

Prospects of Omni-Channel Marketing from the Perspective of Complex Networks: A CiteSpace Knowledge Graph Analysis

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Abstract: With the rapid development of internet technology and mobile devices, omni-channel marketing has become an important trend in modern marketing. This paper conducts a knowledge graph analysis on the research prospects of omni-channel marketing from the perspective of complex networks. This paper conducts big data analysis on hot spots and frontiers of complex network research using CiteSpace Visual analysis based on literatures from 2012 to 2022 in Web of Science. The results show that: (1) There is still considerable research prospect for complex network research related to omni-channel marketing, and the cooperation between different institutions is relatively close; (2) The hot topics of complex network research related to omni-channel marketing are: "Network", "Social structure", "Model", "Supply chain management"; (3) The clustering results of complex network research related to omni-channel marketing can be summarized into three aspects: social, complexity and optimization. This study has certain reference value for grasping the knowledge base, research hotspots of complex network and exploring the latest research frontiers of omni-channel marketing from the perspective of complex networks.

1. Introduction

The study of complex network can be traced back to the 18th century, when the mathematician Euler proposed the "Seven Bridges Problem", abstracting the land as points, extracting the bridge connecting the land as edges, and the edges between the points and the connecting points constitute a network [1]. In the 1820, Qian Xuesen proposed that complex network refer to the network with part or all of the nature of self-organization, self-similar, attractor, small world and scale-free [2]. In this paper, the relevant literature of "complex network" based on CiteSpace is sorted out and it is found that complex network has different definitions in different fields of research. What they have

in common is that the behavior of complexity is orderly. And under the constraints of simple rules, everything tends to spontaneously form a system, which in turn co-evolves into a multi-layered network [3]. Complexity is a nonlinear dynamic study of adaptive systems through coevolution and cooperation [4]. In this paper, complex network is considered as a network with a high [5].

2. Data Sources and Research Methods

2.1. Data Sources

This article selects the Web of Science data source, the data collection time is up to June 6, 2022, the limited document type is “article”, the language is English, the journal source type is “Social Sciences Citation Index”, the category is “Management”, and the theme is “Complex Network”, a total of 1162 articles are retrieved. In order to ensure the scientificity and accuracy of the research, the articles with little relevance to the subject content are analyzed and excluded. In the end, 477 literature records are collected, of which the attributes are mainly “full records and cited references” to obtain sample literature, and 477 valid data are obtained after deduplication. And 477 valid data are obtained after deduplication.

2.2. Research Methods

This study uses CiteSpace software to visually analyze 477 articles, first converts the obtained valid data into a recognizable data format of CiteSpace, and then analyzes the “Complex Network” from the aspects of publishing agency, keyword prominence, keyword co-occurrence and time map, and then draws the research hotspots of “Complex Network” and the research conclusions of this paper.

3. Analysis of Research Results

3.1. Research Highlights in the Study of Complex Network

To a certain extent, the emergence of protrusive words can reveal the emerging research fields that appear at a certain node, and have a certain predictive effect on the future development direction of the research topic [6]. The prominent words of the complex network (see Figure 1) reflect the general development path of its research. The higher the intensity of the prominent words, the higher the frequency of the keyword during the study period.

According to the prominent words, the paper believes that the evolution path of complex network research in the past decade can be divided into the following three stages:

The research focus of the first stage is the improvement of science and technology (2012-2015), such as the design and optimization of transportation network [7], Internet [8], power grid [9], wireless sensor network [10] and other infrastructure network nodes. On this basis, the complex network theory is applied to the operation management, and giving guidance on the operation and management of the enterprise. For example, Hearnshaw & Wilson (2013) pointed out that with the rapid development of economy and technology, supply chain gradually develops from chain to network structure, and each enterprise has its own division and positioning in the supply chain network. Manufacturers, distributors, retailers and final consumers form a relatively complete sales network model [11]. In the study of supply chain network, Mari et al. (2015) found that the identification and protection of important nodes and key edges of supply chain network with complex network theory can improve the stability of supply chain [12]. Ding et al. (2019) believes that network has become the main channel of knowledge dissemination, and the synergistic

advantages of enterprises can be fully played by constructing knowledge network [13].

Top 13 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2012 - 2022
design	2012	3.24	2012	2014	
supply chain management	2012	2.91	2012	2015	
technology	2012	3.64	2013	2015	
knowledge network	2012	2.6	2014	2016	
diffusion	2012	3.59	2015	2017	
dominant logic	2012	2.69	2015	2017	
social structure	2012	2.71	2016	2018	
perspective	2012	2.85	2017	2018	
absorptive capacity	2012	3.7	2019	2020	
model	2012	3.28	2019	2022	
system	2012	2.81	2019	2022	
service	2012	2.66	2019	2019	
leadership	2012	2.82	2020	2022	

Figure 1: Ranking of key words in complex network studies by year

The research focus of the second stage is on social structure (2016-2018). Social network theory is an important paradigm for studying social structure, and social network structure can reveal the deep structure of society [14]. A major research focus of social structure is to analyze the development and optimization of social network structure [15]. Puga-gonzalez & Sueur (2017) used modeling methods to study the social network behavior of macaque monkeys and found that the spatial structure in the model was similar to that of macaque monkeys and could play a role in the complex social network of macaque monkeys [16]. At the same time, scholars have conducted relevant studies on enterprise management from the perspective of network [14]. For example, Sun et al. (2017) proposed a quantitative method to measure the stability of the international oil trade network by analyzing its stability [17]. Chandra & Wilkinson (2017) explained the role of complexity theory in the process of enterprise internationalization from a network perspective [18]. At this stage, scholars began to pay attention to the application and research of complex network theory in social network marketing. For example, Zhu J et al. (2015) took wechat as the research object and analyzed the topological structure of social network platform with complex network analysis method, revealing the small-world attribute of wechat network [19]. Chen et al. (2018) modeled and analyzed the information transmission trajectory of wechat users and discussed the behavioral preferences of wechat users [20]. Park et al. (2016) found through complex network analysis that the Korean government's active management of Facebook platform can promote the development of tourism[21].

The third stage focuses on the optimization of complex network model and the related research of complex network theory in the field of service marketing (2019-2022). For example, Zhou & Wang (2019) ranked the importance of indicators for a large number of service industries by establishing a service network [22]. Yuen et al. (2020) established an improved model of logistics Service Supply chain (LSSC) to identify vulnerable nodes in the logistics service supply chain, which has a guiding role in improving the effectiveness of the logistics service supply chain [23]. Lu et al. (2021) reveals the key factors influencing the quality of government procurement of elderly care services by constructing network topology [24]. Tancrez et al. (2020) used the improved mixed integer programming model to design the express service network and proposed a scheme to minimize the transportation cost [25]. Sohrabi & Karimi (2019) designed a spam filtering system for

Facebook platform with ant colony optimization, differential evolution and other optimization algorithms in order to improve user satisfaction on Facebook [26]. Many scholars have optimized specific problems in the field of marketing through complex networks, especially in the optimization application of social network marketing. But the existing studies have failed to fully reveal the cause of the booming social platform in the field of marketing, most scholars are trying to

use complex network tools to optimize our social media platform, in order to improve the consumer's satisfaction and loyalty, to maintain social media vigorous vitality, innovative marketing mode, attract consumer attention, eventually achieve the marketing goal [27]. In this context, it is necessary to use complex network theory to study the related problems in the field of marketing.

3.2. Institutional Cooperation in Complex Network Research

In this paper, CiteSpace is used to make statistical analysis on the issuing agencies of complex network articles. The results are shown in Figure 2. The node name in the figure is the name of the relevant research institution. The font size represents centrality. The larger the font, the higher the citation rate of the articles sent by the institution. The connection between the nodes represents the cooperation relationship between the institutions. The number of layers of the node ring represents the number of documents sent, and the color of the node ring represents the age of the document issued by the organization. From the figure, we can see that Arizona State Univ and Aalto Univ are the most obvious in the figure, indicating that the institution has a relatively large number of documents on complex network, and the inter-agency cooperative research documents are relatively close, with cross regional cooperation. There is cross regional cooperation. The gradual change of the color of the node ring from the center to the outside of the ring indicates that the research of the institution in the field of complex network has a certain continuity. At the same time, it shows that institutional scholars' enthusiasm for complex network research is increasing year by year.

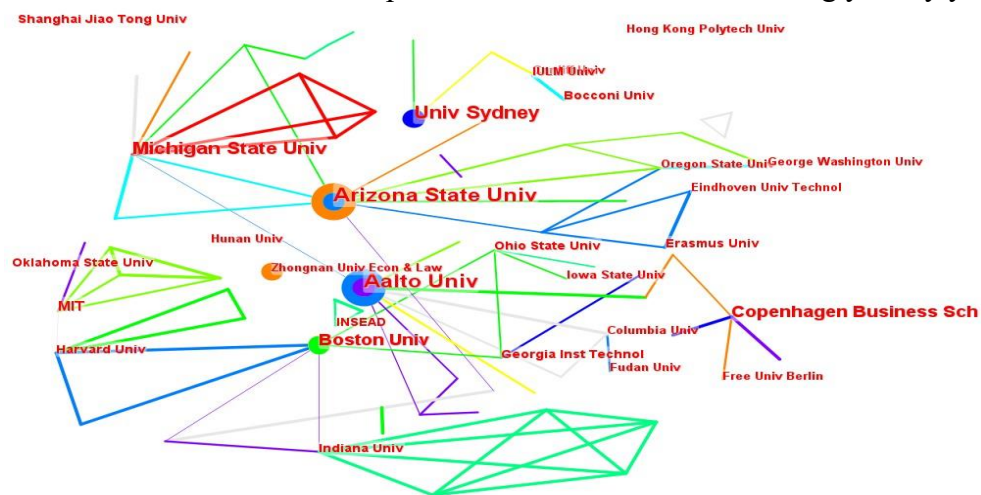


Figure 2: Cooperation map of research institutions

3.3. Research Hotspot Analysis

This paper uses 477 documents to build a keyword co-occurrence map (see Figure 3). Each node represents a keyword, and the size of the node and keyword represents the node weight. The larger the weight, the higher the relevance between the keyword and the topic. The co-occurrence map results are shown in Figure 3. In this paper, 331 nodes and 2033 connections between keywords are obtained. Throughout the whole map, the keywords “performance”, “network”, “innovation”, “management” and “organization” are relatively large, indicating that they occur frequently. To a certain extent, it indicates that performance, network, innovation, management, organization and complex network research are highly related. It is worth noting that “brand equity” can be clearly presented in the atlas, indicating that scholars have begun to pay attention to the application of complex networks in brand marketing. The research on marketing network based on complex network is an inevitable hot spot in the further research of marketing field. However, the node of

“brand equity” is small, indicating that there is still a large space for development of related researches on “brand marketing”, especially the related researches of “brand equity” and “complex network”. In addition, this paper counts the top ten keywords in the frequency of "complex network" related research (see Table 1). To a certain extent, the frequency of keywords reflects the common concerns of scholars in a certain period of time. The higher the frequency of keywords is, the more it can represent the research hotspots in a certain period of time. Centrality reflects the importance of keywords. The higher the centrality, the higher the importance of keywords.

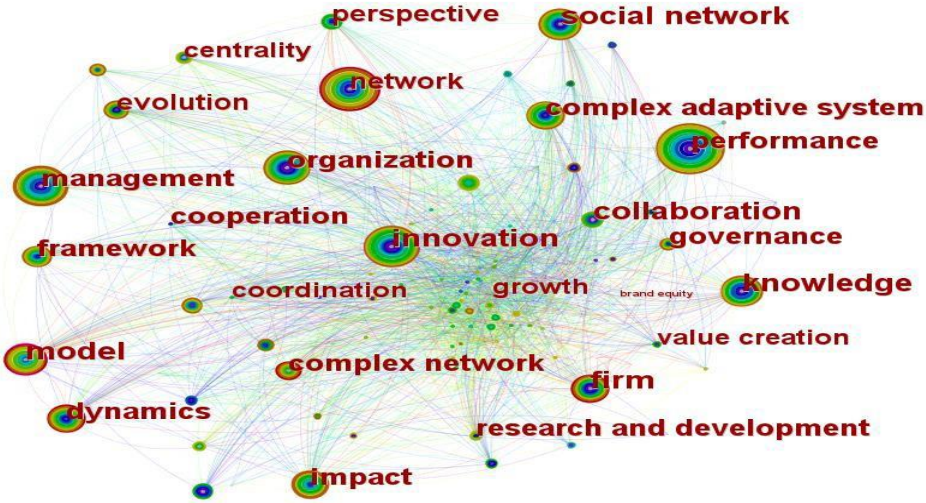


Figure 3: Keywords co-occurrence map

(1) Through the co-occurrence analysis of keywords in complex network research, the main hot spots of this study can be obtained:

(2) “Performance”, “Innovation”, “Management”, “Impact”, “Model” and “Dynamics” are the core issues in the study of “complex network” in the past decade.

(3) The high frequency of “Impact” indicates that scholars pay more attention to the impact brought by the adoption of complex network method.

(4) “Performance”, “Innovation” and “Management” indicate that the scholars have focused on the improvement of management, innovation and performance after the enterprise adopts the complex network method.

(5) The emergence of “Model” and “Dynamics” reflects that scholars have conducted in-depth studies on the optimization of complex network methods and their application in dynamic events.

Table 1: Statistics of the top 10 keywords of complex network frequency

	Count	Centrality	Year	Keywords
1	87	0.07	2012	Performance
2	70	0.10	2012	Network
3	69	0.11	2012	Innovation
4	66	0.10	2012	Management
5	57	0.07	2012	Organization
6	53	0.09	2012	Social network
7	48	0.09	2012	Knowledge
8	46	0.20	2012	Model
9	42	0.07	2012	Impact
10	41	0.07	2012	Dynamics

3.4. Research Frontier Analysis

CiteSpace, v. 5.1.R2 (64-bit) Basic
 June 7, 2022 at 5:52:29 PM CST
 WOS: C:\Users\13\OneDrive\Wos\data
 Timespan: 2012-2022 (Slice Length=1)
 Selection Criteria: g-index (k=25), LRF=3.0, LBY=5, e=1.0
 Network: N=334, E=2033 (Density=0.0372)
 Largest CC: 326 (98%)
 Nodes Labeled: 1.9%
 Pruning: None
 Modularity Q=0.3396
 Weighted Mean Silhouette S=0.7107
 Harmonic Mean(Q, S)=0.4586

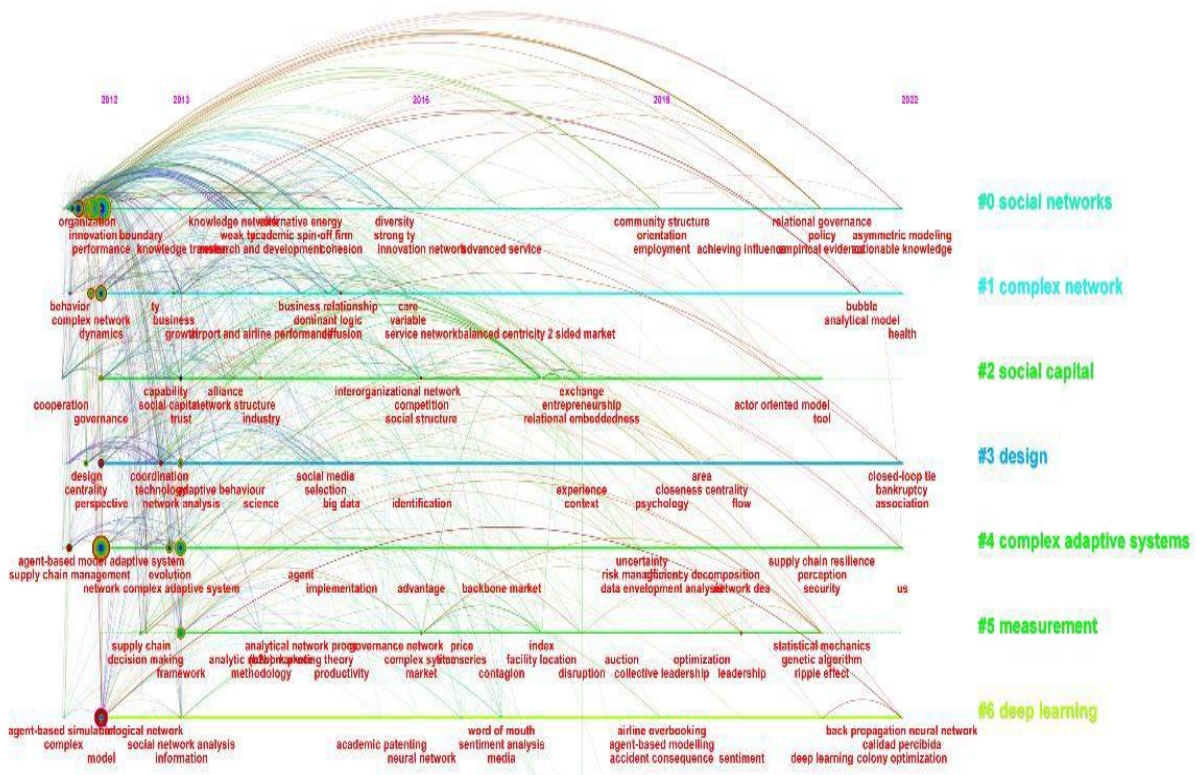


Figure 4: Keyword timeline clustering map

In order to have a clearer understanding of the research process in the field of complex network, this paper uses CiteSpace to perform co-occurrence clustering on documents to obtain a timeline clustering map of complex network keywords (see Figure 4) to explore the research frontiers of complexity. In the timeline clustering graph, CiteSpace is a cluster that describes keywords along the horizontal timeline. Clusters are arranged vertically on the far right in descending order and numbered from 0, which indicates the largest cluster. In general, when the Q value is greater than 0.3, it indicates that the clustering structure of the map division is significant. And when the S value is greater than 0.7, the reliability of the clustering effect is good. Q value and S value of the timeline cluster map in this paper are 0.3396 and 0.7107, indicating that the clustering structure is significant and effective.

According to the vertical data on the right, we can see 7 kinds of clustering results: “#0 social networks” “#1 complex network” “#2 social capital” “#3 design” “#4 complex adaptive systems” “#5 measurement” “#6 deep learning”. The largest cluster is “#0”. Before 2012, some scholars began to explore the mechanism of complex networks from the perspective of social networks. Next is “#1”. Since 2012, scholars have focused more on the complex network itself. The last is “#7”. At this stage, scholars do more research on the specific methods and optimal design of complex

network. From the clustering results, the research on complex network ranges from social network to complex network to optimization methods. Therefore, the clustering results of complex network in this paper are summarized into three aspects.

Social. It mainly exists in cluster #0 and #2. The co-occurrence identifiers are “community structure” and “social structure”, etc., indicating that scholars pay great attention to the application of social network theory in complex network research and the important role of complex network in social network. Studies have found that both individual [19] and animal [14] social networks have the properties of small-world network, scale-free network and other complex network. At the same time, the application of complex network tools can solve practical problems in the process of enterprise operation and management more effectively [17].

Complexity. Mainly exist in cluster #1, #4 and #6, co-occurring identifiers are “system dynamics”, “bubble analytical model”, “agency-based model”, “deep learning model”, etc. It shows that scholars’ research focus has returned to the complex network itself. Many scholars have discussed the basic concept of complex network [28]; Small-world network model, scale-free network model and other typical complex network models [29]; CPM algorithm, FEC algorithm and other complex network algorithms [30]. For example, Gomez & Gleiser (2009) established a complex network structure suitable for human brain function in order to verify that other topological properties except small world topological structure may not exist in the brain functional network [31]. Cheng & Scherpen (2020) established a reduced-order network model in order to improve the minimalism of network system [32].

Optimization mainly exists in cluster #3 and #5, and co-occurrence identifiers are “design centrality Perspective”, “analytical network process”, “decision making”, etc. In recent years, with the rapid development of complex network, a large number of new networks have emerged in the real world, and many complex systems exist directly or indirectly in the form of complex network, such as disease transmission network, community structure network, etc. [33]. In addition to modeling and analyzing complex networks, solving dynamic events with complex network methods has become a hot topic of current research, such as disease risk transmission, consumer risk perception, network control, etc. [34]. Although complex network optimization has made some achievements, but there are still some problems to be solved. Complex network optimization, especially the application of complex network optimization in the field of marketing is still a hot issue that needs to be studied.

4. Research Conclusions and Prospects

Based on 477 documents obtained from Web of Science, this paper adopts the visualization method of CiteSpace, and uses co-occurrence analysis to display the research situation of complex network. The development path and research hotspots of complex network are explored through high- frequency keyword co-occurrence analysis. Keywords clustering is used to explore the research frontiers and contexts of complex network. The results of the data visualization show:

There is still considerable research prospect for complex network research. The number of related research is increasing, but the research field is relatively narrow. At this stage, it mainly focuses on model optimization and algorithm improvement. The guiding role of practical problems related to omni-channel marketing still needs to be strengthened. Further research is needed on how to accurately control consumer omni-channel consumption behavior with the help of complex network tools, so as to improve enterprises' channel management level.

There are many research institutions on complex network, and the cooperation between institutions is also considerable. In the future research on omni-channel marketing based on complex network theory, research institutions should further strengthen the exchange and sharing of

research directions or research results, at the same time, strengthen cross-border research. The cooperation of regional research institutions increases the breadth and depth of research results on omni-channel marketing based on complex network theory through the comparative analysis of research results in different regions.

The research focus related to omni-channel marketing mainly focuses on "Network", "Social structure", "Model", "Supply chain management", etc. Among them, supply chain management is closely related to channel management, just taking opposite perspectives. In future research, scholars need to further expand the research perspective. For example, in the context of the rapid development of the current omni-channel model, emerging purchase methods such as community group purchases and live broadcasts continue to emerge. How to use complex network tools to build user profiles for consumers in the omni-channel network and achieve precision marketing requires further discussion.

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