

Study on the identification of risk paths for financing small and medium-sized technology enterprises based on ISM-MICMAC model

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Abstract. To reduce the financial risk of small and medium-sized technology companies and to identify the risk surface. This paper constructs a system of 12 indicators affecting the financing risk of small and medium-sized enterprises from 3 aspects, secondly, ISM (explanatory structural model) and MICMACM (cross-influence matrix multiplication method) models are constructed respectively; the hierarchy is carried out by ISM and the MICMAC model is used to carry out the influence and dependence relationship between factors. The results show that: the influencing factors of financing risk path of small and medium-sized technology enterprises are divided into dependent factors, linkage factors and independent factors; no influencing factors exist in the quadrant of spontaneous factors; the operation of financial institutions, profitability level and internal accumulation level are dependent factors with high dependence and low driving force, which are the key factors directly affecting the financing risk of small and medium-sized technology enterprises; the legal system, construction of financial institutions, circulation of monetary funds, Independent factors include only government policies, which have a high driving force and will affect the whole body when they occur, and are the key factors to reduce the financing risks of small and medium-sized technology enterprises. They should be carefully considered when making decisions.

Keywords: ISM; MICMAC; risk analysis.

1. Introduction

Small and medium-sized science and technology enterprises are the main driving force for the development of high-tech industries in developing countries and determine the development of a country's economic level. Small and medium-sized science and technology enterprises refer to market-oriented knowledge-intensive economic entities engaged in the development, production and sales of high-tech products, with the commercialization of scientific and technological achievements and technology transfer, technical services and technical consultation as the main content. The quality of its development directly determines the development of the economic level of developing countries. So there are many studies in this area.

Chi[1] Through the analysis of the financing environment of technology-based private SMEs, it is found that the lack of policy interpretation, single financing means, and inability to attract the attention of commercial banks are the main reasons hindering the development of enterprises themselves, and the financing risks of enterprises in the process of operation and development of technology-based private SMEs are identified and analyzed. Yuan[2] analyzes the risks faced by small and medium-sized technology enterprises in the growth, maturity and recession periods of seed stage, start-up stage from the perspective of commercial banks, and concludes that commercial banks need to provide financing services to technology-based SMEs in different life cycles, they need to conduct targeted financing risk assessment and financing capacity evaluation, so as to formulate corresponding financing strategies. Ji[3] analyzes the financing problems of technology-based SMEs such as small scale, irregular operation, and non-disclosure of finance, and puts forward a supply chain with integrity, outsourcing, risk control and sustainability as a new financing model to give play to the promotion role of supply chain risk control and better promote the control of supply chain

finance in the service field. Jin and Ni[4] based on the life cycle theory to analyze the current situation of small and medium-sized science and technology enterprises in different cycles, and then use the evaluation index of enterprise technological innovation activities, the index of potential technological innovation resources of enterprises, the indicators of enterprise technological innovation environment, and the indicators of enterprise technological innovation output to construct corresponding performance evaluation systems, and conclude that small and medium-sized technology enterprises should not only establish a sound financing risk assessment system, but also strengthen the training of enterprise managers. CAI[5] compares the project financing situation of small and medium-sized technology enterprises in China at this stage and analyzes the financing characteristics of different projects, and concludes that the causes of risk are imperfect credit guarantee system, limitations in internal organizational forms and management models of science and technology enterprises, imperfect financing mechanisms for science and technology enterprises, and lack of management talents.

Several academics have identified the funding concerns that small and medium-sized technology enterprises must deal with. They have presented their results using model analysis and theoretical analysis, and they are highly important. The following two shortcomings are shown by this paper's assessment of the literature since the risks connected to a company's financing are interconnected and indivisible in many ways: It is challenging to create a comprehensive indicator system due to two factors: first, the number of influencing factors that scholars have studied is limited and not comprehensive enough; and second, there is no logical classification of indicators in the selection of indicators and the number of selected indicators is small. As a consequence, this research uses measures from different angles to develop an index system employing information from the original literature. After that, it investigates how to identify funding risk paths for small and medium-sized technology businesses.

2. Construction of financing risk index system for small and medium-sized technology enterprises

The political environment, economic environment and the internal environment of enterprises are selected as the first-level indicators, and the government policy (x_1) and legal system (x_2) are selected as the indicators of the political environment. Select the construction of financial institutions (x_3), the operation of financial institutions (x_4), the circulation of money and funds (x_5), and the credit guarantee (x_6) as indicators of the economic environment; The growth of the enterprise (x_7), the level of profitability (x_8), the level of R&D activities (x_9), the level of internal accumulation (x_{10}), the symmetry of information (x_{11}), and the risk control (x_{12}) are selected as indicators of the internal environment of the enterprise. Among them, government policies reflect the state's support for small and medium-sized enterprises, and the legal system reflects the legal protection of small and medium-sized enterprises in terms of financing, such as loans and listings; The construction of financial institutions reflects the number of institutions that are compatible with the construction of small and medium-sized enterprises, the operation of financial institutions reflects the operation mechanism of bank financial institutions that constrain the financing of small and medium-sized enterprises, the circulation of money and funds reflects the level of the asset-liability ratio of enterprises, whether enterprises are inclined to borrow to expand their scale, and credit protection reflects the important factors for obtaining external financing resources; Enterprise growth reflects the development prospects of small and medium-sized enterprises, the growth rate of the main business is used to explain the growth of the enterprise, the profit level reflects the specific indicators of the business results of the enterprise, the research and development activities reflect the innovation ability of small and medium-sized enterprises, the internal accumulation level reflects whether small and medium-sized enterprises give priority to their own retained profits for internal financing, reducing

dependence on external funds, information symmetrically reflects the degree of understanding of enterprise managers on the finance, operation and other aspects of the enterprise, and risk control reflects the choice of financing methods of enterprises, such as online lending.

In summary, the index system constructed in this paper is shown in Table 1.

Table 1. Construction of financing risk index system for small and medium-sized technology enterprises

Tier 1 indicators	Secondary indicators	Metric code	REF
Political environment	Government policy	x_1	[1]
	Legal system	x_2	[1]
economic environment	economic environment	x_3	[2]
	Financial institutions operate	x_4	[2]
	Circulation of monetary funds	x_5	[2]
	Credit Protection	x_6	[6]
The internal environment of the enterprise	Enterprise growth	x_7	[7]
	Profitability level	x_8	[6]
	R&D activities	x_9	[6]
	Internal accumulation level	x_{10}	[7]
	Information symmetry	x_{11}	[6]
	Risk control	x_{12}	[6]

3. ISM Method

ISM (Interpretative Structural Modelling) [8] is an analysis method commonly used in the field of systems engineering, which can discover general patterns in systems and can transform ambiguous ideas into intuitive models with good structure, especially suitable for the analysis of systems with many variables and complex relationships without clear structure, and also for ranking of programs. In this paper, the ISM model is used to analyze the financing risks of small and medium-sized technology enterprises. The steps of ISM are as follows.

STEP1: Provide adjacency matrix, i.e. the original data.

STEP2: Compute the adjacency matrix and add the unit matrix to obtain the new matrix.

STEP3: Calculate the reachable matrix. The reachable matrix formula is: reachable matrix = adjacency matrix + unit matrix. The number 1 in the reachable matrix indicates that there is a path between an element and another element, and the number 0 indicates that there is no path from an element to another element.

STEP4: The attainable set R represents the set of elements in the corresponding row of an element of the attainable matrix that contains 1, while the prior set Q represents the set of elements in the corresponding column of an element of the attainable matrix that contains 1. STEP4: Calculate the attainable set, the prior set, and their sub-tables, which include the attainable set R, the prior set Q, and the intersection of the two sets, i.e., the intersection $A=RQ$. The intersection of the preceding set Q and the reachable set R is represented by the intersection set A.

STEP5: Calculation to obtain the hierarchical decomposition, which is used to show the relationship between the hierarchical distribution of the elements.

4. MICMAC Method

MICMAC (Mtarices Impacts Croises-Multiplication Classement) [9] is a method proposed by Duperrin and Goddet to analyze the interrelationships and interactions between system factors, and

is commonly used to identify variables in systems with high dynamics and tell dependencies. The MICMAC analysis method applies the principle of matrix multiplication. If the first factor directly affects the second factor, and the second year factor directly affects the third factor, then all changes in the first factor can be transferred to the third factor, and there is an indirect influence relationship between the first factor and the third factor, and so on.

The results of MICMAB analysis are graphically represented by axes, also known as the driver-dependency matrix, where the horizontal coordinates represent the dependencies and the vertical coordinates represent the drivers. The driving force of an element can be obtained by calculating the number of elements that can reach it, and the dependency can be obtained by calculating the number of elements that reach it, which divides the elements into four clusters: 1 independent cluster, 2 dependent cluster, 3 linked cluster, and 4 spontaneous cluster. After determining the recursive structure of each influencing factor by constructing the ISM model, MICMAC is then used to further determine the position and role of the influencing factors in order to analyze the financing risks of small and medium-sized technology enterprises in a more targeted manner.

5. Empirical analysis

5.1. ISM Hierarchy Analysis

In this paper, 20 experts in the field of modern business were invited to conduct a structured questionnaire survey, in which they scored the above 12 indicators in a two-way influence relationship based on their experience and professional perceptions into four measures, with the scoring criteria of 0 (no influence), 1 (weak influence), 2 (medium influence), and 3 (strong influence). In order to prevent the subjective looseness of the scores given by the experts from offsetting the variability of the impact, 15 questionnaires that were given relatively tight scores were selected for the study. To eliminate individual differences, their scores were averaged and rounded to construct the adjacency matrix $A = (a_{ij})_{N \times N}$, the matrix element $a_{ij} = 1$ when the element S_i has an influence on S_j , and the matrix element $a_{ij} = 0$ when the element S_i has no influence on S_j . As shown in Table 2, the listed 12 influencing factors and their ^{direct} binary relationships with each other form a matrix of order A. This matrix is the adjacency matrix of the risk path of financing for small and medium-sized technology enterprises.

Table 2. Adjacency matrix

Factors	f ₁	f ₂	f ₃	f ₄	f ₅	f ₆	f ₇	f ₈	f ₉	f ₁₀	f ₁₁	f ₁₂
f ₁	0	1	0	1	1	0	0	0	0	0	0	0
f ₂	0	0	0	0	0	1	1	0	1	0	0	1
f ₃	0	0	0	0	1	0	0	0	0	0	0	1
f ₄	0	0	0	0	0	0	0	0	0	0	0	0
f ₅	0	0	0	1	0	0	0	0	0	0	0	1
f ₆	0	0	0	0	0	0	1	0	0	0	0	0
f ₇	0	0	0	0	1	0	0	1	1	0	0	0
f ₈	0	0	0	0	0	0	0	0	0	1	0	0
f ₉	0	0	1	0	0	0	0	1	0	1	0	0
f ₁₀	0	0	0	0	0	0	0	0	0	0	0	0
f ₁₁	0	1	0	0	0	0	0	1	0	0	0	0
f ₁₂	0	0	0	0	0	0	0	0	0	0	1	0

The distribution of elements at each level is examined using the adjacency matrix, and matrix B, the reachable matrix of the financing risk path for small and medium-sized technology enterprises, can be constructed by adding the adjacency matrix and the unit matrix, as shown in Table 3.

Table 3. Reachable matrix

Factors	f ₁	f ₂	f ₃	f ₄	f ₅	f ₆	f ₇	f ₈	f ₉	f ₁₀	f ₁₁	f ₁₂
f ₁	1	1	1	1	1	1	1	1	1	1	1	1
f ₂	0	1	1	1	1	1	1	1	1	1	1	1
f ₃	0	1	1	1	1	1	1	1	1	1	1	1
f ₄	0	0	0	1	0	0	0	0	0	0	0	0
f ₅	0	1	1	1	1	1	1	1	1	1	1	1
f ₆	0	1	1	1	1	1	1	1	1	1	1	1
f ₇	0	1	1	1	1	1	1	1	1	1	1	1
f ₈	0	0	0	0	0	0	0	1	0	1	0	0
f ₉	0	1	1	1	1	1	1	1	1	1	1	1
f ₁₀	0	0	0	0	0	0	0	0	0	1	0	0
f ₁₁	0	1	1	1	1	1	1	1	1	1	1	1
f ₁₂	0	1	1	1	1	1	1	1	1	1	1	1

If a link path exists between the components, it may be seen in the reachability matrix. If the value is 1, it indicates that there is a path from one element to another, and if it is zero, there is no such path[10].

The hierarchical distribution may be broken down into the following categories, as illustrated in Table 4, in accordance with the attainable matrix: 1. the reachable set R, which denotes the collection of elements in the "reachable matrix" when each element's associated row contains one (1); 2. the preceding set Q, which stands for the collection of elements in the corresponding column of the "reachable matrix" that include the number 1. The intersection of the preceding set Q and the reachable set R is represented by the intersection set A.

Table 4. Table of reachable sets and prior sets and their intersections

Factors	Accessible set R	Advance assembly Q	Intersection A = R ∩ Q
f ₁	1,2,3,4,5,6,7,8,9,10,11,12	1	1
f ₂	2,3,4,5,6,7,8,9,10,11,12	1,2,3,5,6,7,9,11,12	2,3,5,6,7,9,11,12
f ₃	2,3,4,5,6,7,8,9,10,11,12	1,2,3,5,6,7,9,11,12	2,3,5,6,7,9,11,12
f ₄	4	1,2,3,4,5,6,7,9,11,12	4
f ₅	2,3,4,5,6,7,8,9,10,11,12	1,2,3,5,6,7,9,11,12	2,3,5,6,7,9,11,12
f ₆	2,3,4,5,6,7,8,9,10,11,12	1,2,3,5,6,7,9,11,12	2,3,5,6,7,9,11,12
f ₇	2,3,4,5,6,7,8,9,10,11,12	1,2,3,5,6,7,9,11,12	2,3,5,6,7,9,11,12
f ₈	8,10	1,2,3,5,6,7,8,9,11,12	8
f ₉	2,3,4,5,6,7,8,9,10,11,12	1,2,3,5,6,7,9,11,12	2,3,5,6,7,9,11,12
f ₁₀	10	1,2,3,5,6,7,8,9,10,11,12	10
f ₁₁	2,3,4,5,6,7,8,9,10,11,12	1,2,3,5,6,7,9,11,12	2,3,5,6,7,9,11,12
f ₁₂	2,3,4,5,6,7,8,9,10,11,12	1,2,3,5,6,7,9,11,12	2,3,5,6,7,9,11,12

The results show that the factors influencing the financing risk path of small and medium-sized technology enterprises can be divided into 4 layers, and these 4 layers of influencing factors are divided into 3 layers, namely, the direct factor layer, the core factor layer and the deep factor layer. The direct factor layer includes the first layer in the table (f₄ financial institution operation, f₁₀ internal accumulation level), the core factor layer includes the second layer in the table (f₈ profitability level), the third layer (f₂ legal system, f₃ financial institution construction, f₅ money flow, f₆ credit guarantee, f₇ enterprise growth, f₉ R&D activities, f₁₁ information symmetry, f₁₂ risk control), and the deep factor layer includes the fourth layer in the table (f₁ government policy) [11].

The hierarchical relationship schematic is a graphical presentation of the adjacency matrix, as shown in Figure 1.

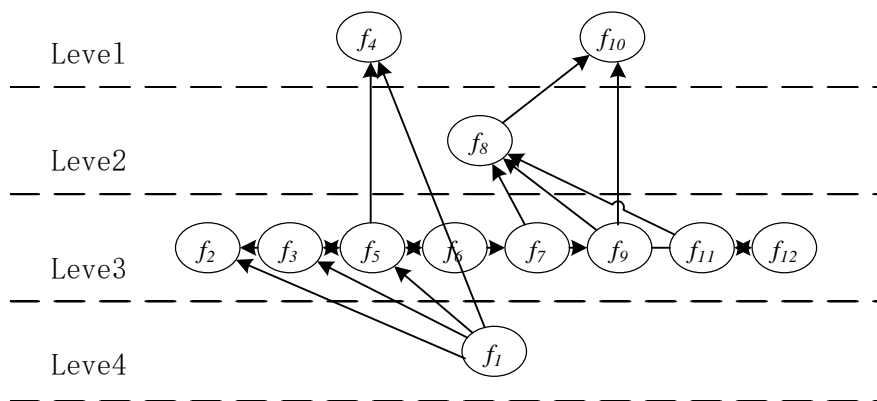


Figure 1. Schematic diagram of the hierarchical relationship

The direct factor layer is the most representative evaluation index that can intuitively judge and reflect the financing risk path of small and medium-sized technology enterprises. The direct factor is the result of the operation and function of the core factors, and is fed back to the direct factors. The operation of f4 financial institutions is affected by f1 government policy and f5 monetary fund circulation, while the internal accumulation level of f10 is related to the triangular influence of f8 profit level and f9 R & D activities in the core factor layer.

The core factor layer plays a top-down role in the interplay between the risk paths of SME financing. f8 profitability level depends on f7 enterprise growth, f9 R&D activities and f11 information symmetry, and acts on f10 internal accumulation level, and L3 has a large and controllable influence on L2.

Deep factor layer f1 Government policies are the basis and prerequisite for influencing the risk path of financing for SMBs in science and technology. Therefore, reducing the financing risk of small and medium-sized technology enterprises requires giving full play to the role of the government and focusing on changes in the external environment.

5.2. MICMAC calculation and analysis

Based on the MICMAC model constructed in Section 4, the driving forces and dependencies of each indicator are calculated and shown in Table 5[12].

Table 5. Statistical results of drivers and dependencies of influencing factors

Factors	Driving force (x)	Dependency (y)
f1	12	1
f2	11	9
f3	11	9
f4	1	10
f5	11	9
f6	11	9
f7	11	9
f8	2	10
f9	11	9
f10	1	11
f11	11	9
f12	11	9

The MICMAC cluster classification diagram of factors influencing the financing risk path of small and medium-sized technology enterprises can be drawn in accordance with the following MICMAC model construction after using the ISM model to analyze the factors influencing the financing risk path of small and medium-sized technology enterprises, as shown in Figure 2.

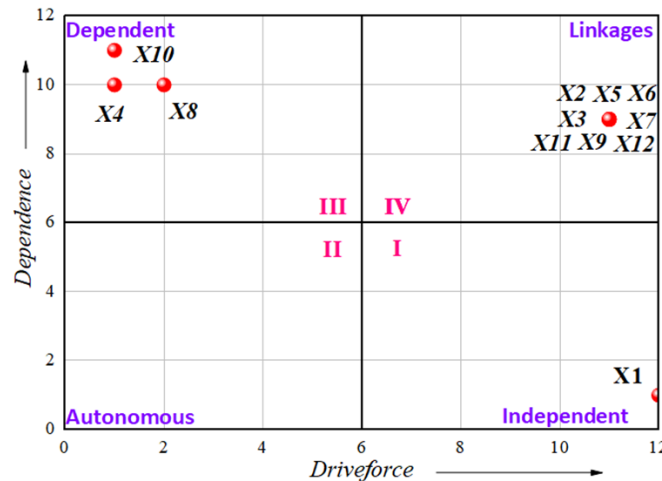


Figure 2. MICMAC result

According to the MICMAC cluster classification in Figure 2, it can be seen that the factors influencing the financing risk path of small and medium-sized technology enterprises are mainly dependent factors, linkage factors and independent factors, and no influencing factors exist in the spontaneous factors quadrant. Further analysis shows that.

Dependency factors include f_4 financial institution operation, f_8 profitability level, and f_{10} internal accumulation level. The dependency factors show high dependency and low driving force, indicating that these factors are influenced by other factors and are the key factors that directly affect the financing risk of SMBs, and they also need to pay more attention to this and pay attention to their chain reaction when SMBs assess their financing risk.

The linkage factors include f_2 legal system, f_3 financial institution construction, f_5 money flow, f_6 credit guarantee, f_7 enterprise growth, f_9 R&D activities, f_{11} information symmetry, f_{12} risk control, the linkage factors have a relatively high dependence and drive, there is a large instability between them, each factor will affect each other, this part of the factors is less controllable, small and medium-sized technology enterprises on this aspect of the factors The decision related to this aspect needs multiple considerations.

Independent factors only include f_1 government policies, independent factors have a high driving force, and when they undergo certain changes, they will have a greater impact on the whole system. It can be concluded that this type of factor is the focus of reducing the financing risk of small and medium-sized technology enterprises, and taking the lead in solving the problems of such factors can help solve the problems of other factors, but at the same time, the relevant decisions involving independent factors should be more deliberate.

6. Conclusion

6.1. ISM Model

The ISM model is used to hierarchically divide the 12 main influencing factors into 4 main measures. In order to eliminate individual differences, thus constructing the adjacency matrix A, and then analyzing the distribution of elements at each level based on the adjacency matrix, constructing matrix B; the results show that the impact of financing risk path of small and medium-sized technology enterprises is divided into 4 layers, and the 4 layers of influencing factors are divided into 3 layers, which are the direct factor, core factor layer and deep factor layer. The direct factor layer includes the first layer in the table (f_4 financial institution operation, f_{10} internal accumulation level), and the analysis results show that f_4 financial institution operation is influenced by f_1 government policies and f_5 money flow, while f_{10} internal accumulation level constitutes a triangular influence relationship with f_8 profitability level and f_9 R&D activities in the core factor layer; the core factor layer includes the second layer in the table (f_8 profitability level), which has an impact on the

financing of small and medium-sized technology enterprises The mutual influence between risk paths plays a top-down role, f8 profitability level depends on f7 enterprise growth, f9 R&D activities and f11 information symmetry, and acts on f10 internal accumulation level, L3 has a greater influence on L2 and is controllable; the third layer (f2 legal system, f3 construction of financial institutions, f5 money flow, f6 credit guarantee, f7 enterprise growth, f9 R&D activities, f11 information symmetry, f12 risk control), and the deep factor layer includes the fourth layer in the table (f1 government policy). f1 Government policy is the basis and prerequisite for influencing the risk path of financing for SMBs in science and technology. Therefore, reducing the financing risk of small and medium-sized technology enterprises requires giving full play to the role of the government and focusing on the changes in the external environment.

6.2. MICMAC model

Using the MICMAC model cluster classification, it is concluded that the influential factors affecting the financing risk path of small and medium-sized technology enterprises are mainly dependent factors, linkage factors and independent factors, and there are influential factors present in the spontaneous factors quadrant. Among them, the dependency factors show high dependency and low driving force indicating that this category of factors is more influenced by other factors and is the key factor that directly affects the financing risk of SMBs in science and technology, which are f4 financial institution operation, f8 profitability level, and f10 internal accumulation level. The linkage factors have a relatively high dependence and driving force, but the factors in this part are poorly controllable, which are f2 legal system, f3 construction of financial institutions, f5 money flow, f6 credit guarantee, f7 enterprise growth, f9 R&D activities, f11 information symmetry, and f12 risk control. Independent factors have a high driving force and are the focus of reducing the financing risk of SMEs in science and technology should take the lead in addressing such factors.

This paper analyzes the financing risks that small and medium-sized technology enterprises face and briefly discusses the factors influencing the current financing challenges faced by small and medium-sized technology enterprises. It also provides an overview of the identification of financing risk pathways for small and medium-sized technology enterprises. This paper combines the idea of science and technology innovation drive, focuses on the operational risk and financing environment of small and medium-sized technology enterprises, and provides a thorough evaluation of financing risk path identification of small and medium-sized technology enterprises. It analyzes the factors of small and medium-sized technology enterprises in political environment, economic environment, and internal environment of enterprises as well as financing difficulties.

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