Journal of Agricultural Science and Technology (JAST)
In Press, Pre-Proof Version

An analysis of the actors' communication network in the knowledge and innovation system of the handmade silk carpet industry in the rural areas of Zanjan province

Elham Ahmadifard[1], Homayoun Farhadian[1]*, Esmail Karamidehkordi[1], and Hossein Shabanali Fami[2]

Abstract

Effective communication is pivotal for the prosperity of businesses as it facilitates the exchange of ideas, thoughts, and emotions. It is also crucial for motivation and awareness. Rural handwoven carpet weavers, particularly in the context of handmade silk carpet production, grapple with significant challenges concerning recognizing all stakeholders and establishing timely connections. These challenges have a substantial impact on the adoption of innovation in carpet production and the overall enhancement of productivity. This research was conducted to scrutinize the communication network of carpet weavers within the Knowledge and Innovation System (KIS) of handmade silk carpet production in rural areas. Data were gathered through interviews with 270 rural households in Zanjan province, specifically in the Tarom, Khodabandeh, and Zanjan counties, utilizing a structured questionnaire. Social Network Analysis (SNA) in UCINET was employed to examine the interactions among these actors, and graphical representations were created using Net Draw. The results revealed that the network's density varied across different levels, showing weakness in some cases, moderate strength in others, and strong connections in select instances.The findings suggest that interactions within the network of handmade silk carpet weavers are predominantly confined to local connections. Given that production occurs under a Family owned production system, and weavers acquire their skills from "FMs" (family members) or other individuals in their villages, their interactions are primarily concentrated on these "FMs" and "WNVKRs" (weavers in the same neighborhood or village or with kinship relations). Therefore, considering the status of the weavers' communication network and its importance in the knowledge and innovation system, it is suggested that through training courses, workshops, festivals and such programs, communication between the weavers and other key actors is established, and the weavers Get to know the roles and duties of other actors in the handwoven carpet production chain so that they can refer to them when needed.

[1] Department of Agricultural Extension and Education, Faculty of Agriculture, Tarbiat Modares University, Tehran, Islamic Republic of Iran.
[2] Department of Agricultural Manegement and Development, Faculty of Agriculture, University of Tehran, Islamic Republic of Iran.
*Corresponding author; e-mail: h.farhadian@modares.ac.ir or HomayonFarhadian@gmail.com

Keywords: Handmade Carpet, KIS, Network Analysis, Production Actors' Interactions, Zanjan Province.

1 Introduction

Thorough knowledge of a product with all its cultural and artistic features establishes a chain of trust between producers and consumers (Egharloo and Allameh, 2022). Handicrafts in developing countries have cultural and identity values that set them apart from the products of industrial countries and foster capacities for international cultural exchanges and the development of cultural heritage for communities. So, it seems necessary to learn about the competitive advantage of Persian handmade carpets (HCs) as one of the most important handcrafts. The artistic potential of these carpets reveals the need for scholarly accounting for their competition and globalization (Mirzaei, 2015). Handicrafts, including HCs, are a major source of non-petroleum exports (Kashyzadeh and Darounkola, 2021). Iran is a leading carpet producer and exporter in the world (Shojaei et al., 2023; Ahmadifard, & Farhadian, 2023; Bilgin et al., 2011).

Despite the significance of HCs in exports and job creation, this industry has been struggling with many challenges in recent years. The managerial changes in HC officials in these years have been harmful to the body of the HC art industry due to the differences in their decisions and interests. The HC has various problems, such as sanctions and the entailing issues like raw material shortage for production and the higher end price of the carpets, the lag of producers and weavers from production, and the old and outdated designs due to the fear of non-sale of new designs (Akbari and Abbasi, 2019). The export of HCs has fluctuated over time. Other effective parameters, including competitors, have destabilized the economy of this industry (Kashyazadeh and Darounkola, 2021).

The industry also suffers from technical backwardness, low productivity relative to other economic activities (Mohammadi Ostad Kolayeh and Bayat, 2016), weaving by Family owned production system that results in low quality and quantity, a traditional system of skills training, inadequate and ineffective supervision by employers, and low investment by cooperatives in raw material supply (Mirkatouli, 2009). Carpet-weaving at home is practically impossible to control. Therefore, this industry struggles to meet the preferences and demands of foreign customers. In Iran, 90 percent of the carpets are Woven in rural areas, where the weavers have no adequate knowledge of customer demands in international markets (Pishkhani, 2024; Bilgin et al., 2011).

The handmade silk carpet industry (HSCI) Zanjan province, Iran started in 1969. The first silk carpet weavers resided in Qom province. Then, rural weavers from Zanjan learned the skill at their workshops and developed the initiative in the rural areas of Zanjan province (Ahmadifard

and Karamidehkordi, 2016). Presently, the silk carpets Woven in Zanjan are of high quality and can rival the products of Isfahan, Qom, and Kashan. However, its carpets are often exported under the name of other provinces, especially Qom, for various reasons, such as the similarity of texture and designs of carpets produced in other provinces and in some cases (Ahmadifard and Karamidehkordi, 2018), the lack of market knowledge and sales skills. As a result, the added value of the carpet decreases, which leads to a decline in the number of weavers (Zanjan carpet expert, 2023).

Given these challenges and problems, it is necessary to examine the interaction between silk weavers in rural areas of Zanjan and other actors. Communication refers to the verbal or non-verbal transfer of ideas, thoughts, and emotions between a sender and a receiver. This transfer is crucial for businesses (Stupnikova, 2023; Genç, 2017). Regardless of the business size, communication is key for business success. It is a process that allows for achieving public relations goals. Communication is vital because it fosters awareness, persuasion, motivation, and mutual understanding (Purwanto, Wafa, & Sanjani, 2023; Genç, 2009). In a production chain, information flows along with the flow of inputs. Concerning the information flow, the components are linked bilaterally, and communication is key for decision-making to develop and maintain production units. The information enables production units to make optimal decisions and maximize profit (Ahmadifard and Karamidehkordi, 2018).

Sociology studies the communication patterns among people, organizations, institutions, and governments at different levels of society (Wasserman and Faust, 1994). The study of KISs helps understand the current situation of the KISHC and identify gaps and issues (Wieczorek and Hekkert, 2012). Regarding innovation, "SNA" can reveal how actors interact, how information and resources flow among them, and how their roles and relationships are organized. The data for "SNA" are usually based on measuring the relationships between actors and a set of players and their characteristics.

2 LITERATURE REVIEW

The network science methods have proven to provide a deeper understanding of a system along with more traditional approaches and qualitative knowledge (Valeri and Baggio, 2021).

Network analysis (NA) is a research approach that focuses on the relationships between social units rather than their personal characteristics (Brown et al., 2016). "SNA" is a common tool to study systems (networks) of interconnected people and evaluate how much people and personal communications help the system's performance in terms of the selected indices. NA allows the

ranking of the network elements to improve the communication of the research results (Gava, Favilli, Bartolini, and Brunori, 2017).

The NA shows the relationships in terms of the networks of nodes and ties. Nodes are the individual actors in the network, and ties are the connections between them. The results of graph-based structures are often complex. Networks play a critical role in determining how to solve problems, manage organizations, and measure their success in achieving their goals (Hekkert et al., 2011).

There is extensive literature on SNA. With a long history as a research instrument in sociology, SNA is a method of program assessment. Social networks are used in various fields, especially in commerce (Cross, Cross, and Parker, 2004) and emerging innovation (Gloor, 2006). The literature review shows that research on the social network of the HC industry has been scarcely studied, which justifies the current research.

Valeri and Baggio (2021) concluded that network science methods could be quite useful and effective. They can also help a very precise methodological approach that may rationalize a messy set of ideas, models, and theories. Broda, Granger, Chow, & Ross (2023) and Wey et al. (2008) define social groups as networks of nodes linked by social ties. This approach investigates people and groups in the context of the communications of the group members.

By identifying and measuring the potential of actors, Haghigahtnaeini, Houdasni, Ashrafi, and Golzari (2022) concluded that there are many actors in this field, but the government and public sectors practically dominate and the private sector and local communities play a minor role.

Montemurro, A. (2023) with review social investment strategies in European education concluded that NA answer the need for new research sensibilities and new methods and concepts to better comprehend the new actors, organizations, forms of relationships and participation.

Karimigoghari, Rezaiemoghaddam, and Rezaie (2018) with review Social network analysis, a new approach to explain pluralistic extension and education system found that the dynamic institutional network lacked the interaction of all actors in the context of extension-educational activities. There was also an imbalance of power between governmental organizations and non-governmental organizations. In an analysis of the information network of rural silk carpet weavers, Ahmadifard and Karamidehkordi (2018) found that the weavers' main information sources were employers and "FMs" in the employer-based systems while local actors and market actors were the most essential information source in the self-employed system.

Gholifar, Abbasi, Pezeshkirad, Salehi, and Rezaie (2018) with analyzing information and interaction network among active actors in aquaculture activities management in Alborz

damwatershed concluded that governmental had higher centrality (authority) than non-governmental organizations in the information sharing, cooperation, and participation.

This study investigated the participants involved in the production of handmade silk carpets within the rural regions of Khodabandeh, Tarom, and Zanjan counties, which were chosen as the primary units of analysis due to the abundance of weavers in these areas. The list of villages can be found in Table 2. The primary objective was to scrutinize the network of interactions among the key weavers within households and other stakeholders within the KIS of silk handmade carpet (HC) production.

Stakeholders in the KISHC include all actors who are involved in the different stages of production (before, during and after production). Despite the importance of some activists, the weavers do not even know about their existence in the production chain. The weavers' awareness and in the next stage their communication with key actors will play an important role in the development and strengthening of the weavers' CN. These stakeholders encompassed the public sector, associations, market participants, and local actors, as detailed in Table 3.

The study of the interactions and communications of the actors involved in the production in the knowledge and innovation system of the handmade carpet (KISHC) needs to be investigated due to the importance of communication and information sharing in the transfer of ideas and the creation of innovation in production industries and units and the need for innovation in the industry of HCs. These actors include public and private organizations, weavers, and market actors. The research questions are: Which actors (formal and unformal, market and local) play a role in the KISHC production? Which actors do the weaver households communicate more with? Which actors are more important in the communication network (CN)?

3 Materials and Methods

The study employed a quantitative survey approach to examine the network of connections between weavers and various stakeholders in the KIS of the HSCI. Data were acquired through structured interviews with rural households engaged in silk carpet-weaving, utilizing quantitative research techniques (questionnaire). Network theory was applied to assess the configuration of interactions between the primary weavers and other participants within the KIS. The SNA was employed to investigate the connections among a multitude of diverse actors, offering tools for visualizing, quantifying, and evaluating these relationships, as described by Borgatti (2006).

The study's statistical population encompassed all silk carpet weavers located in Zanjan, Tarom, and Khodabandeh counties. To determine the estimated count of silk and wool carpet weavers in various counties, information was obtained from the Carpet Office within the Industry, Mining,

and Trade Organization. Subsequently, Zanjan, Tarom, Mahneshan, and Khodabandeh counties were accorded higher priority, as they were identified to have the greatest concentration of weavers based on the provided data.

A multi-stage stratified sampling approach was employed for the sample selection process.

1. Initially, to address limitations related to both budget and time, the sampling scope was narrowed down to encompass three counties with the highest concentration of silk weavers: Zanjan, Tarom, and Khodabandeh.

2. The Industry, Mining, and Trade Organization of Tehran province furnished a list of villages within these three counties that had the highest numbers of weavers.

3. Subsequently, the researchers acquired contact details for rural district governors within these designated villages through the Rural District Office and the Governor's Office of Zanjan province. They reached out to these officials to request information about the most prominent weavers in each village who possessed extensive social connections within the HSCI.

4. Following this, the snowball sampling technique was utilized to expand the pool of participating weavers and estimate the total count of silk carpet weavers within each village.

Following the county selection, one or more districts with the greatest concentration of weavers were identified. Subsequently, the rural districts boasting the highest numbers of weavers were chosen from each of these districts. Villages were then categorized into four groups based on the number of weavers, ranging from 1 to 100. Employing the Korjesi and Morgan formula with a 5% margin of error, a sample of 270 households involved in weaving was drawn from the total pool of 3,312 silk weavers across the three counties.

Numerous variables can be calculated for NA and can be used depending on the research goal.

3.1 Concepts in NA

3.1.1 Centrality indices(CIs)

Degree centrality shows the relative importance of a node in a network. In general, it is calculated for a certain node X as the ratio of the nodes connected to the node to the total number of nodes in the network (reduced by 1) (Bródka, Skibicki, Kazienko, & Musiał, 2011)

Betweenness centrality (BC) is the measurement of a node that has a mediating role in the network. If a node is located on the only way that other nodes should pass through, such as communications, links, transportation, or transactions, it must be an important node and it may have high *BC* (L. C. Freeman, 1977; Zhang & Luo, 2017).

Closeness centrality (CC) means the measurement of the total distances of a node from the other nodes. If the shortest distance of the paths of node N with other nodes in the network is small, the node has a high CC (Wasserman & Faust, 1994; Zhang & Luo, 2017).

Eigenvector centrality (EC) is another index that is based on the idea that an actor is more central if it is linked to other actors that are themselves central. Accordingly, it can be argued that the centrality of a node depends on not only the number of adjacent nodes but also its centrality value (Pradhan, Angeliya, & Jalan, 2020; Ruhnau, 2000).

3.1.2 Cohesion indices

Density shows the intensity of network use and specifies the ratio of the likely ties that exist. It is based on the assumption that all ties and links that exist in a network are known and a distinction is made between 'de facto' and 'potential' relations (Leon, Rodríguez-Rodríguez, Gómez-Gasquet, & Mula, 2017).

Transitivity shows network stability (Eshaghi, Hejazi, Hosseini, and Rezaie, 2020). *Fragmentation* is the reverse scale of the measurement of links or link abundance in a network (Makagon, McCowan, and Mench, 2012). *The diameter* is the longest distance between two nodes in a network (Makagon et al., 2012). It is the highest eccentricity in whole the graph. Eccentricity is the highest distance that the node can have from the other nodes (Emamgholizadeh, 2014). *Radius* is the lowest eccentricity of the whole graph (Emamgholizadeh, 2014).

Average distance is the average of the shortest distances between two nodes in the network. This index represents a concept of the closeness of the members of a community. A higher index means that not so many individuals in the social network know each other directly and their relationships are established through more mediators (Zandian, Moradian, and Hassanzadeh, 2018).

Norm distance refers to the extent to which the actors in an international network share common innovation, organizational culture, value systems, or language (Fang and Pigneur, 2007).

Data required for the analysis of the network of the actors in the KISHC were collected by a questionnaire composed of structured questions. The questionnaire was filled out by 270 silk carpet-weaving households in the rural areas of Zanjan, Tarom, and Khodabandeh.

The research used the network theory to analyze the structure of the relations between the actors of this system. All mathematical calculations were performed by UCINET. The graphs were drawn in Netdraw, which is an auxiliary tool of UCINET.

4 Results

The descriptive statistics show that the respondents were, on average, 40 years old. In age, the highest frequency (46%) was for the 38-48 group, and in gender, the highest frequency (52%) was for women. In the educational level, the highest frequency (60.4%) was for people with basic literacy. The mean history of weaving was 21-30 years. Regarding the production methods, the highest frequency (73%) was for the Family owned production system.

The next sub-section reports the results of analyzing the interactive relationships of the weavers with other actors in the KIS of handmade silk carpet production.

4.1 The analysis of the CN between weaver households and other actors in the KISHC

Due to the high number of weaver households (270 households), the studied villages and the production method were selected as the criteria for analyzing the actors' CN.

The ties of the actors with the weaver households in each village were evaluated over a scale from weak (households with no ties = 0; households with ties = 1) to moderate (households with no ties or one or more ties per year = 0; households with more than one or more ties per year = 1), and strong (households with no ties or one or more ties per year and season = 0; households with more than one or more ties per season = 1).

The results regarding the coherence indices of the communications (Table 1) showed that the highest value of the density was for the weak ties with the actors. This index can be reduced by reinforcing the links and establishing closer and stronger ties. The highest transitivity of the ties was 0.852 for strong communication, reflecting the high stability of the network. The comparison of fragmentation among the three states shows that it can be increased to 0.673 by reinforcing the relationships. The diameter was 4 in all three states. Also, the radius was 2 in all three communicational states.

The average distance is a concept of the closeness of a community's members. A higher average distance means that fewer people in the social network know each other directly and the ties are based on more mediators. As the links are reinforced, this index reduces. It is 2.016 for strong relationships, implying that the direct ties of the weavers with the weaver families increase in stronger relationships. As the ties are reinforced and when stronger ties are requested, more people who lack strong ties are discarded from the network, which increases the norm distance. As people's distance increases from one another, the norm distance increases. It was 2.265.

Table 1. The cohesion indicators of the network of interactions with actors in KISHCs

	Density	Average Distance	radius	diameter	Fragmentation	Transitivity	Norm Distance
Weak Network	0/159	2/294	2	4	0/354	0/669	1/010
Moderate Network	0/084	2/167	2	4	0/573	0/759	1/617
Strong Network	0/056	2/016	2	4	0/673	0/852	2/265

Regarding the CIs, the results in Table 2 revealed that the communications of the weavers differed in the studied rural areas and among different production methods. The classification of the communications showed that in the weak tie status, the weavers in Koloeim Cillage of Tarom County with the self-employed production system and a frequency of 0.357 had the most number of ties (Fig 1). In the moderate tie status, the villages of Qeshlaq and TekmehDash in Zanjan County with the Shared-based production system and a frequency of 0.167 had the highest degree centrality (Fig 2), and in the strong tie, the weavers in the villages of Meshkin, Degahi, and Koloeim in Zanjan and Tarom counties with the self-employed and Shared-based production system and a frequency of 0.095 had the highest number of ties (Fig 3).

Based on the *EC* in the weak tie status, the most influential weavers were in the villages of Koloeim and Valyaran in Tarom and Zanjan counties with the self-employed production system and frequencies of 0.202 and 0.203, respectively. In the moderate tie status, the most influential weavers were in Qeshlaq in Zanjan County with the Shared-based production system and a frequency of 0.196. In the strong tie status, the most influential weavers were in the villages of Meshkin, Degahi, and Koloeim in Zanjan and Tarom counties with the self-employed and Shared-based production system and a frequency of 0.178.

Based on the *BC*, in the weak tie status, the weavers in the village of Koloeim in Tarom with the self-employed production system and a frequency of 0.066 had the greatest controlling and mediating role in the network. In the moderate tie status, the strongest controlling power in the network of ties was for the weavers in the village TekmehDash in Zanjan County with the Shared-based production system and a frequency of 0.046. In the strong time status, the weavers in Koloeim in Tarom with the Family owned production system and a frequency of 0.013 had the highest mediating power. Based on the CC, in the weak tie status, the weavers in Koloeim in Tarom County with the self-employed production system and a frequency of 0.596 had the highest rate of access. In the moderate tie status, those in the villages of TekmehDash and Qeshlaq in Zanjan County with the Shared-based production system and a frequency of 0.500 had the highest CC. In the strong tie status, the weavers in the villages of Koloeim, Degahi, and

296 Meshkin in Tarom and Zanjan counties with the self-employed and Shared-based production
297 system and a frequency of 0.464 had the highest CC.

298 **Table 2.** CIs for weavers' interactions with other actors in KISHCs.

		Weak				Moderate				Strong			
Villages	**ID Number**	Degree	Closeness	Betweenness	Eigenvector	Degree	Closeness	Betweenness	Eigenvector	Degree	Closeness	Betweenness	Eigenvector
Jezla	**V11**	0/119	0/546	0/001	0/139	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
	V12	0/262	0/575	0/029	0/185	0/071	0/485	0/000	0/147	0/071	0/461	0/001	0/166
Bagh	**V21**	0/143	0/551	0/001	0/158	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
	V23	0/214	0/565	0/007	0/170	0/119	0/492	0/000	0/153	0/048	0/458	0/000	0/146
JalilAbad	**V31**	0/095	0/542	0/000	0/101	0/048	0/481	0/000	0/110	0/048	0/458	0/000	0/146
ChoreKandy	**V41**	0/238	0/570	0/012	0/183	0/095	0/489	0/001	0/172	0/071	0/461	0/001	0/166
	V42	0/238	0/570	0/022	0/136	0/071	0/485	0/000	0/147	0/071	0/461	0/001	0/166
	V43	0/143	0/551	0/007	0/145	0/119	0/492	0/002	0/187	0/071	0/461	0/001	0/166
DashTapeh	**V51**	0/095	0/542	0/000	0/115	0/095	0/489	0/001	0/151	0/071	0/461	0/002	0/157
Gheshlagh	**V61**	0/167	0/556	0/014	0/148	0/071	0/485	0/001	0/125	0/048	0/458	0/000	0/146
	V63	0/190	0/560	0/005	0/176	0/167	0/500	0/014	0/196	0/024	0/455	0	0/074
Vananagh	**V71**	0/119	0/546	0/001	0/139	0/048	0/481	0/000	0/110	0/024	0/455	0	0/074
Leghahi	**V81**	0/143	0/551	0/003	0/144	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
	V82	0/143	0/551	0/004	0/130	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
	V83	0/143	0/551	0/003	0/144	0/095	0/489	0/001	0/172	0/071	0/461	0/001	0/166
Valyaran	**V91**	0/119	0/546	0/002	0/120	0/048	0/481	0/000	0/110	0/048	0/458	0/000	0/146
	V92	0/286	0/580	0/021	0/203	0/048	0/481	0/000	0/110	0/048	0/458	0/000	0/146
TekmeDash	**V101**	0/167	0/556	0/003	0/158	0/095	0/489	0/001	0/172	0/071	0/461	0/001	0/166
	V102	0/262	0/575	0/021	0/190	0/048	0/481	0/000	0/110	0/048	0/458	0/000	0/146
	V103	0/167	0/556	0/003	0/158	0/167	0/500	0/046	0/176	0/071	0/461	0/001	0/166
Sohrein	**V111**	0/119	0/546	0/007	0/125	0/048	0/481	0/000	0/110	0/048	0/458	0/000	0/146
	V112	0/119	0/546	0/002	0/120	0/048	0/481	0/000	0/110	0/048	0/458	0/000	0/146
	V113	0/095	0/542	0/000	0/124	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
Meskin	V121	0/143	0/551	0/001	0/158	0/095	0/489	0/001	0/172	0/048	0/458	0/000	0/146
	V122	0/262	0/575	0/014	0/192	0/095	0/489	0/001	0/162	0/095	0/464	0/003	0/178
Armaghankhaneh	V131	0/119	0/546	0/003	0/127	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
	V132	0/214	0/565	0/032	0/171	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
DizajAbad	V141	0/095	0/542	0/000	0/115	0/095	0/489	0/001	0/151	0/071	0/461	0/002	0/157
	V142	0/167	0/556	0/002	0/155	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
Agkand	V151	0/167	0/556	0/010	0/151	0/119	0/492	0/002	0/187	0/048	0/458	0/000	0/146
Homayoun	V161	0/095	0/542	0/000	0/124	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
	V162	0/143	0/551	0/012	0/114	0/119	0/492	0/024	0/120	0/048	0/458	0/000	0/146
AghcheGhonbad	V171	0/119	0/546	0/001	0/139	0/095	0/489	0/003	0/153	0/071	0/461	0/001	0/166
Sarmsaglo	V181	0/143	0/551	0/001	0/158	0/071	0/485	0/002	0/117	0/048	0/458	0/000	0/146
	V182	0/190	0/560	0/009	0/136	0/071	0/485	0/000	0/147	0/048	0/458	0/000	0/146
Deghahi	V191	0/119	0/546	0/000	0/143	0/095	0/489	0/001	0/151	0/071	0/461	0/002	0/157
	V193	0/238	0/570	0/011	0/17	0/119	0/492	0/002	0/187	0/095	0/464	0/003	0/178
Sole	V201	0/119	0/546	0/001	0/130	0/048	0/481	0/000	0/110	0/048	0/458	0/000	0/146
Gogarchinak	V211	0/119	0/546	0/001	0/139	0/095	0/489	0/001	0/172	0/048	0/458	0/000	0/146
GaraVali	V221	0/095	0/542	0/000	0/124	0/048	0/481	0/000	0/110	0/024	0/455	0	0/074
Gohe	V231	0/119	0/546	0/001	0/139	0/071	0/485	0/000	0/135	0/048	0/458	0/000	0/146
Koloeim	V241	0/167	0/556	0/002	0/167	0/095	0/489	0/001	0/172	0/071	0/461	0/013	0/147
	V242	0/357	0/596	0/066	0/202	0/119	0/492	0/004	0/168	0/095	0/464	0/003	0/178
Sheat	V251	0/095	0/542	0/000	0/124	0/095	0/489	0/001	0/172	0/048	0/458	0/000	0/146
	V253	0/095	0/542	0/004	0/097	0/095	0/489	0/000	0/138	0/048	0/458	0/000	0/146

299 Family owned production system=1, Self-employed production system= 2, Shared-based production system=3,
300 Vmn=m=Village Code, n= Production Method.
301

According to Table 3 about the CIs, in the weak and moderate tie statuses, "WNVKRs" and "FMs" with a frequency of 1 had the highest level of communications, and the strong tie status, "FMs" with a frequency of 1 had the highest degree centrality.

Concerning the *EC* index for the actors, it was found that in the weak and moderate tie statuses, "WNVKRs" and "FMs" had the highest frequencies (0.467 and 0.604, respectively), and in the strong time status, "FMs" with a frequency of 0.701 had the highest effectiveness in the network with abundant links with other influential actors.

The *BC* of the actors revealed that in the weak and moderate time statuses, "WNVKRs" and "FMs" with frequencies of 0.128 and 0.158, respectively had the highest controlling and mediating power, and in the strong time status, "FMs" with a frequency of 0.170 had the highest controlling and mediating power.

CC for the actors showed that in the weak and moderate tie statuses, "WNVKRs" and "FMs" had the highest speed of access with frequencies of 0.713 and 0.585, respectively, and in the strong tie status, "FMs" with a frequency of 0.534 had the highest speed of access.

317 **Table 3.** Indicators of the centrality of interactions of different actors' in KISHC.

Actors	Weak				moderate				strong			
	Degree	Closeness	Betweenness	Eigenvector	Degree	Closeness	Betweenness	Eigenvector	Degree	Closeness	Betweenness	Eigenvector
O1: Carpet Office of Zanjan province	0/022	0/444	0	0/014	0	0/295	0	0	0	0/295	0	0
O2: Ministry of Industry, Mine and Trade of the city	0/044	0/450	0/000	0/025	0	0/295	0	0/000	0	0/295	0	0/000
O3, O17: Iran National Carpet Center	0	0/295	0	-0/000	0	0/295	0	-0/000	0	0/295	0	0/000
O4: Iran Business Training Center	0	0/295	0	0/000	0	0/295	0	-0/000	0	0/295	0	0/000
O5: ECommerce Development Centre Of Iran	0	0/295	0	0/000	0	0/295	0	0/000	0	0/295	0	-0/000
O6: The Academic Center for Education, Culture and Research	0/044	0/435	0/000	0/022	0	0/295	0	0/000	0	0/295	0	0/000
O7: Work and Knowledge Conservatories -Zanjan	0	0/295	0	0/000	0	0/295	0	0/000	0	0/295	0	0/000
O8: Work and Knowledge Conservatories -County	0	0/295	0	-0/000	0	0/295	0	0/000	0	0/295	0	0
O9, O18: Colleges of Art	0	0/295	0	0/000	0	0/295	0	0/000	0	0/295	0	0
O10: University of Applied Science and Technology	0	0/295	0	0/000	0	0/295	0	0/000	0	0/295	0	0
O11: Department of vocational education Zanjan Province	0/089	0/441	0/000	0/049	0	0/295	0	0/000	0	0/295	0	0
O12: Department of vocational education -County	0/022	0/432	0	0/013	0	0/295	0	0	0	0/295	0	0
O13: Carpet-Weaving Private Educational Institutions	0	0/295	0	0/000	0	0/295	0	0	0	0/295	0	0
O14: State Welfare Organization of Iran (SWOI)	0/044	0/447	0/000	0/025	0	0/295	0	0	0	0/295	0	0
O15: Imam Khomeini Relief Foundation	0/111	0/477	0/002	0/064	0	0/295	0	0	0	0/295	0	0
O16: Missouri Basij Organization	0/044	0/435	0/000	0/020	0/022	0/398	0	0/011	0	0/295	0	0
O19: Research Institute of Color & Cover Science & Technology	0	0/295	0	0/000	0	0/295	0	0	0	0/295	0	0
O20: Iran Carpet Research Institute	0	0/295	0	0/000	0	0/295	0	0	0	0/295	0	0
O21: Iran Nanotechnology Innovation Council	0	0/295	0	0/000	0	0/295	0	0	0	0/295	0	0
O22: Trade Union of Manufacturers and HC Weavers	0	0/295	0	0	0	0/295	0	0	0	0/295	0	0
O23: Trade Union of Carpet Sellers and HC materials	0	0/295	0	0	0	0/295	0	0	0	0/295	0	0
O24: Union of Rural HC Cooperative Companie-Zanjan	0/156	0/467	0/002	0/086	0	0/295	0	0	0	0/295	0	0
O25: Union of Urban HC Cooperative Companie-Zanjan	0/067	0/454	0/001	0/029	0/044	0/403	0/000	0/023	0	0/295	0	0
O26: Union of Urban HC- County	0	0/295	0	0	0	0/295	0	0	0	0/295	0	0
O27: Trade Union of HC Weaver	0	0/295	0	0	0	0/295	0	0	0	0/295	0	0
O28: Lessors or Sellers of Maps	0/222	0/485	0/004	0/124	0/022	0/403	0	0/016	0	0/295	0	0
O29: Sellers of Other Raw Materials	0/333	0/534	0/014	0/181	0/022	0/403	0	0/016	0	0/295	0	0
O30: Belonging to the market who buy and sell silk carpets	0/333	0/534	0/014	0/184	0/022	0/403	0	0/016	0	0/295	0	0
O31: Dyer	0/089	0/464	0/001	0/048	0	0/295	0	0	0	0/295	0	0
O32: lint Collector	0/089	0/450	0/001	0/044	0	0/295	0	0	0	0/295	0	0
O33: Darner	0/044	0/438	0/000	0/020	0	0/295	0	0	0	0/295	0	0
O34: Designer	0/022	0/426	0	0/012	0	0/295	0	0	0	0/295	0	0
O35: Chelekeshan	0/089	0/464	0/001	0/048	0	0/295	0	0	0	0/295	0	0
O36: Businessmans or Employers of HCs	0/867	0/668	0/091	0/412	0/400	0/465	0/020	0/275	0/022	0/385	0	0/016
O37: WNVKRs	1	0/713	0/128	0/467	1	0/585	0/158	0/604	0/933	0/520	0/131	0/677
O38: Fellow Villager Weavers or Relatives living in the city	0/556	0/577	0/037	0/275	0/244	0/431	0/005	0/166	0/133	0/399	0/001	0/106
O39: FMs	1	0/713	0/128	0/467	1	0/585	0/158	0/604	1	0/534	0/170	0/701
O40: Local brokers only buying carpets	0/133	0/450	0/001	0/066	0/044	0/406	0/000	0/032	0	0/295	0	0
O41: Local intermediaries between the employer and the weaver	0/444	0/538	0/020	0/217	0/111	0/419	0/002	0/069	0	0/295	0	0
O42: Village council members	0/822	0/655	0/082	0/399	0/600	0/494	0/042	0/400	0/244	0/412	0/005	0/197

318

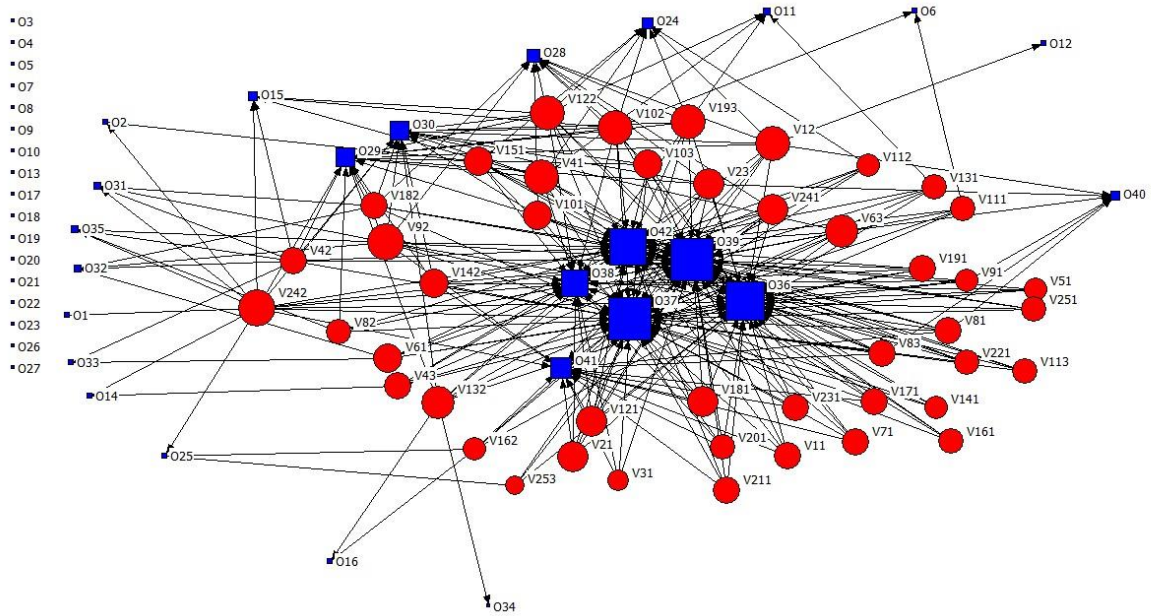

Figure 1. Network actors' interactions of KISHC with weavers in different rural areas (weak connection).

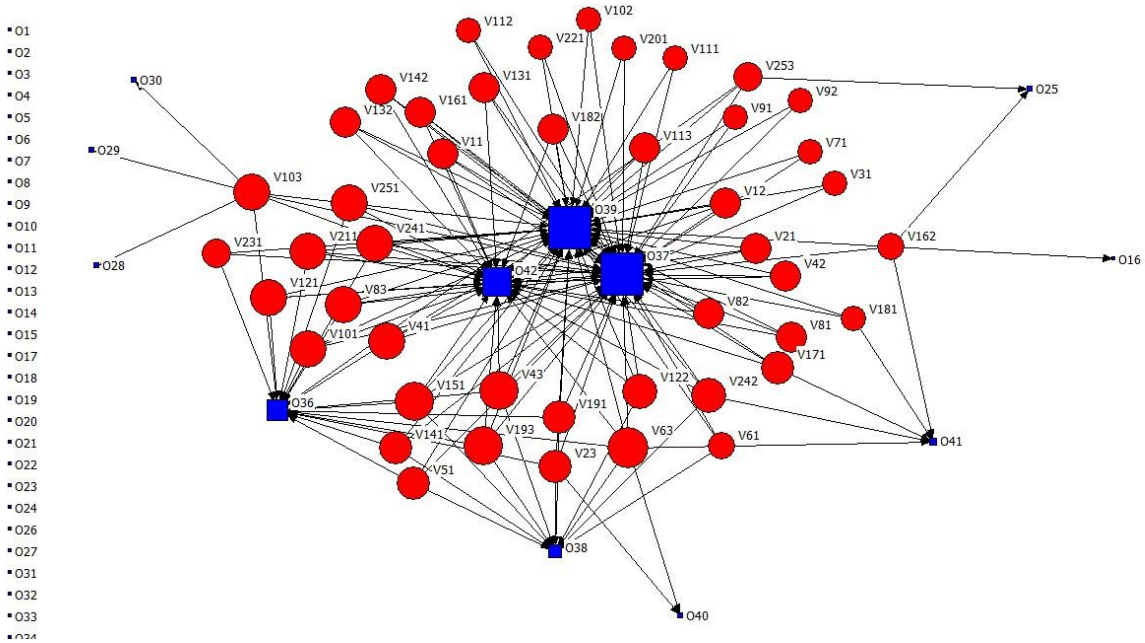

Figure 2. Network actors' interactions of KISHC with weavers in different rural areas (moderate connection).

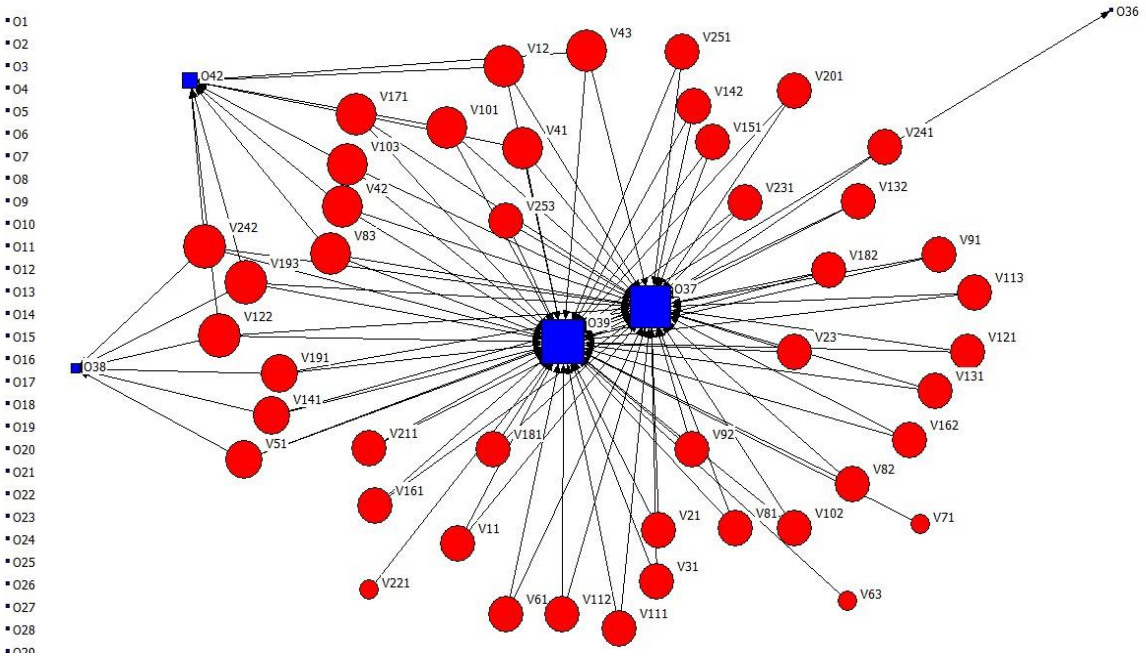

Figure 3. Network actors' interactions of KISHC with weavers in different rural areas (strong connection).

5 Discussion

Communication serves as the means through which information is transmitted from a sender to a receiver, encompassing the exchange and comprehension of opinions, thoughts, and meanings, whether conveyed verbally or non-verbally, intentionally or unintentionally, consciously or unconsciously. The current state of Handmade Carpets (HCs) is a reflection of deficiencies in the communication network for information exchange between the sender and the primary recipients, who happen to be the weavers within each family.

Diverse actors and stakeholders are engaged in the preservation and revitalization of the Persian Handmade Carpet Industry, and these actors are interconnected, collectively forming a network. It is, therefore, crucial to identify and investigate these key actors and structurally analyze their relationships. Thus, the primary objective of this study was to scrutinize the network of interactions among actors within the "KIS" of HSCI.

The coherence indices indicate that the communication network of weavers with other actors exhibits a notably low density. The findings reveal that the predominant production system in rural areas is Family owned production, where in weavers are responsible solely for weaving, while the selling aspect is managed by employers. Weavers typically need to refer to the employer or their representative to address issues during the weaving process or resolve any related problems. This production method results in limited connections among weavers, driven by concerns about design replication. Consequently, their interactions with other actors in rural areas are limited. In this context, the coherence indices illustrate that connections between

weavers and other actors, particularly local actors like WNVKRs, are more prevalent. This observation aligns with the findings of Ahmadifard and Karamidehkordi (2018) and Mirkatouli (2009) and underscores the influence of local actors in the communication networks among rural weavers, contradicting the results of Gholifar, Abbasi, Pezeshkirad, Salehi, and Rezaei (2018). Interviews with households further reveal that most weavers have acquired their weaving skills from "FMs" and "WNVKRs", explaining their extensive connections with these individuals for weaving-related queries and problem-solving.

These findings collectively highlight the fact that weavers maintain minimal or, in some instances, no communication with organizations, associations, and market actors. Consequently, they remain uninformed about new facilities, innovations, training programs, and other developments in the realm of HCs. Additionally, weavers have limited connections with associates, corroborating the findings of Naeini, Houdsani, Ashrafi, and Golzari (2022) regarding the limited role of the private sector. As per interview results, individuals who possess carpet-weaving insurance or have family ties to the union head have the most extensive connections. This finding corresponds with the results of Karimigoughari, Rezaeimoghaddam, and Rezaei (2018) concerning the absence of a dynamic network in the interactions of all actors involved in educational and extension activities. Most weavers lack trust in associations, as they have sold their carpets at prices below market value, leading weavers to believe that the union has not been beneficial for them. Consequently, there is a need for strategies aimed at monitoring union activities and enhancing weavers' connections with both formal and informal actors, as these individuals are the implementers of policies and decisions relating to HC production, and improved connections will address numerous HC production challenges.

The Coherence Indices (CIs) pertaining to weavers' connections across various rural areas and production system revealed that the highest frequency was associated with the self-employed production system. In this particular system, weavers assume full responsibility for the entire production chain, and as their success relies on knowledge concerning input quality and aligning with market requirements, they maintain the greatest number of connections within the production chain. Consequently, self-employed weavers possess a more robust communication network and exert more influence. However, since the majority of weavers in the surveyed regions are engaged in the Family owned production system, the density of connections is comparatively lower in the context of coherence indices.

6 Conclusions and Recommendations

In this study, we explored the "CN" of silk carpet weavers in relation to their interactions with various stakeholders within the KIS. Our findings revealed that the most extensive connections were established with local individuals, particularly among weavers who employed the self-employed production system. In cases where weavers are responsible for their own input supply within the self-employed system, their limited network of connections and lack of awareness regarding innovative practices contribute to their production setbacks and a decline in the value of their products. Consequently, it can be inferred that a primary reason why most weavers opt for the Family owned production system is the inadequacy of connections between them and other actors in the production chain. Furthermore, the involvement of intermediaries such as council members and rural governors in the network of connections, along with their shortcomings in raising awareness within the target community, exacerbates this issue. Additionally, the limited connections between market participants and carpet buyers, coupled with a lack of awareness regarding market dynamics, results in reduced incorporation of designs from other regions and traditional motifs. This, in turn, leads to the export of products from this province under the branding of other regions.

In summary, the following recommendations can be proposed:

- Recognizing the significance of weavers' interactions with other stakeholders within the "KIS", the government should prioritize the enhancement of "CNs" among the KIS participants. This can be achieved by introducing innovative practices to the rural carpet-weaving community and conducting workshops to increase their understanding of the roles and responsibilities of relevant organizations and associations. Such efforts will be instrumental in enhancing the KIS's overall performance.
- Supervising the activities of rural governors and members of rural councils and appointing individuals known for their integrity and dedication.
- Fostering the development of skilled designers within Zanjan province while encouraging the participation of designers from Qom.
- Considering the importance of strengthening the communication network of weavers and its role in market development, use innovations in production and to strengthen the self-employed procuction system, it is necessary to monitor the activities of the main institution of carpet in rural areas. In recent years, except for renewing the carpet weaving insurance card and in some cases the role of the employer and broker in the production, the rural carpet union has not played any other role and from itself main duties that are to support the weavers and act as an

intermediary between the education section, research, market with the weavers has distanced itself that there is a need untill the Ministry of Industry and Mining, to have the necessary supervision in this field.

7 Acknowledgment

The research paper originated from a doctoral thesis in the field of agricultural extension and education at Tarbiat Moddares University, in addition to a period of sabbatical work at the Department of Agricultural Management and Development at the University of Tehran. The authors wish to convey their deepest appreciation to both Tarbiat Moddares University and the University of Tehran for their collaboration in facilitating the research and enhancing its quality.

8 Reference

1. Ahmadifard, E., & Farhadian, H. (2023). An Analysis of Transformation Institutions in the Knowledge and Innovation System of the Handmade Carpet Industry. *Journal of Agricultural Science and Technology, 25(2),* 285-300.

2. Ahmadifard, E., & Karamidehkordi, E. (2018). Information Chain of rural silk hand woven carpet producers in the Zanjan Township. *Journal of Agricultural Education Administration Research*, *10*(44), 55-73.

3. Ahmadifard, E., & Karamidehkordi, E. (2016). Rural Carpet Weavers' Access to Silk Carpet Designs: A Case Study in the Zanjan Township. *goljaam, Scientific Journal of Handmade Carpet, 12(29),* 119-140. 20.1001.1.20082738.1395.12.29.6.3

4. Akbariarbatan G, Abbasi R. (2020). Analyzing the challenges of hand_made carpet weavers during the economic sanctions period. *goljaam; 15 (36)* ,199-218.

5. Broda, M. D., Granger, K., Chow, J., & Ross, E. (2023). Using social network analysis in applied psychological research: A tutorial. *Psychological Methods*, *28*(4), 791.

6. Gougheri, H. K., Moghaddam, K. R., & Rezaei, A. (2018). Social network analysis, a new approach to explain pluralistic extension and education system: the case of Kerman Province. *Iranian Journal of Agricultural Economics and Development Research (IJAEDR)*, *49*(2).

7. HaghighatNaeini, G., Houdsony, H., Ashrafi, M., & Golzari, N. (2022). Identification and Capacity Assessment of Managerial Actors of Urban Regeneration and Renewal at National and Local Level (City of Tehran) and Analysis of Their Correlation Network. *Journal of Architecture and Urban Planning, 14(35),* 5-26.

8. Mohammadi Ostadkelayeh A, Bayat N, Khorasani M, Nik Ravesh R. (2017). Identify and analyze the factors affecting the carpet industry downturn in rural areas (Case Study: Turkmen carpets - Gonbad-e Qabus Township). *goljaam; 12 (30)* ,67-82.

9. MirKatouli, J.. (2009). A Study of Economic-Socil Reasons for The Quality Decline of Turkman Carpets. *Geographical Research, 24(3 (94))*, 51-66.

10. Bródka, P., Skibicki, K., Kazienko, P., & Musiał, K. (2011). *A degree centrality in multi-layered social network.* Paper presented at the 2011 International Conference on Computational Aspects of Social Networks (CASoN).

11. Freeman, L. C. (1977). A set of measures of centrality based on betweenness. *Sociometry, 40*(1), 35-41. doi:https://doi.org/10.2307/3033543

12. Kashyzadeh, K. R., & Darounkola, A. H. (2021). Application of taguchi approach to forecast the wages of persian silk carpet weavers. *International Journal of Engineering and Management Research, 11*(3), 67-72. doi:https://doi.org/10.31033/ijemr.11.3.11

13. Leon, R. D., Rodríguez-Rodríguez, R., Gómez-Gasquet, P., & Mula, J. (2017). Social network analysis: A tool for evaluating and predicting future knowledge flows from an insurance organization. *Technological forecasting and social change, 114*, 103-118. doi:https://doi.org/10.1016/j.techfore.2016.07.032

14. Ruhnau, B. (2000). Eigenvector-centrality—a node-centrality? *Social networks, 22*(4), 357-365. doi:https//:doi.org/10.1016/S0378-8733(00)00031-9

15. Valeri, M., & Baggio, R. (2021). Italian tourism intermediaries: A social network analysis exploration. *Current Issues in Tourism, 24(9)*, 1270-1283 .

16. Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications .

17. Wey, T., Blumstein, D. T., Shen, W., & Jordán, F. (2008). Social network analysis of animal behaviour: A promising tool for the study of sociality. *Animal behaviour, 75*(2), 333-344. doi:https://doi.org/10.1016/j.anbehav.2007.06.020

18. Zhang, J., & Luo, Y. (2017). *Degree centrality, betweenness centrality, and closeness centrality in social network.* Paper presented at the Proceedings of the 2017 2nd International Conference on Modelling, Simulation and Applied Mathematics (MSAM2017)

19. Cross, R. L., Cross, R. L., & Parker, A. (2004). *The hidden power of social networks: Understanding how work really gets done in organizations*. Harvard Business Press.

20. Egharloo, B. A. S., & Allameh, M. (2022) Place of Color and Motif in Evaluating Hand-woven Carpets. *Journal of Art Faculty, Shahid Chamran University of Ahvaz Place of Color and Motif in Evaluating Hand-woven Carpets.26(10)*, 52-65.

21. Genç, R. (2017). The importance of communication in sustainability & sustainable strategies. *Procedia Manufacturing*, *8*, 511-516.

22. Genc, R. (2009). Profesyonel Yöneticinin Yöntem ve Kavramları. Istanbul: Seckin Yayınevi

23. Gloor, P. A. (2006). *Swarm creativity: Competitive advantage through collaborative innovation networks*. Oxford University Press.

24. Gholifar, E., Abbasi, E., Pezeshkirad, G., Salehi, H., & Rezaei, A. (2018). Analyzing information and interaction network among active actors in aquaculture activities management in Alborz damwatershed in Mazandaran province. *Iranian Agricultural Extension and Education Journal*, *14*(1).

25. Pishkhani, G. R. (2024). Women Weavers and Their Agency: Reconsidering Rug Weaving in Contemporary Iran. Journal of Middle East Women's Studies, 11176365.

26. Pradhan, P., Angeliya, C. U., & Jalan, S. (2020). Principal eigenvector localization and centrality in networks: Revisited. Physica A: Statistical Mechanics and its Applications, 554, 124169.

27. Shojaei, P., Haqbin, A., & Amin, M. (2023). Barriers to the implementation of the UNIDO's program for export consortia: a case study of the Iranian handmade carpet industry. Journal of Modelling in Management, 18(3), 659-685.

28. Stupnikova, V. (2023). Non-Verbal Communication in Business Negotiations between Finland and Estonia. Bachelor's thesis, Valkeakoski campus, International Business Summer 2023.

29. Purwanto, A., Wafa, A., & Sanjani, M. A. F. (2023). Interpersonal Communication Strategies in Building an Image of Contigency Perspective of Accommodation. Managere: Indonesian Journal of Educational Management, 5(3), 267-279.

30. Montemurro, A. (2023). *Social investment strategies in European education: a comparative study of Italian new philanthropic organizations* (Doctoral dissertation, Université de Strasbourg).

31. Carpet expert of the Department of Industry, Mining and Trade of Zanjan Province (1402). Unwell state of Zanjan carpet industry. Access through the website: https://www.irna.ir/news/85169028/%D8%AD%D8%A7%D9%84-%D9%86%D8%A7%D8%AE%D9%88%D8

تحلیل شبکه تعاملات کنشگران در نظام دانش و نوآوری صنعت فرش دستباف ابریشمی در مناطق روستایی استان زنجان

الهام احمدی فرد، همایون فرهادیان، اسماعیل کرمی دهکردی، و حسین شعبانعلی فمی

چکیده

ارتباطات موثر نقش مهمی در موفقیت کسب وکارها دارد، زیرا سبب انتقال ایده‌ها و افکار و احساسات می‌گردد و برای ایجاد انگیزه و اطلاع‌رسانی حیاتی است. شناخت و ارتباط کافی و بموقع با همه کنشگران از جمله مسائل مهمی است که بافندگان فرش دستباف روستایی، به ویژه در زمینه تولید فرش دستباف ابریشمی با آن روبرو هستند. این مسائل در کاربرد نوآوری در تولید فرش دستباف و افزایش بهره‌وری در آن تأثیر بسزایی دارد. هدف این مطالعه تحلیل دقیق شبکه ارتباطی بافندگان با دیگر کنشگران در نظام دانش و نوآوری تولید فرش دستباف ابریشمی در مناطق روستایی است. داده‌ها با استفاده از مصاحبه با 270 خانوار روستایی در مناطق روستایی استان زنجان در سه شهرستان طارم، خدابنده و زنجان با استفاده از پرسشنامه ساختاریافته گردآوری شدند. تعاملات بین این کنشگران با استفاده از تحلیل شبکه اجتماعی در نرم‌افزار UCINETبررسی شد و گراف‌های موردنظر در نرم افزار Net Draw ترسیم شد. نتایج نشان داد که تراکم شبکه در سطوح مختلف متفاوت است، در برخی موارد ضعیف، در برخی موارد قدرت متوسط و در نمونه های دیگر اتصالات قوی را نشان می‌دهد. یافته‌ها نشان می‌دهد که تعاملات درون شبکه بافندگان فرش دستباف ابریشمی عمدتاً به ارتباطات محلی محدود می‌شود. با توجه به اینکه تولید تحت شیوه مزدی خانگی اتفاق می‌افتد، و بافندگان مهارت‌های خود را از اعضای خانواده یا دیگر افراد در روستا بدست می‌آورند، که تعاملات آن‌ها در درجه اول بر روی «اعضای خانوار»، «بافندگان همسایه، هم‌روستایی و فامیل» متمرکز است. بنابراین با توجه به وضعیت شبکهٔ ارتباطی بافندگان و اهمیت آن در نظام دانش و نوآوری پیشنهاد می‌گردد که از طریق دوره‌های آموزشی، کارگاه‌ها، جشنواره‌ها و از این قبیل برنامه‌ها، بافندگان با نقش و وظایف سایر کنشگران کلیدی در زنجیرهٔ تولید فرش دستباف آشنا شوند تا در مواقع نیاز به آن‌ها مراجعه کنند.