

## Research Article

# Structural Evolution of Regional Firm Network System under the Influence of Industrial transfer: A Case Study of the Refrigeration Industrial Cluster of Minquan County

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The transplanted firm is an important force to promote the network evolution and cluster transformation and upgrading of the undertaking firm. From the micro-analytic perspective of firm network, this paper puts forward a theoretical framework with “relationship-network-evolution” as the main line. Taking the refrigeration industry cluster in Minquan County of China as a case study and keeping the firm networks of economic relation, technical cooperation, and social communication firm network in 2009, 2013, and 2017 as the research objects, this paper analyzes the structure and evolution characteristics of regional firm network system, proposes the degree and effect of the local embeddedness of transplanted firms, and discusses their differences between international and interregional transplanted firms. The results revealed that: (1) the local embeddedness of transplanted firms significantly promotes the development of refrigeration industry network. (2) The network power of large-scale transplanted firms in the cluster is increasing day by day, and the network presents a multi-core trend. (3) The local embeddedness of some transplanted firms is not high, and the overall connectivity of the network is not strong. (4) Network intermediary nodes have strong heterogeneity, and the intermediary role of some large transplanted firms in the network needs to be improved. (5) The three network systems have similar structural characteristics, and social capital plays an important role in the local embeddedness of transplanted firms and the development of regional firm network. (6) Compared with international transplanted firms, interregional transplanted firms are more adaptable in terms of local embeddedness. The research results provide a reference for the construction of similar industrial clusters in China and other developing countries.

## 1. Introduction

In China's social and economic construction, there are relatively prominent problems of urban-rural development differences and unbalanced and insufficient regional development. In the past 20 years, China's domestic industrial transfer from the eastern coastal areas to the inland central and western regions is greatly important for narrowing regional differences and promoting coordinated development [1, 2]. The transplanted firms from the eastern coastal areas carry the flow of capital, technology, and information, and their local embeddedness brings valuable opportunities for industrial development, technology learning, transformation, and upgrading in the central and western regions,

and can enhance the related diversity of the local clusters. It helps to break the rigidity and lock-in state of traditional industrial clusters, so the local embeddedness of transplanted firms can be regarded as the “windows of location opportunity” for undertaking the transformation and upgrading of local clusters. At present, China's domestic industrial transfer is still in a relatively rapid development stage. The vast central and western regions are trying to guide the transplanted firms to achieve local embeddedness and build a compact and efficient regional production and innovation network to promote the mid- to high-end connection between regional industries and global value chains (GVCs), so as to create more competitive characteristic industrial clusters.

Seen from the existing theoretical research and economic practice, the local embeddedness of the transplanted firms can promote the industrial development and economic prosperity to a certain extent, but there are also problems that some transplanted firms are difficult to embed locally, and some clusters are not highly developed. First, due to the “space of place” and “institution thickness,” it will face a mismatch in terms of technology, structure, space, and system, thus limiting the global-local production network connection [3, 4]. Second, due to the high mobility of global capital, once the local environmental viscosity is reduced, the problem of “migratory economy” or “footloose embeddedness” may arise [5, 6]. Third, if the transplanted firms adopt the strategy of “club convergence,” the phenomenon of “cathedrals in desert” and “enclave economy” will be formed [7, 8]. Fourth, due to the instinct to maintain “network power,” transplanted firms often adopt the strategy of technical blockade, thus falling into the local “low technology trap” and “poverty growth” [9, 10]. It should be pointed out that the discussion on the above issues is mainly based on the research on global industrial transfer represented by FDI. At present, there are also studies focusing on the local embeddedness of domestic transplanted firms and the interactive coupling between the transplanted and local firms [11, 12], but the comparison of the local embeddedness, regional networking behavior and mechanism of global and domestic transplanted firms still need to be strengthened.

Therefore, based on the perspective of firm network analysis at the micro-scale, this paper puts forward a theoretical framework with “relationship-network-evolution” as the main line, and then, takes the refrigeration industrial cluster in Minquan County, Henan Province, which is located in the central region of China, as a research case. A large amount of first-hand data of connections among firms have been obtained by investigating the firm network system of the cluster for economic relation, technical cooperation, and social communication in 2009, 2013, and 2017 is established, and then, the social network analysis method (SNA) is employed to analyze the network structure and its evolution characteristics of regional firms, determine the degree and effect of local embeddedness of transplanted firms, and discuss whether there are also embeddedness difficulties and failures in the process of local embeddedness of domestic transplanted firms, in order to provide decision-making reference for local governments to formulate scientific and reasonable industrial undertaking policies and cluster cultivation policies. The detailed chapters are shown as below. The first part is the introduction, the second part gives the theoretical framework, the third part presents the data sources and analytical method, the fourth part analyzes the proposed regional firm network structure and evolution, and the fifth part concludes this paper.

## 2. Theoretical Framework

The research on the local embeddedness of transplanted firms began in the 1960s, and the early studies mainly focused on the construction of industrial linkages

between transnational corporations (TNCs) and host countries [13]. In the 1990s, the concept of “embeddedness” was absorbed into the theoretical framework of new economic geography in several turns of research direction [14, 15], and economic geographers began to pay more attention to the relationship construction, institutional constraints, and cultural influences in the local embeddedness of transplanted firms [16–18]. After the 21<sup>st</sup> century, the Manchester School proposed the theory of global production networks (GPNs) [19–21], and more studies began to analyze the global and local strategic coupling from the perspective of GPN [22, 23]. At present, the research hotspots from the perspective of economic geography mainly include the network construction between transplanted and local firms [24], technology spillover and learning innovation [25], the role of social capital [26, 27], etc., Observation angles include economic embeddedness, technological embeddedness, social embeddedness, political embeddedness, cultural embeddedness, institutional embeddedness, cognitive embeddedness, etc., [28].

There are many entry points for the research on the local embeddedness of transplanted firms, “firm network” is a very effective research perspective at the micro-scale [29–31]. Therefore, based on the industrial cluster theory, global production network theory, and embeddedness theory, a theoretical framework was constructed with “relationship-network-evolution” as the main line (Figure 1). Industrial transfer is essentially a process of “industry/firm-region” interaction. With the gradual local embeddedness of the transplanted firms, the product supply and demand, technical cooperation, and social exchanges will be established. With these relationships as links, and firms and related institutions as nodes, an interactive network will be formed, and the connection between local and global production networks will be realized. With the advancement of the local embeddedness of transplanted firms and global embeddedness of local clusters, the regional firm network will show unique structural and evolutionary characteristics, and the regional industry will also achieve a rise and transition in the global value chain. At present, there are relatively few researches on industrial transfer based on the perspective of “firm network,” and there is a lack of clear understanding of the embeddedness process and mechanism of the transplanted firms. The theoretical framework and empirical research based on this framework can make up for the insufficiency of existing research.

## 3. Data Sources and Analytical Method

*3.1. Data Collection.* Minquan County is located in Henan Province in the central region of China. The refrigeration industry is a traditional and iconic industry in Minquan County. In the 1980s, there were only limited number of local firms, which formed the early stage of the refrigeration industry cluster in Minquan County. Since 2010, a large number of firms have transplanted from the eastern coastal areas. At present, the number of transplanted firms accounts

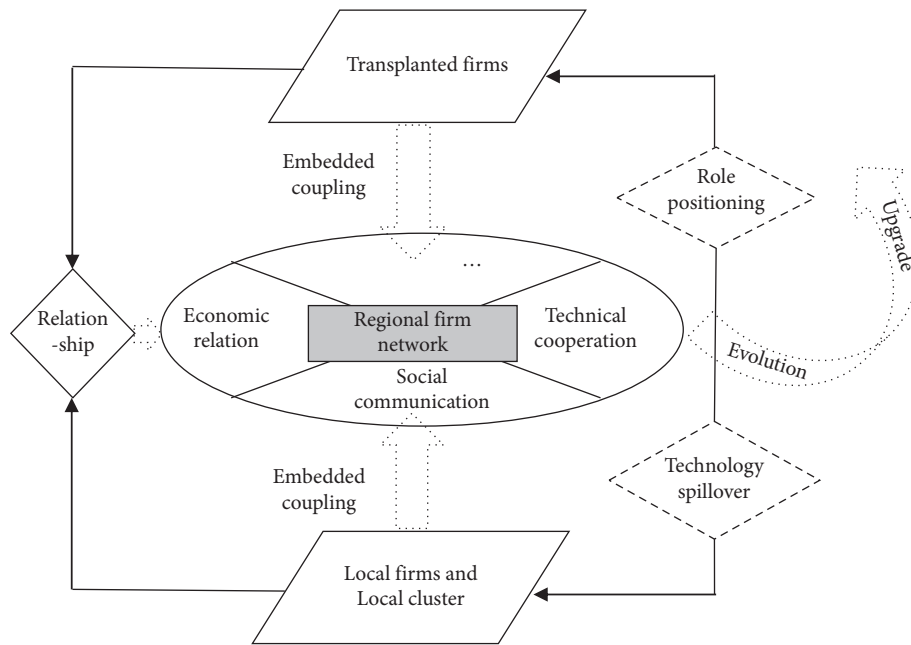


FIGURE 1: Theoretical framework of this Study.

for more than 60% of the total number of firms in the cluster, and they are from other regions in China, distinct obvious regional and industrial characteristics. Therefore, it is very suitable for the research on the local embedding of inter-regional transplanted firms. The data mainly originated from two rounds of research on the Minquan refrigeration industrial cluster from July to October 2014 and from November to December 2017. After 2017, the number of new firms in the cluster was relatively small. In addition, the COVID-19 had a great impact on the operation of the cluster in 2020, including the connection between firms. The data after 2020 is not suitable for comparison with previous data. So, no new research was conducted in the later period. It extracts the economic relation, technical cooperation, and social communication firm network of the cluster in 2009, 2013, and 2017 in the survey. Economic relation mainly refers to upstream and downstream supply relationships, subcontracting or OEM production between firms. Technical cooperation mainly refers to joint research and development of new products, patent transfer, technical assistance, etc., between firms. Social communication mainly refers to informal contacts between firms, including personal friendships among business owners, personal exchanges, etc., According to the annual report of the Industrial Cluster Management Committee in Minquan County, there were 15 firms in 2009, including 1 firm settled in Minquan refrigeration industry cluster through industrial transfer, and 14 local firms in Minquan. In 2013, there were 39 firms, including 23 transplanted firms and 16 local firms. From 2013 to 2017, 11 new firms were added and 6 closed down; therefore, there were 44 firms in total in 2017 (Table 1), including 17 firms that transplanted whole machine (T1), 10 firms that transplanted supporting equipment (T2), 9 local firms of whole machine (L1), and 8 local firms of supporting equipment (L2).

**3.2. Construction and Extraction of Network System.** First, the firm relationship data within the cluster obtained by the survey was verified and processed. The connection between firms was reserved and assigned a value of 1 only when confirmed by both parties; otherwise, it was assigned a value of 0. In the analysis of the survey data of the firm contacts, only the firm A and B believe that there is a certain connection between them, such as a technical cooperation relationship, the connection can be confirmed. In other words, if the firm A believes that it has a technical cooperation relationship with B, but the firm B does not think that it has a technical relationship with A, we do not think there is a technical relationship between A and B in this paper. This is done to ensure the objectivity of firm contacts. By sorting out the survey results, the symmetric relationship matrix of economic relation, technical cooperation, and social communication among firms within the cluster at each time section is finally constructed, and a network of undirected and weightless economic relation, technical cooperation, and social communication (Figure 2) among the Minquan refrigeration firms in 2009, 2013, and 2017 was extracted.

**3.3. Measurement Analysis of Network System.** The purpose of firm network system analysis is to examine the structural characteristics and evolution laws of network systems, identify important nodes, and interpret the similarity of network systems. Examining the overall structure of the network system is mainly based on node degree distribution, centripetal-centrifugal structure, and network centralization. Examining network accessibility is mainly based on node degree, network density, and average shortest length path. Identification of broker is mainly based on the betweenness centrality of the nodes. Analysis of the evolution law of the network system during the research period is

TABLE 1: General situation of the firms in the refrigeration industrial cluster of Minquan county.

Classification no.	Origin	Product	Number of firms	Firm name
T1	Transplanted	Whole machine	17	BS, WB, AKMDQ, HM, HKDL, XXH, XY, KMR, LK, HG, ZX, KBE, KW, AKM LCC, ASDDRSQ, ASDDJSJ, JT
T2	Transplanted	Supporting equipment	10	CX, AJ, SY, MH, HY, SNDQ, XD, XLPJ, ZC, HX
L1	Local	Whole machine	9	AX, JX, XP, ZB, XL, BXLCC, SC, YT, DLB
L2	Local	Supporting equipment	8	BH, GB, HKPJ, HKDQ, JXPJ, LL, SB, YF

mainly based on the number of nodes, node degree distribution, core nodes, and the change of broker [32–34].

In addition, in order to simultaneously analyze the structural similarity of economic relation, technical cooperation, and social communication network systems, and as well as to analyze whether they have similar evolutionary laws, this paper also proposes a model to measure the similarity of network systems. Assuming that there are undirected and weightless networks  $X$  and  $Y$ , the nodes of the two are exactly the same, but the connection relationship in the network system may be different, so the similarity measure formula of the two network systems is as follows:

$$S_{XY} = \frac{\sum_{i \neq j}^n \sqrt{(X_{ij} - Y_{ij})^2}}{n(n-1)}. \quad (1)$$

In the formula,  $S_{XY}$  is the similarity of the network system  $X$  and  $Y$ ,  $X_{ij}$  is the connection between the nodes  $i$  and  $j$  in the network  $X$ ,  $Y_{ij}$  is the connection between the nodes  $i$  and  $j$  in the network  $Y$ . If there is a connection between the nodes in the undirected and weightless network,  $X_{ij}$  and  $Y_{ij}$  are equal to 1; otherwise, they are equal to 0.  $n$  is the number of nodes. The value of  $S_{XY}$  is between 0 and 1. A value of 0 indicates that the network  $X$  is exactly the same as  $Y$ , and a value of 1 indicates that the two do not have any identical network connections.

#### 4. The Structure and Evolution of Firm Network

On the basis of constructing the firm network within the cluster, the social network analysis method was employed to focus on analyzing the connectivity and coreness of the Minquan refrigeration firm network, identifying the intermediary nodes of the network and judging the local embeddedness of the transplanted firm. It also analyzes the structural similarity between economic, technological, and social networks, and explores the process, mechanism, and effect of the local embeddedness of transplanted firms.

*4.1. The Overall Connectivity of the Network System Is Not Strong, Showing a Centripetal-Centrifugal Structure.* On three timestamps, the density of Minquan refrigeration industry network is less than 0.20, and the average shortest path is more than 2 (Table 2), indicating that the interconnection between network nodes is relatively sparse, the network development is not perfect, and the “relationship proximity” between the firms

is low. The most obvious is the technical cooperation network. The technical cooperation network density in the three periods is less than 0.10, indicating that the technical connection strength between the firms is less than one-tenth of the fully connected network. Furthermore, the average shortest path of the technical cooperation network during the study period is constantly increasing, indicating that the technical cooperation network still has a trend of gradual sparseness.

In Table 3, the network node degree value of the Minquan refrigeration firm has a very large difference on three timestamps, and the node degree distribution shows a layering phenomenon. The degree distribution probability approximately shows “rightward inclined long-tailed distributions,” and low degree value nodes occupy a larger proportion in the network. It shows that the network development is unbalanced, and most of the firms have low degree value and are more dependent on the core node firms in the network. At the same time, it shows strong centripetal-centrifugal distribution characteristics, and the density difference between the two areas is very large. For example, the densities of the core areas of economic relation, technical cooperation, and social communication networks were 0.44, 0.35, and 0.64, respectively, and the densities of the fringe areas in 2017 were 0.07, 0.04, and 0.09, respectively.

*4.2. The Local Embeddedness of Some Transplanted Firms Are Not High.* From the centripetal-centrifugal distribution of transplanted firms, it can be seen that most of the transplanted firms are located in the fringe area or the centripetal-centrifugal junction area, and the number of firms located in the core area is very small. In 2017, there were 10 firms located in the core area in the three types of networks, of which there were still only 2 transplanted firms; there were 18 firms located in the fringe areas in the three networks, and 14 of them were transplanted firms. Therefore, most of the transplanted firms have not entered the core circle of the Minquan refrigeration industry network, and the degree of embeddedness in the network is not high.

In order to deeply analyze the reasons for the insufficient local embeddedness of the transplanted firms, the number of firm connections between and within each category for T1, T2, L1, and L2 is calculated and normalized in the three networks, respectively (that is, the ratio of the actual number of connections to the theoretical maximum number of connections). It can be seen from Figure 3 that in terms of



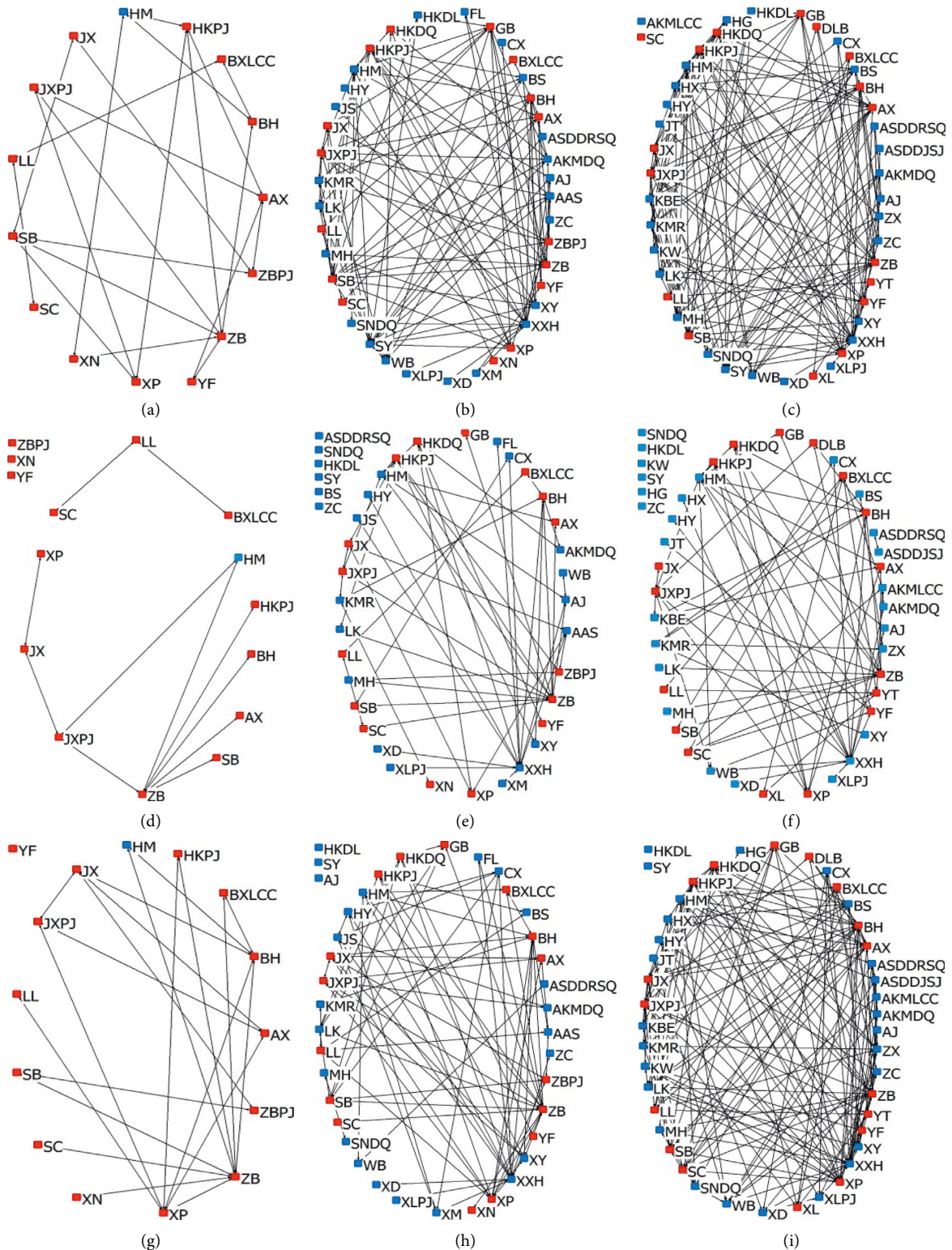


FIGURE 2: Relationship network of refrigeration firms in Minquan county. (a) Economic relation network in 2009. (b) Economic relation network in 2013. (c) Economic relation network in 2017. (d) Technical cooperation network in 2009. (e) Technical cooperation network in 2013. (f) Technical cooperation network in 2017. (g) Social communication network in 2009. (h) Social communication network in 2013. (i) Social communication network in 2017.

economic relation, both 2013 and 2017 showed the characteristics of  $L1-L2 > T1-L2 > T1-T2 > T2-L1$ , indicating that the economic relations between transplanted and

surrounding firms were relatively weak. In terms of technical cooperation, both 2013 and 2017 showed the characteristics of  $L1-L1 > L1-L2 > T1-L2 > T1-T2 > T1-L1 > T2-L1 > T2-L2$ ,

TABLE 2: Density and average shortest path of refrigeration firms network in Minquan County.

	2009			2013			2017		
	Economic relation	Technical cooperation	Social communication	Economic relation	Technical cooperation	Social communication	Economic relation	Technical cooperation	Social communication
Density	0.20	0.10	0.19	0.14	0.07	0.10	0.16	0.07	0.17
Average shortest length path	2.66	2.08	2.07	2.45	2.71	2.52	2.30	2.93	2.17

TABLE 3: Node degree value of refrigeration firms network of Minquan County.

Classification No	Firm name	2009			2013			2017		
		Economic relation	Technical cooperation	Social communication	Economic relation	Technical cooperation	Social communication	Economic relation	Technical cooperation	Social communication
T1	AAS	—	—	—	5	4	4	—	—	—
T1	AKMDQ	—	—	—	7	2	2	6	2	7
T1	AKMLCC	—	—	—	—	—	—	0	4	3
T1	ASDDJSJ	—	—	—	—	—	—	2	1	6
T1	ASDDRSQ	—	—	—	1	0	1	3	1	6
T1	BS	—	—	—	5	0	2	8	2	8
T1	HG	—	—	—	—	—	—	6	0	2
T1	HKDL	—	—	—	3	0	0	7	0	0
T1	HM	3	2	2	11	6	5	11	10	12
T1	JT	—	—	—	—	—	—	1	1	1
T1	KBE	—	—	—	—	—	—	7	3	4
T1	KMR	—	—	—	6	3	2	9	4	5
T1	KW	—	—	—	—	—	—	5	0	5
T1	LK	—	—	—	5	2	5	7	1	9
T1	WB	—	—	—	7	1	2	9	4	9
T1	XXH	—	—	—	14	11	12	17	13	19
T1	XY	—	—	—	6	2	6	4	1	6
T1	ZX	—	—	—	—	—	—	6	2	9
T2	AJ	—	—	—	4	4	0	3	2	1
T2	CX	—	—	—	1	2	5	3	2	5
T2	FL	—	—	—	2	1	2	—	—	—
T2	HX	—	—	—	—	—	—	12	1	6
T2	HY	—	—	—	1	1	4	1	1	5
T2	JS	—	—	—	1	1	5	—	—	—
T2	MH	—	—	—	3	2	1	11	1	4
T2	SNDQ	—	—	—	2	0	1	6	0	5
T2	SY	—	—	—	15	0	0	15	0	0
T2	XD	—	—	—	1	1	1	1	1	5
T2	XLPJ	—	—	—	1	1	1	1	1	5
T2	XM	—	—	—	2	1	4	—	—	—
T2	ZC	—	—	—	1	0	1	5	0	6
L1	AX	4	1	3	7	2	4	12	4	12
L1	BXLCC	2	1	2	2	2	3	3	5	6
L1	DLB	—	—	—	—	—	—	3	3	4
L1	JX	2	2	4	5	4	6	9	1	12
L1	SC	1	1	1	2	2	1	0	4	9
L1	XL	—	—	—	—	—	—	2	2	5
L1	XP	3	1	6	7	3	9	10	6	14
L1	YT	—	—	—	—	—	—	2	5	4
L1	ZB	6	6	8	9	11	14	12	10	17
L2	BH	3	1	5	10	6	9	11	8	16

TABLE 3: Continued.

Classification No	Firm name	2009			2013			2017		
		Economic relation	Technical cooperation	Social communication	Economic relation	Technical cooperation	Social communication	Economic relation	Technical cooperation	Social communication
L2	GB	—	—	—	10	1	4	8	2	7
L2	HKDQ	—	—	—	4	5	5	7	5	13
L2	HKPJ	4	1	2	10	6	5	15	4	14
L2	JXPJ	3	3	3	12	4	6	14	8	13
L2	LL	2	2	1	2	2	4	3	2	7
L2	SB	4	1	2	15	2	6	14	2	10
L2	XN	2	0	1	1	1	1	—	—	—
L2	YF	2	0	0	3	1	1	9	5	4
L2	ZBPJ	3	0	2	7	3	4	—	—	—

\*Some firms have no data in 2009 and 2013 because these factories were built after 2009 or 2013, and some firms have no data in 2017 because those firms were closed down by 2017.



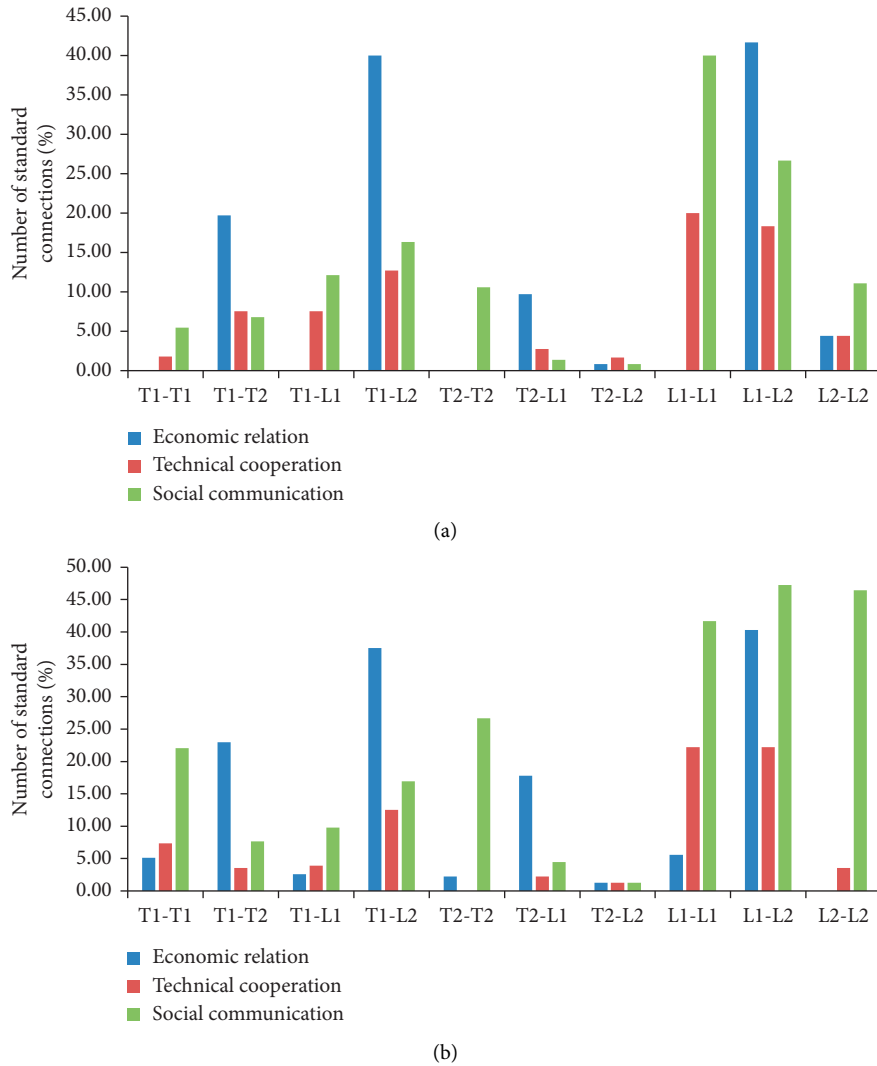


FIGURE 3: Number of standard connections for different types of firms in 2013 and 2017.

indicating that the technical cooperation between transplanted and surrounding firms were also relatively weak. In terms of social communication, the characteristics of L1-L1 > L1-L2 > T1-L2 > L2-L2 > T1-L1 > T2-T2 > T1-T2 were presented in 2013, and the characteristics of L1-L2 > L2-L2 > L1-L1 > T2-T2 > T1-T1 > T1-L2 > T1-L1 > T1-T2 in 2017 indicated that the social connection between the transplanted and the surrounding firms are weaker.

**4.3. The Multi-Core Characteristics of Network Systems Are Becoming More and More Obvious.** In the three networks in 2009, the degree value of ZB ranked first and was much higher than other nodes, indicating that ZB was the absolute core of the network in the Minquan refrigeration industry network in 2009. In 2013, ZB and XXH ranked first in the technical cooperation network, and the degree value far surpassed other firms. ZB and XXH ranked first and second in the social communication network. The degree value of XXH ranked third, and ZB is in the ninth place in the economic relation network. Therefore, the dominance of the

old local firm ZB has changed after 2013, and the transplanted firms XXH has also become the core node of the network. In 2017, the degree value of XXH ranked the first among the three networks, followed by ZB, HM, BH, and HKPJ alternately, indicating that XXH has replaced ZB as the absolute core of the network in 2017. It is worth noting that, the “rightward inclined long-tailed distributions” of the three network nodes in 2017 is not as obvious as in 2013, indicating that the multi-core characteristics of the Minquan refrigeration industry network are more prominent with the entry of large-scale transplanted firms such as XXH and HM.

**4.4. Intermediary Nodes Have Strong Heterogeneity.** The importance of a node in network connectivity, that is, its “network power” is not only related to its degree value, but also closely related to its mediating role in the network. Nodes with high betweenness centrality often act as intermediaries on the shortest connection lines of other nodes, and the intermediary becomes the “broker” for other nodes to communicate with each other.

TABLE 4: Intermediary node and its betweenness centrality of refrigeration firms network in Minquan County.

No.	2009 (%)		2013 (%)		2017 (%)	
	Technical cooperation	Social communication	Technical cooperation	Social communication	Technical cooperation	Social communication
1	ZB/24.18	ZB/42.95	XXH/30.64	XXH/27.87	ZB/22.65	XXH/27.38
2	JXPJ/13.19	XP/28.48	ZB23.66	ZB/27.50	XXH/22.52	ZB/11.91
3	JX/7.69	BH/14.10	BH/18.33	BH/13.50	BH/18.08	JXPJ/8.47
4	—	—	HKDQ/8.55	HM/9.23	KMR/10.85	BH/8.42
5	—	—	AJ/8.51	XP/6.71	SC/10.70	HM/8.20
6	—	—	HM/6.47	HKDQ/5.68	JXPJ/9.13	WB/6.31
7	—	—	HKPJ/4.96	WB/4.55	HM/6.65	HKDQ/5.72
8	—	—	AAS/4.86	SB/4.47	AKMDQ/5.54	HKPJ/3.77

TABLE 5: Similarity degree of refrigeration firms network in Minquan County.

	Economic relation-technical cooperation	Social communication-economic relation	Social communication-technical cooperation
2009	23.08	23.08	24.18
2013	11.15	14.23	8.97
2017	13.64	16.91	13.21

Considering that the products in the economic relation network will have a specific flow, two whole machine firms that are in contact with a supporting equipment firm at the same time may rarely have industrial connections, so the following focuses on identifying the intermediary nodes in the technical cooperation network and social communication network. Taking the top 20% nodes of betweenness centrality on three timestamps for analysis (Table 4), it can be found that the intermediary nodes in the Minquan refrigeration industry network have strong heterogeneity, including large-scale whole machine firms, smaller-scale supporting equipment firms, local firms, and newly-settled transplanted firms. These firms either have high degree values or occupy key positions in the network, thus becoming intermediaries for other firms to contact.

It should be noted that the intermediary nodes of the Minquan refrigeration industry network are mainly local firms, and the proportion of transplanted firms are relatively low. For example, in the intermediary nodes of the technical cooperation network and social communication network in 2017, the proportion of transplanted firms were 44.44% and 33.33%, respectively. The research results also show that some leading transplanted firms, such as WB and AKMDQ, which are highly expected by local governments, fail to play the corresponding role of internal leading and external communication.

*4.5. Economic, Technological, and Social Relational Network Systems Have Similar Structural Characteristics.* The formula (1) is employed to calculate the similarity of any two of the three networks at each time section (Table 5). The results show that the similarity of the three networks in 2009 is relatively close, while the similarity between the three networks in 2013 and 2017 is generally expressed as “social communication-technical cooperation similarity > economic relation-technical cooperation

similarity > social communication-economic relation similarity.” It can be seen from Table 1 that the economic relation network and social communication network of the Minquan refrigeration firms have similar densities, which are much higher than the density of technical cooperation network, but the structure of social relation network is the closest to technical cooperation network from the similarity of network structure. The main interview also found that the intra-cluster technology flow mainly occurs between firms with relatively close social relations. This phenomenon just confirms the existing results that social communication is the lubricant of tacit knowledge transmission. In addition, the degree centrality of the social communication network ranks first in the three timestamps, indicating that the construction of the social communication network has a stronger directionality, and the connection of the entire network is more dependent on the core node firms.

## 5. Conclusions

Based on the perspective of firm network, and putting forward a research framework of “relationship-network-evolution,” this study extracts the economic relation, technical cooperation, and social communication firm network of the refrigeration industrial cluster of Minquan County in 2009, 2013, and 2017. Then, it analyzes the structure and evolution characteristics of the firm network, determines the degree and effect of local embeddedness of transplanted firms, and discusses whether there are also embeddedness difficulties and failures in the process of local embeddedness of domestic transplanted firms. The following conclusions are drawn:

- (1) The local embeddedness of transplanted firms has significantly promoted the development of the Minquan refrigeration industry network. In 2009, only 1 of the 15 firms in the cluster transplanted in. In 2017, a total of 44 major firms included 27

transplanted firms. Transplanted firms not only had an obvious advantage in quantity, but their output value accounted for more than 80% of the total output value of the cluster, and the large-scale, high-efficiency star firms in the cluster basically are all transplanted firms of the whole machine such as AKMDQ, WB, XXH, and ASDDRSQ. It can be said that it is the local embeddedness of the transplanted firms that promotes the development of the firm network within the cluster.

- (2) The “network power” of large-scale transplanted firms in the cluster is increasing day by day, and the network presents a multi-core trend. Before 2009, most of the local firms in the cluster were local firms derived from “Old Ice Bear,” and ZB, the largest whole machine firm, naturally became the core of the network. By 2013, the transplanted firms XXH and HM had a sudden emergence, the absolute core position of the local firm ZB was severely impacted, and the Minquan refrigeration industry network showed a certain multi-core trend. As of 2017, the degree value of transplanted firms XXH ranked the first in the three networks, and the local firm ZB and transplanted firms HM, BH, and HKPJ followed alternately. Moreover, the degree distribution of the three network nodes has the feature of “rightward inclined long-tailed distributions,” which is significantly weaker than that in 2013. It can be seen that its multi-core characteristics are also more obvious during the study period as the network develops.
- (3) Some of the transplanted firms have low local embeddedness, and the overall network connectivity is not strong. Although the cluster has undertaken many transplanted firms since 2010, the regional firm network construction is not perfect, and the overall network connectivity is not ideal. Among them, the technical cooperation network not only has a low level of connectivity, but also tends to become sparse, indicating that a good atmosphere for technical learning and collaborative innovation has not yet been formed within the cluster. The results of centripetal-centrifugal structure analysis show that the degree of local embeddedness of the transplanted firms are not high, and they are mainly distributed in the fringe area of the firm network. There are three main reasons for this phenomenon. First, most of the local firms in the cluster originated from “Old Ice Bear,” and this unique “identity” makes them form relatively close formal and informal connections, but the network performance of some transplanted firms is not ideal due to the lack of such social capital. Second, transplanted firms generally do not agree with the supporting capabilities and business models of local firms. Large-scale whole machine firms such as WB and AKMDQ seek farther, and even purchase spare parts from the original place. Third, when some whole machine firms moved to Minquan, they also brought some original

supporting firms, which formed a closer connection between them and showed a strong “personal club” feature.

- (4) The network intermediary nodes have strong heterogeneity, and the intermediary role of some large transplanted firms need to be improved. The measurement results show that the intermediary role of some large-scale transplanted firms is not prominent, which is quite different from common sense. In general, leading transplanted firms tend to have stronger capital and technological advantages, as well as greater “network power,” and the location of network “structural holes” makes it easier for them to become the absolute intermediary of global-local production network connection. In the technical cooperation network, similar firms are used to be called “technological gatekeeper.” In the Minquan cases, the intermediary role of some large-scale transplanted firms is weak. The reasons are as follows. First, the local embeddedness of the relevant firms is not high. For example, the local procurement ratio of AKMDQ is very low, and its technology research and development activities are all located in the Qingdao headquarters. Middle and senior management personnel return to Qingdao to rest on weekends. Second, the Minquan refrigeration industry cluster is still a regional “Marshallian industrial district,” and the degree of strategic coupling with the global production network is relatively low.
- (5) The three networks have similar structural characteristics, and social capital plays an important role in network development. This paper quantitatively measures the similarity between any two networks in the same year by building a model. The results show that the social communication network and technical cooperation network have the highest similarity, and the social communication network is more dependent on core nodes. Looking back on the history of the Minquan refrigeration industry, it can be seen that the “Old Ice Bear” collapsed and gave birth to more small- and medium-sized firms. At the same time, as a relationship link, it also attracted many transplanted firms to move in. This phenomenon is vividly called “an ice bear fell down, and thousands of bear soldiers stand up.” As an important virtual asset or social capital, the identity of “Old Ice Bear” plays an important role in the development of the Minquan refrigeration industry network. The implicit relationship network formed based on this identity has become the background of the Minquan refrigeration industry network to a certain extent. Furthermore, it has a subtle influence on the economic connection and technical cooperation between firms, especially the transmission of tacit knowledge.
- (6) Compared with international transplanted firms, interregional transplanted firms are more adaptable in terms of local embeddedness. It can be seen that,

domestic transplanted firms are less likely to encounter structural dislocation, cognitive dislocation, and other embeddedness obstacles under the comprehensive effect of institutional environment adaptation, local cultural identity, and social capital lubrication, and there are fewer difficulties and failures in local embeddedness compared with global transplanted firms. Based on the above findings, it is necessary to strengthen research in two aspects in the future. One is the mechanism of cultural identity and social capital in the local embeddedness of transplanted firms, and the other is the deep impact of social exchanges between firms on economic relations and technical cooperation.

The innovation of this paper is that it studies the local embeddedness of transplanted firms from the perspective of “firm network,” and the theoretical framework constructed with “relationship-network-evolution” as the main line can clearly study and judge the process, mechanism, and effect of local embeddedness of transplanted firms. Combined with the empirical research of the Minquan refrigeration industry cluster, it was found that the transplanted firms strengthen their local embeddedness by establishing economic, technological, and social connections with local firms, and affect the evolution and upgrading of local industrial cluster. In addition, the domestic transplanted firms are less likely to encounter embedded obstacles such as structural dislocation and cognitive dislocation, and have stronger adaptability than global transplanted firms. The abovementioned research framework construction and empirical analysis provide a new path and paradigm for the existing industrial transfer research. The disadvantage of the research is that some small-scale firms are omitted in the research process, resulting in a small number of samples, and the extracted firm network can only approximate the actual situation of the Minquan refrigeration industry to the greatest extent. The firm connection relationship is binarized to construct an undirected and weightless relationship network, which cannot reflect the strength difference and directionality of the connection and will affect the accuracy of structural analysis to a certain extent. In addition, the local embeddedness and de-embeddedness of transplanted firms often have a long time period, and short-term observation and research may not be able to form accurate conclusions. In the future, it is necessary to observe and analyze the network construction and interaction coupling through a longer research period, and further explore the network evolution mechanism of the cluster firms under the influence of the local embeddedness of the transplanted firms.

### Data Availability

Data used for this work are available upon request from the corresponding author.

### Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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