

The Key Constraints of Innovation Strategies for Clustered Firms: On the Perspective of Global Value Chain

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Abstract—This paper draws on cluster innovation theory to recognize key factors impacting two types of innovation mode of clustered firms. An index system of the factors impacting clustered firms' innovation is provided on the perspective of micro (enterprise), medium(cluster and GVC), and macro (government). Analytic Hierarchy Process (AHP) is used to quantify the weight of each factor. The results show that in the four first-level indexes, clustered firms' abilities are the key factor to impact their innovation strategies. According to the comparison among the second indexes, ten of them, including R&D capability, marketing capability, GVC governance, and so on, have significant influences on their innovation strategies. Our findings have theoretical and practical implications for cluster research in general.

Keywords-Global Value Chain, Clustered Firms, Innovation Mode

I. INTRODUCTION

In traditional research framework, theories about cluster innovation were concentrated on the knowledge transfer and innovation network, which formed three literatures about network environment(Steven Casper,2007)[1]、resource ability (Jean-Marc Callois, 2009) [2], and knowledge spillover(Effie Kesidou, Henny Romijn2008)[3]. However, the rapid development of globalization weakens the characteristic of the regionalization and localization. Embedding in global value chain(GVC) to take part in international division proves to be a useful way for clusters to improve the regional competence and cope with challenges coming from globalization(Gereffi 1999)[4]. Therefore, scholars begin to research the localized cluster from the perspective of globalization. For example, Humphrey, J. &Schmitz,(2008) [5] analyzed the different performances of the clusters drawing on theory of GVC. Federica Saliola and Antonello Zanfei(2009)[6] testified the effect of knowledge transfer on industry cluster based on globalized R&D network. The empirical study of Oliver and Garrigos(2008) [7] indicates the technology spillover will be stronger in a cluster. Crestanello and Tattara[8], through their open innovation model, pointed out that ubiquitous knowledge spillover in GVC helps local firms obtain advanced knowledge, which will consequently improve their innovation performances.

The literature from perspective of globalization offers a

better view for the research of cluster innovation(Morrison, Pietrobelli ,Rabellotti,2008)[9]. But there are still some shortcomings of extant theory. First, research on the cluster innovation has largely focused on the effecting factors in GVC.Very little is known about the issue which one of them determines innovation performance of clustered firms. The synthesized effect of these factors is also ignored. This is especially relevant as cluster innovation will be impacted by many factors in GVC, it is difficult to explain the innovation strategy of clusters from a single factor. The key constraints shall be figured out for a better understanding of cluster innovation.Second, existing literature ignores the different type of innovation of clustered firms,hence, fails to distinguish the different effect of these factors on different type of innovation of clustered firms.Hence, further research must be made to classify the type of innovation of clustered firms. This paper,therefore, divides clustered firms innovation into independent innovation and imitative innovation, constructs an index system of the factors impacting from perspective of micro (enterprise), medium view(cluster and GVC),and macro view(government),uses the Analytic Hierarchy Process (AHP) to find out key constraints of innovation strategy for clustered firms.

The remainder of the paper is structured as follows. The next section describes methodology we used in this paper. We then outline the procedures we used to collect and analyze our data and provide the results. The results are then discussed in Section 4. Section 5 provides the conclusions, limitations of the study, and suggestions for future research.

II. METHODOLOGY

On the perspective of global value chain, choices of the innovation mode in the local clusters are affected by many factors, such as enterprise strategy, the regional environment, macroeconomic policy and value chain relationships and so on. In order to make the right selection, the key constraints of the cluster innovation must be found. So we construct an index system of the factors effecting the cluster innovation and get the key constraints of the cluster innovation by AHP, settle base for deeply research of the cluster innovation in the GVC.

Analytic Hierarchy Process(AHP) is a multi-factor analysis method which integrates qualitative and

quantitative analysis together. Based on mathematics and psychology, the AHP was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It's suitable to evaluate the results difficult for direct and accurate measurement. As the factors affecting firm innovation in clusters involve a large number of qualitative evaluations, it is difficult to find alternative quantitative indicators to measure. Therefore, we use AHP to compare the relative weigh of different factors to identify the key constraints of firm innovation in clusters.

III. RECOGNITION OF KEY CONSTRAINTS OF THE CLUSTER INNOVATION

A. Index System of the Factors Effecting the Cluster Innovation

We deeply analyses the factors effecting innovation mode of industry clusters On the perspective of global value chain based in former research, and construct an index system of the factors effecting the cluster innovation from micro view(enterprise), medium view(cluster and GVC),and macro view(government).

TABLE I. INDEX SYSTEM OF FACTORS AFFECTING FIRM INNOVATION IN CLUSTER

Global value chain A1	The technical control trend B1	patent, the control of core technology
		brand, the control of market channels
	Governance B2	market-based type
		balanced type
		seized type and level type
	Independence of the subsidiaries B3	strong independence: the resources mainly supplied by the multinational companies
		weak independence: the resources mainly supplied by the cluster
	Evolution phases of the network B4	vertical integration phase, vertical interaction phase
		vertical and horizontal (two-way) interaction phase and network phase
	Embedded degree B5	if the leading firms supply market and technical information
		if the leading firm supply technical training
		if the leading firms develop products with local firms together
Cluster	Social	trust and commitment

Cluster A2	capital B6	similar cultural background is easier for communication
	Regional market B7	scale of regional market
		demand of regional clients
	Innovative capability B8	the intensity of the colleges, research centers and the firm R&D centers
		the relationship between the R&D institutions and the cluster members
	Type of the cluster B9	the high-tech industry cluster: like IT
		the traditional industry cluster: like the textile industry
	Maturity of the cluster network B10	introduction period: the local network haven't formed
		maturity period: the local network mainly form up
		recession period: the appearance of evil competition like the price war
enterprise A3	R&D capability B11	the technological basis
		the technical talent
	Manufacturing capability B12	capability of learning technologies
		capability of introducing, digesting and absorbing
	Marketing capability B13	the ability to expand the market
		the ability to build the brand
	Strategic orientation B14	R&D orientation: the R&D ability is the key element to determine the core competencies
market orientation: the marketing capability is the key element to determine the firm to be successful or not		
external environment A4	Intellectual property protection B15	completeness of the intellectual property protection laws
		Intensity of intellectual property protection
	Policy B16	Financial supporting policy of technical innovation
		financial subsidies policy of technical innovation
Market B15	external market changes too fast industry technology changes too fast	

B. Determination of the Weight of Indexes

Firstly, providing 1-9 scale to measure the different cases of index comparison.

Secondly, using Delphi method to do pairwise comparison of indexes, and getting a comparison matrix $A(a_{ij})$ to indicate the relative importance.

TABLE II. THE REFERENCE TABLE OF PROPORTIONAL SCALE WITH DIFFERENT CLASSIFICATION

Value(x_i/x_j)	explanation
1	Index x_i and x_j have same importance
3	Index x_i has a little more importance than x_j
5	Index x_i is obviously important than x_j
7	Index x_i is strongly important than x_j
9	Index x_i is extremely important than x_j
2, 4, 6, 8	correspond to the middle situation of two adjacent judgments

Thirdly, calculating the index weight by using the data from the comparison matrix A, as:

- 1) Summing each column of matrix.

$$a_{.j} = \sum_i^n a_{ij} \quad (i, j=1,2,\dots,n)$$

- 2) Dividing every data in the matrix by the corresponding column, and getting a new normalized comparison matrix by column

$$A^*(a_{ij}^*) \circ a_{ij}^* = \frac{a_{ij}}{a_{.j}} \quad (i, j=1,2,\dots,n)$$

- 3) Calculating mean value of each row in $A^*(a_{ij}^*)$, then getting the weight of each

$$\text{index. } W_i \cdot W_i = \frac{\sum_j^n a_{ij}^*}{n} \quad (i, j=1,2,\dots,n)$$

At last, doing the consistency checking of the comparison matrix.

The greater the value of consistency index C.I. is, the greater the degree of deviation between the comparison matrix and the complete consistency will be. On the contrary, if the value of C.I. is smaller, the comparison matrix will be closer to the complete consistency. As we see in Table 3, our results show that the consistency is in the permitted range and the results are valid.

TABLE III. The average random consistency index

n	1	2	3	4	5
RI	0	0	0.58	0.9	1.12
n	6	7	8	9	
RI	1.24	1.32	1.41	1.46	

C. Results

Using the above method to confirm the weight of all the indexes, we can conclude the sequence of the weights for the factors affecting the choices of the innovative mode. (Table 4 –Table 8)

TABLE IV. THE COMPARISON MATRIX AND THE CONSISTENCY CHECKING FOR A1-A4

	A1	A2	A3	A4	weight	$\lambda_{\max}=4.02$ CR=0.0075 The result meets the consistency.
A1	1	3	1/5	5	0.2318	
A2	1/3	1	1/5	3	0.1995	
A3	5	5	1	7	0.3985	
A4	1/5	1/3	1/7	1	0.1702	

TABLE V. THE COMPARISON MATRIX AND THE CONSISTENCY CHECKING FOR B1-B5

	B1	B2	B3	B4	B5	weight	$\lambda_{\max}=4.02$ CR=0.0075 The result meets the consistency.
B1	1	1/7	1/9	1/3	1	0.2334	
B2	7	1	1/9	1/5	7	0.2906	
B3	9	9	1	7	7	0.1414	
B4	3	5	1/7	1	3	0.1344	
B5	1	1/7	1/7	1/3	1	0.2101	

TABLE VI. THE COMPARISON MATRIX AND THE CONSISTENCY CHECKING FOR B6-B10

	B6	B7	B8	B9	B10	weight	$\lambda_{\max}=5.2581$ CR=0.0576 The result meets the consistency.
B6	1	1/4	1/7	1/9	1/7	0.0652	
B7	4	1	5	1/7	1/5	0.1452	
B8	7	1/5	1	1/6	1/7	0.1142	
B9	9	7	6	1	5	0.4108	
B10	7	5	7	1/5	1	0.2646	

TABLE VII. THE COMPARISON MATRIX AND THE CONSISTENCY CHECKING FOR B11-B14

	B11	B12	B13	B14	weight	$\lambda_{\max}=4.1421$ CR=0.0532 The result meets the consistency.
B11	1	7	1	7	0.3929	
B12	1/7	1	1/7	5	0.1445	
B13	1	7	1	5	0.3555	
B14	1/7	1/5	1/5	1	0.1071	

TABLE VIII. THE COMPARISON MATRIX AND THE CONSISTENCY CHECKING FOR B15-B17

	B15	B16	B17	weight	$\lambda_{\max}=3.0178$ CR=0.0171 The result meets the consistency.
B15	1	1/5	1/7	0.1483	
B16	5	1	1/5	0.2889	
B17	7	5	1	0.5627	

TABLE IX. THE SEQUENCE OF ALL INDEXES

Enterprise A3	0.3985	R&D capability B11	0.3929
		marketing capability B13	0.3555
		absorptive capability B12	0.1445
		strategic orientation B14	0.1071
Global value chain A1	0.2318	governance B2	0.2906
		the technical control trend of the leading firms B1	0.2334
		the embedded degree B5	0.2101
		the independence of the subsidiaries B3	0.1414
		the evolution phases of the network B4	0.1344
Cluster A2	0.1995	the cluster type and the nature of products B9	0.4108
		the maturity of the cluster network B10	0.2646
		regional market B7	0.1452
		the innovative capability B8	0.1142
		social capital B6	0.0652
External environment A4	0.1702	market B17	0.5627
		policy B16	0.2889
		intellectual property protection B15	0.1483

IV. DISCUSSION

D. Comparative Analysis of the First-level Indexes

According to the comparison among the first-level indexes, the enterprise has the highest weight of 0.3985, which indicates that although embedded in the global value chain expands the resource boundary of the enterprises, the innovative mode of the firms in the cluster is still affected by internal factors, such as research capacity, market capacity, strategic orientation, etc. The weight of global value chain is in the second place, for 0.2318, which is highly above the cluster factor and external environmental factor. If the enterprises are embedded in the global value chain, it will be easier for them to get the international advanced knowledge, technology and information, and to have an important impact in choosing the innovation mode. This is consistent with the realistic experience of the late-developed countries. The weight of Cluster is 0.1995, indicating that on the background of the global value chain, this factor doesn't have significant impacts on the choices of

the innovative decisions. The factor of external environment has the lowest weight. Compared with the other three factors, this one has the least impact.

E. Comparative Analysis of the Second-level Indexes

1) *The enterprise*: Through learning the existing research literatures, we divided the enterprise factor into four parts: R&D capability, marketing capability, manufacturing capability and absorptive capability. According to the comparison among these four indexes, R&D capability and marketing capacity have the highest weight of 0.3929 and 0.3555 respectively, totally more than 70%. This indicates that the technological capability and the ability to open up the market are the key factors to decide the firm's choices of technological innovation. In contrast, the manufacturing capability and the absorptive capability have lower weights. This means formulation of the strategic orientation actually builds on the basis of their R&D capability and marketing capacity.

2) *The Global Value chain*: According to the comparison among these five indexes, the governance and the technical control trend carried out by the multinational firms have higher weights of 0.2906 and 0.2334 respectively. This indicates that in the global value chain oriented by multinational firms, their strategic decision is the key factor to decide the choices of technological innovation. In addition, it shows that when the enterprises in developing countries embed into the global value chain, the choices of the technological innovation mode are always in the passive position. The embedded degree has the weight of 0.2101. This means whether the subsidiaries embed into the cluster, and whether they build extensive and close relationship between the cluster members, are another important factor affecting the innovative choices. The independence of the subsidiaries and the evolution phases of the global value chain network have lower weights of 0.1414 and 0.1344 respectively. This means the above two factors have less influence on cluster innovation.

3) *The Cluster*: According to the comparison among these five indexes, the cluster type has the highest weight of 0.4108. This means different industry has different technological innovative trend. The regional market has the weight of 0.2646, which indicates that the scale of the local market and the demanding characteristics have important effects on the choices. The intellectual resources and the regional market take the second place, of 0.2792 and 0.2342 respectively. The social capital has the lowest weight. This result is different to the view stressed by many scholars who believe social capital has significant impact on the cluster innovation. The result indicates that although the formation of social capital has a certain influence on the cluster innovation, however, comparing with the cluster type, the regional market and other factors, its impact on cluster innovation is not so significant.

4) *The External Environment*: According to comparison among these three indexes, the external market environment has the highest weight of 0.5627, indicating that external market is the key factor to determine the choices of innovative mode. Almost all choices are determined by the market outlook and technical environment. The policy and the intellectual property protection have the weights of 0.2889 and 0.1483 respectively. The policy has higher impact than intellectual property protection. On the one hand, this means government plays a very important role in the innovative policy. On the other hand, this indicates that the intellectual property protection environment has changed a lot than before in China.

V. CONCLUSION

We conduct this study to provide a more nuanced perspective on the factors impacting clustered firms' innovation strategies on the perspective of GVC. We argue that innovation of Clustered firms is the result of a complex interaction of firms abilities, cluster environment, foreign companys' strategies and other various factors. Hence, the key factors which impacting clustered firms' innovation strategies shall be found out. In that sense, We deeply analyses the factors impacting innovation mode of clustered firms On the perspective of GVC based on former research, constructs an index system of factors impacting clustered firms' innovation strategies on perspective of micro (enterprise), medium (cluster and GVC), and macro (government). The Analytic Hierarchy Process (AHP) is used to quantify the weight of each factor and key factors is figured out.

The results show that in the four first-level indexes, clustered firms' abilities are the key factors to impact their innovation strategies, which indicates that the innovation mode of clustered firms is determined by firms' internal factors, such as research capacity, market capacity, strategic orientation, etc.. According to the comparison among the second indexes, ten of them, including R&D capability, marketing capability, GVC governance, technical control bias of the leading firms, embeddedness degree, type of cluster, regional market and policies, have significant influences on the clustered firms' innovation strategies, which means that they are the key factors to determine clustered firms' innovative choices.

This research draws on cluster innovation theory to recognize key factors impacting two types of innovation mode of clustered firms. Conclusions were drawn in the GVC context. However, There are also shortcomings in our study. First, we use the Delphi method to assign the weight of each factor, which is mainly based on subjective judgments of experts and scholars. Therefore, conclusions may be biased. Second, Second, the impacts of GVC embeddedness on innovation in clustered firms can exhibit their full potential in the long run. Hence, longitudinal studies may help test and substantiate some of the cross-sectional findings in the present study. Therefore, in our future research, we will choose a wide range of

enterprises to do empirical research.

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