indicators through different paths and are the most fundamental factor.

5.3 Recommendations

Real estate development projects are characterized by large capital investment, long construction period and strong complexity, so the pre-project feasibility study stage and the whole process of capital management are very important for the normal operation of the project. Small and medium-sized real estate enterprises are less able to resist risks, so they should pay more attention to the analysis of the feasibility study stage, cost control and working capital management, to reduce the impact of uncertainties and unexpected factors, and ensure the normal operation of the project.

With the development of the real estate industry and the improvement of people's requirements for living standards, the operational characteristics of real estate enterprises have gradually changed from rough and tumble to meticulous work, which has put forward higher requirements for the engineering quality of real estate projects. In addition, in the construction works of real estate development projects, the risk brought by unqualified quality is often huge and irreversible, so real estate enterprises should always put the quality of project engineering in first place and regard it as the most basic condition of project construction.

The development of the real estate market is related to the rise and fall of the national economy. The macro policies related to the real estate industry reflect the national institutional arrangements and ensure that the development of the real estate market does not contradict the social development, which has an important impact on the whole process of project development of real estate enterprises. Therefore, small and medium-sized real estate enterprises should actively understand and analyze the latest national macro policies, grasp the real-time trends of the real estate market, and make scientific adjustments and responses to avoid possible risks to the maximum extent.

6. Conclusion

Through literature research, this paper finds out the relevant indicators that affect the engineering capital risk of small and medium-sized real estate enterprises. DEMATEL is used to calculate the impact degree, affected degree, centrality, and cause a degree of the indicators, and the importance of each risk indicator is obtained to find out the key indicators. On this basis, through the ISM model to establish the impact of small and medium-sized real estate enterprise capital risk multi-tier ladder structure model, combing the logical relationship between the various risk indicators. The conclusions are as follows:

(1) In DEMATEL, the three indicators of 'out of control of development progress, insufficient financing channels, and insufficient funds of enterprises themselves' have the greatest impact on the operational risk of project funds in small and medium-sized real estate enterprises, and enterprises need to focus on control in this regard.

(2) In the ISM, the lack of an independent capital budget system, the imbalance between market supply and demand, and the limitation of national macro policy are the underlying factors that affect the operation risk of project funds of small and medium-sized real estate enterprises. They affect the middle-level and surface indicators in different ways, thereby increasing the risk of enterprise funds and responding to their focus.

Acknowledgments

The order of the author's name is in alphabetical order, and the workload of each author is equivalent.

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