Research on Influencing Factors of Collaborative Supply of SME Cluster Using ISM and MICMAC Approach

Shipian Wu¹,a,∗ and Bing Xiao²,b

¹School of Computer Science, Guangdong Polytechnic Normal University, Guangzhou, China
²School of Computer Science, Guangdong Polytechnic Normal University, Guangzhou, China

a1378999633@qq.com, b88093096@qq.com

∗Bing Xiao

Keywords: SME cluster, Collaborative supply, Influencing factors, ISM, MICMAC.

Abstract. In order to solve the problem of limited resources of SMEs. Based on the system perspective, this paper constructs the ISM model of SME cluster collaborative supply, identifies the influencing factors of SME cluster collaborative supply from the perspective of three-dimensional structure, and analyzes the influencing factors by using ISM and MICMAC approach. The research results show that the influencing factors of SME cluster collaborative supply have a six-level hierarchical relationship. Provide theoretical basis for managers to solve the problem of collaborative supply of SME clusters

Introduction

According to statistics, China’s SMEs account for 98% of the total number of enterprises, contribute more than 60% to GDP, contribute more than 50% to taxes, create 80% of jobs and occupy an important position in the national economy. The report of the 19th National Congress of the Communist Party of China proposes to deepen supply-side structural reforms, strengthen support for SME innovation, and cultivate several world-class advanced manufacturing clusters.

However, Due to their inherently small business scale, limited resources, and insufficient innovation capacity, SMEs are often rejected by other collaborative entities when seeking collaboration with the outside world, which limits their own development and makes it difficult to meet market requirements and gradually losing their social competitiveness. Therefore, in order to further improve the competitiveness of SMEs, pool resources, and improve the operability of collaboration, SMEs need to use the power of clusters to collaborate with the outside world.

Based on a lot of reading of the existing research results, this paper finds that scholars at home and abroad mainly focus on the relationship between individual enterprises, industry, industrial cluster benefits[5], collaborative innovation risks, and innovation performance[6], Complex network theory[7], two-stage game[8], network structure[9]and other different perspectives on SME collaboration research. The study found that scholars have jointly pointed out that the problems existing in the coordination of SME clusters include financing difficulties, lack of innovation, difficulty in obtaining information, irrational distribution of benefits, insufficient government support, and significant influences of network relationship elements and resource elements. These problems are related to the mutual supply between the subjects. However, the existing literature on the coordination of SME clusters from the perspective of supply side is still scarce. Therefore, this article hopes to study the coordination of SME clusters from the perspective of the supply side, that is, it will focus more on the analysis of the important factors affecting the supply of resources among the cooperative subjects. By sorting out the relevance and hierarchy of key influencing factors, it helps collaborators understand the network relationship elements of the collaborators and the focus of the collaborative supply process, so as to perform resource integration and resource sharing more efficiently.
Analysis on the Connotation System of Cooperative Supply of SME Clusters

SME cluster refers to a large number of SMEs and institutions in a specific industry clustered in a specific region to form a stable and sustainable competitive advantage group[10]. The collaborative process is a process of optimizing the selection of elements through a competitive mechanism. The optimal combination structure pursued by the elements has obvious nonlinear characteristics. The goal of collaboration is to pursue opening itself up in competition, sharing and matching with other elements. The ultimate goal is to pursue the creation of synergistic amplification effects and maximize the self-interest in multiplying the "surplus"[11].

The collaborative supply of SME clusters studied in this article refers to a series of resource supply activities in the process of collaborative innovation by SME clusters. The main body of the SME cluster collaborative supply system includes SMEs, governments, universities and research institutions, intermediary organizations and financial institutions. They form an interrelated and complex non-linear relationship. Through the flow and supply of resources, they jointly promote the development of coordinated supply activities.

Among them, SMEs are the initiators and implementers of collaborative supply activities, the core subject of collaborative supply, and a communication bridge that connects other entities. In the system, it has the role of providing project research and employment for universities and scientific research institutions; helping the government stabilize the national economy and employment rate; and obtaining business and profit for intermediary organizations and financial institutions. Universities, research institutes, governments, intermediary organizations, and financial institutions are auxiliary to collaborative supply activities. Universities and scientific research institutions provide enterprises with knowledge and technological innovation, and they enter the higher education talents such as technical personnel, scientific research researchers and managers. The government not only provides policies, funds, and reward mechanisms for coordinated supply activities, but also creates an institutional environment conducive to coordinated supply by guiding the direction of supply and monitoring the role of illegal behavior, thereby increasing the initiative of the main body. Intermediary organizations such as consulting agencies, legal institutions, and industry associations provide professional services such as consulting, guidance, and rights protection for coordinated supply, playing a role of lubrication and adjustment. Financial institutions provide financial support for SMEs in financing and loans. The purpose of the SME cluster collaborative supply system is to fully promote the further agglomeration of various resources under the joint action of all participants, reduce the system's transaction costs, improve the efficiency of collaborative supply activities, achieve multi-party "win-win" and improve the overall Supply capacity. According to the connotation analysis of the SME cluster collaborative supply system, a SME cluster collaborative supply structure model (Figure 1) can be constructed. It can be seen from the model that the cooperative supply of SME clusters mainly reflects the cooperation between cooperative entities, and the cooperative behavior between economic actors in a region can ensure the efficiency and effectiveness of the entire social and economic environment improvement[12].

Analysis of Influencing Factors of Collaborative Supply of SME Clusters Based On Three-Dimensional Structure Model

The collaborative supply of SME clusters is a process that is affected by a variety of factors. Foreign scholar Agostino Villa found the importance of collaborative factors in clusters in studying the network contract between SMEs stipulated in Italy from 2010 to the end of 2016, and showed that Italy is using synergy as the main line to improve the innovation capacity of SMEs, while other European countries are also starting to create networks and clusters in a similar way, thereby making the industrial system more innovative and stimulating[13]. Therefore, understanding the role and correlation of the influencing factors of SME cluster collaborative supply plays a vital role in the development of collaborative supply activities.

At present, some scholars mentioned that the current level of informationization and Internet application capabilities of small and medium-sized enterprises in the cluster area is generally low and
uneven. Therefore, before the small and medium-sized enterprise cluster chooses to cooperate with the outside, it must first solve the internal coordination problem of the cluster, so as to As a main body, the cluster explores the external coordination problem[14]. In the following research, only the external influence factors of SME cluster coordination are considered from the perspective of supply.

Measuring the effect of the collaborative supply of SME clusters depends not only on the resources of the cooperative subject, but also on the level and environment of the collaborative supply itself. Therefore, take the main resources, the level of collaborative supply and the environment as the three dimensions. The effect of the cooperative supply of SME clusters is the result of the combined action of the cooperative subject resources, the cooperative supply level and the environment. It can be expressed by the following model: \( g = f(z, s, h) \). In the above formula, \( g \) represents the cooperative supply effect of SME clusters, \( z \) represents the main resource, \( s \) cooperative supply level, \( h \) environment, and the three are independent variables of \( g \).

The main resource is the material basis for the coordinated supply activities. It mainly includes policies, financial allocations, funds, talents, innovative technologies, consulting services, jobs, project research and tax payments. The supply level determines the success of collaborative supply activities. The supply level is mainly reflected by the degree of synergy and synergy results. The degree of synergy reflects the response speed of the subject's synergy, and also affects the tightness, orderliness, and interaction strength of the integration among the subjects [14]. The synergy results represent the total effect of synergistic supply. A good external environment is the guarantee for the smooth development of collaborative supply activities, and it also determines the development direction of the entire collaborative supply activities. It mainly affects the coordinated supply activities through two factors: market economy and transportation logistics. Through the above analysis, a three-dimensional structural model of collaborative supply of SME clusters was finally constructed (Figure 2).

![Figure 1. Supply-side SME cluster collaborative supply model.](image1)

![Figure 2. Three-dimensional model of collaborative supply for SME clusters.](image2)
Construction and Analysis of ISM-MICMAC Model for SME Cluster Cooperative Supply

Based on the above analysis, use ISM and MICMAC methods to further analyze the relationship between influencing factors.

Building the ISM Model

Due to the obvious causal relationship between some indicators, the four indicators of employment, taxation, consulting business and financing business need to be excluded when explaining the structural model. In this way, the influencing factor index of ISM is obtained (Table 1).

Table 1. Influencing factors of SME cluster collaborative supply.

| Primary indicators | Secondary indicators | Serial number |
|--------------------|----------------------|---------------|
| Subject resource   | Policy Support        | S1            |
|                    | Financial appropriation | S2           |
|                    | Talent introduction   | S3            |
|                    | Talent introduction   | S4            |
|                    | consultation service  | S5            |
|                    | project research      | S6            |
|                    | Corporate capital     | S7            |
|                    | Loan financing        | S8            |
| Synergistic supply | Degree of synergy     | S9            |
| level              | Collaborative innovation level | S10 |
| Surroundings       | Market economy        | S11           |
|                    | Transportation logistics | S12        |

By inviting experts to set up a discussion group to analyze the influencing factors and establish an initial reachability matrix. The rule for establishing the matrix is that when the element Si directly affects Sj, the value is assigned to 1; when the element Si does not directly affect Sj, the value is assigned to 0. According to the above rules, an adjacency matrix is obtained, which is a square matrix containing only 0 or 1 (Table 2).

Table 2. The Initial reachability matrix.

| number | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 |
|--------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| S1     | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 1   | 0   |     |
| S2     | 0  | 0  | 0  | 0  | 1  | 0  | 1  | 0  | 0  | 0   | 0   |     |
| S3     | 0  | 0  | 0  | 0  | 1  | 0  | 1  | 0  | 1  | 1   | 0   |     |
| S4     | 0  | 0  | 0  | 0  | 0  | 1  | 1  | 0  | 0  | 0   | 0   |     |
| S5     | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 1  | 0   | 0   |     |
| S6     | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 1  | 1  | 0   | 0   |     |
| S7     | 0  | 0  | 0  | 0  | 1  | 1  | 0  | 0  | 0  | 1   | 0   |     |
| S8     | 0  | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0   | 0   |     |
| S9     | 0  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 1  | 0   | 0   |     |
| S10    | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   | 0   |     |
| S11    | 1  | 1  | 0  | 0  | 0  | 0  | 1  | 0  | 0  | 0   | 0   |     |
| S12    | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 1  | 0  | 0   | 0   |     |

Then the adjacency matrix is used to calculate the reachability matrix. Lists the reachable set, the antecedent set, and the common set according to the reachability matrix.
The results are shown in Table 4: The values of driving force and dependence are obtained according to Table 3. The driving force refers to the number of reachable sets of each variable, and the dependency refers to the number of antecedent sets of each variable. The results are shown in Table 4:

| Influencing factors | Reachability set(R) | Antecedent set(C) | Intersection Set(R∩C) |
|---------------------|---------------------|-------------------|----------------------|
| S1                  | 1,2,3,4,5,6,7,8,9,10,11 | 1,11              | 1,11                 |
| S2                  | 2,3,4,5,6,7,8,9,10    | 1,2,11            | 2                    |
| S3                  | 3,4,5,6,9,10          | 1,2,3,4,5,6,7,8,9,11,12 | 3,4,5,6,9           |
| S4                  | 3,4,5,6,9,10          | 1,2,3,4,5,6,7,8,9,11,12 | 3,4,5,6,9           |
| S5                  | 3,4,5,6,9,10          | 1,2,3,4,5,6,7,8,9,11,12 | 3,4,5,6,9           |
| S6                  | 3,4,5,6,9,10          | 1,2,3,4,5,6,7,8,9,11,12 | 3,4,5,6,9           |
| S7                  | 3,4,5,6,7,8,9,10      | 1,2,7,11          | 7                    |
| S8                  | 3,4,5,6,7,9,10        | 1,2,7,8,11        | 7                    |
| S9                  | 3,4,5,6,9,10          | 1,2,3,4,5,6,7,8,9,11,12 | 3,4,5,6,9,10       |
| S10                 | 10                   | 1,2,3,4,5,6,7,8,9,10,11,12 | 10                 |
| S11                 | 1,2,3,4,5,6,7,8,9,10,11 | 1,11              | 1,11                 |
| S12                 | 3,4,5,6,9,10,12      | 12                 | 12                   |

Then directly calculate the layered results of the interpreted structural model through MATLAB code (Figure 3).

**Building the MICMAC Model**

The values of driving force and dependence are obtained according to Table 3. The driving force refers to the number of reachable sets of each variable, and the dependency refers to the number of antecedent sets of each variable. The results are shown in Table 4:

| Number | Driving Power | Dependence Power | Influencing factors | Driving Power | Dependence Power |
|--------|--------------|------------------|--------------------|--------------|------------------|
| S1     | 11           | 2                | S7                 | 8            | 5                |
| S2     | 9            | 3                | S8                 | 7            | 4                |
| S3     | 6            | 11               | S9                 | 6            | 11               |
| S4     | 6            | 11               | S10                | 1            | 12               |
| S5     | 6            | 11               | S11                | 11           | 2                |
| S6     | 6            | 11               | S12                | 7            | 1                |
In the driving force and dependency matrix, the horizontal axis represents the dependency of factors, and the vertical axis represents the driving force of factors. Get the MICMAC matrix according to Table 4(Figure4).

**Analysis of ISM-MICMAC Model Results**

It can be seen from Figure 4 that the influencing factor of SME cluster collaborative supply is a six-level hierarchical structure model. In the ISM model, the first layer is the direct influencing factor, and it is also the target layer of the model \{S10\}, that is, the level of collaborative innovation. The level of collaborative innovation in the MICMAC matrix is at a high level of dependency and a low driving force depends on the cluster, indicating that it is vulnerable to others. The influence of factors is often caused by the accumulation of other factors, and once it occurs, it may directly cause coordination failure.

The second layer of the ISM model is the key influencing factors \{S3, S4, S5, S6, S9\}, that is, talent introduction, innovative technology, consulting services, project research, and degree of synergy. They are all direct factors that affect the level of collaborative innovation of the cluster. In the MICMAC matrix, it is in a region of high dependence and medium driving force, with high dependence and a certain degree of linkage power. It is the most intuitive indicator for the collaborative supply activities of SME clusters. These indicators should be monitored in real time.

The third and fourth layers are the deep-seated factors \{S7, S8, S12\}, that is, financing, corporate capital, and transportation logistics. Corporate capital directly affects talent introduction, innovative technologies, consulting services, and project research, while project research and innovation technology is also directly affected by financing. At the same time, transportation logistics has a direct impact on the introduction of talents and the degree of synergy. In the MICMAC matrix, these three factors are in an independent cluster of the matrix, which has a higher driving force. This shows that these factors have a greater influence on other factors in the system, but are less affected by other factors, and can affect the coordinated supply situation by affecting factors at various levels. Therefore, these three factors should be included in the primary monitoring focus in collaborative supply management.

The fifth and sixth tiers are the fundamental influencing factors \{S2, S1, S11\}, that is, the state fiscal appropriation, policy support, and market economy. Among them, policy support and market economy are macro-influencing factors of collaborative supply of clusters. Policy support is a background factor, and the market economy is an important exogenous factor. The combined effect of the two macro factors has a direct impact on national fiscal appropriations. The state fiscal appropriation is located in an independent cluster with low dependence and high driving force, which has a strong driving force and can be considered as the source of the failure of cooperative supply. It is not easy to get indirect control by controlling other factors. If not handled properly, it is likely to affect the entire collaborative activity. Collaborating entities should pay enough attention to these factors, and should try to control the spread of their influence, and at the same time, do a good job of prevention of subsequent risks.

**Conclusion**

The relationship between the influencing factors of the cooperative supply of SME clusters is intricate, so the analysis of the hierarchical and driving factors of the factors helps to better understand the relationship between them and provides a theoretical basis for the management of cooperative supply. At the same time, in the development of SME cluster collaborative supply activities, all factors should be regarded as a whole, comprehensive prediction and management should be carried out, and the overall view of "whole and part" should be correctly grasped, so as to improve the efficiency of collaborative supply and ensure synergy Effectiveness and stability of resource supply.
Acknowledgement

This research was financially supported by the Guangdong Province Graduate Education Innovation Program Project [No. 2018GJXM70], Science and Technology Plan Project of Guangdong Province [No. 2016A040404016] and Guangdong Province Education Department Innovation Team Project [No. 2017KCXT021]

References

[1] Wang Weixing, Li Zhenjie. The Impact of SME Financing Structure on Debt Financing Costs: Based on Empirical Evidence from Listed Companies of Small and Medium-sized Boards [J]. Journal of Hunan University of Science and Technology (Natural Science Edition), 2017, 32 (02): 114-121.

[2] Deng Anqiu, Zhang Quanen. Causes and Resolutions of Financing Difficulties for Small and Medium-sized Enterprises in China [J]. Management Modernization, 2011 (02): 21-23.

[3] Matopoulos, Aristides, Vlachopoulou, Maro & Manthou, Vicky. (2006). Exploring chain, network and cluster collaborative practices: Implications for SMEs. IJNVO. 3. 142-155. 10.1504/IJNVO.2006.009531.

[4] Chen Rong, Liang Changyong, Ye Chunsen. Empirical Research on the Collaborative Innovation System of SMEs from the Perspective of Industrial Clusters [J]. Science & Technology Progress and Policy, 2016, 33 (07): 74-81.

[5] Shi Baisheng. Thoughts on the collaborative innovation development model of small and medium-sized enterprises based on the benefits of industrial clusters: Taking Hunan Shanshan New Materials Co., Ltd. as an example [J]. Innovation and Entrepreneurship Education, 2016, 7 (02): 89-93.

[6] Wu Weihong, Zhao Yan, Zhang Aimei. Empirical Research on the Relationship between Enterprise Collaborative Innovation Risk and Innovation Performance [J]. Science & Technology Progress and Policy, 2018, 35 (19): 88-95.

[7] Fan Ruguo. Research on Collaborative Innovation of SME Clusters Based on Complex Network Theory [J]. Business Economics and Management, 2014 (03): 61-69.

[8] Li Jun, Zhu Xianqi, Zhang Yan. Research on the collaborative innovation mechanism of SME clusters based on two-stage game [J]. Economic Issues 2018 (02): 69-75.

[9] Du Danli, Kang Min, Zeng Xiaochun, Wei Sipeng. Research on the Stability of Collaborative Innovation Alliance of Science and Technology SMEs from the Perspective of Network Structure—Taking Heilongjiang Province as an Example [J]. Research on Science and Technology Management, 2017, 37 (18): 134-142.

[10] Michael E. Porter. Clusters and New Economics of Competition [J]. Harvard Business Review, November-December, 1998.

[11] H. Haken. Synergy [M]. Beijing: Atomic Energy Press, 1984: 8-16.

[12] Antonelli, Dario, Cassarino, Irene & Villa, Agostino. (2006). Analyzing collaborative demand and supply networks of SMEs. IJNVO. 3. 128-141. 10.1504/IJNVO. 2006.009530.

[13] Agostino Villa, Teresa Taurino (2018) From industrial districts to SME collaboration frames, International Journal of Production Research, 56: 1-2, 974-982.

[14] Sun Na. Research and Countermeasures on Information Network Relationship of SME Clusters in Jilin Province [J]. China Market, 2018 (36): 31-32.