Scientific Measurement and Visualization Analysis of International Omni-channel Retailing Research (2011-2020)-Research on Knowledge Graph-Based on Co-word Analysis

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Abstract. With the development of digital technologies such as cloud computing, big data, and 5G, omni-channel retailing has become the direction of the retail industry reform. To understand the research context, hot spots, and future development trend of global omni-channel retailing in the past decade and provide a reference for relevant research, this paper collects relevant articles in the WOS database from 2011 to 2020, uses the co-word analysis method to make statistics and analysis on keywords, and uses Bicomb, Spss and Excel software to conduct cluster analysis and strategic coordinate analysis on omni-channel retailing research. The results show that the research on omni-channel retailing logistics and supply chain, the research on omni-channel integration and management, and the research on omni-channel digital marketing and consumer behavior are the three hot areas of omni-channel retailing research. In the future, the mixed methods combining quantitative researches (such as machine learning, artificial neural network, and quantitative model) with qualitative research (such as case research and interviews) can be used from a mixed perspective of consumers and retailers to conduct in-depth research on the operation mechanism and the decision-making mechanism of omni-channel retailing and the interdisciplinary research combining omni-channel and organizational management.

1. Introduction
Omni-channel retailing creates shopping scenarios for consumers anytime and anywhere through the re-combination and cooperation of brick-and-mortar store channels, PC network channels, and mobile terminal channels to meet the undifferentiated online and offline buying needs and seamless connectivity experience[1]. With the development of digital technologies such as cloud computing, big data, and 5G, as well as the rise of omni-channel consumers, retail channels have changed from single-channel, multi-channel and cross-channel to omni-channel [2], while omni-channel retailing has become the direction of the retail industry reform. The topic of omni-channel retailing has also attracted increasing attention from scholars; From theoretical research on omni-channel retailing (Brynjolfsson et al., 2013; Rigby, 2011) [3] to empirical research (Hübner et al., 2016; Cao, 2015); From the definition of the concept of omni-channel retailing (Brynjolfsson et al., 2013; Rigby, 2011) to the research on omni-channel integration and management (Cao, 2015), omni-channel supply chain research (Rai, 2018) and omni-channel consumer behavior research (Kokho et al., 2018; Rodriguez et
al., 2017; Kazancoglu et al., 2018); From a single scientific study (Hübner et al., 2016; Cao, 2015) to interdisciplinary research (Song et al., 2020), etc., certain academic achievements have been accumulated. With the continuous innovation of digital technology and the normalization of Covid-19 prevention and control work, the global retail industry is facing a lot of uncertainties and turbulence. Therefore, sorting out and summarizing the research results of omni-channel retailing is conducive to the academic circles to quickly and accurately grasp the macro development in this field and the frontier trends, achievements, and research focus of the discipline development, providing a valuable reference for the rapidly changing global retail reform.

2. Data acquisition and processing
In this paper, the subjects such as "omni-channel", "omni-channel", "omni-channel retailing" or "omnichannel retailing" are intensively and centralized searched in English in the four databases of SCI, SSCI, CPCI-S, and CPCI-SSH in the core set of the web of science. According to the artificial screening of the titles and abstracts of the articles, 305 valid pieces of literature are finally retrieved.

In this paper, the Bicomb system is used to retrieve the keywords of 305 documents collected from the WOS database, and then standardized processing is carried out, for example, to unify "omnichannel retailing", "omni-channel retail", "omni-channel retailing" and "omni-channel retail" into "omni-channel retailing"; unify "online retail", "online retailing" and "e-commerce" into "e-commerce", etc. In the end, 941 keywords have been obtained, with a cumulative frequency of 1433 times. Based on Donohue's formula:

\[ T = \frac{1}{2} \left( 1 + \frac{1}{\sqrt{1 + 8 I_1}} \right) \]

(\( I_1 \) is the number of keywords with word frequency 1)[4], keywords with word frequency greater than or equal to 5 are identified as high-frequency words in this study, and 21 high-frequency keywords are obtained (see Tab. 1 for details). The statistical results of high-frequency keywords show that most of the research on omni-channel retailing focuses on the themes of omni-channel logistics and supply chain management, omni-channel marketing and consumer behavior, and omni-channel integration.

Table 1. The high-frequency keywords in papers on omni-channel retailing published in the WOS database from 2011 to 2020

| Serial number | Keywords                        | Frequency | Serial number | Keywords                        | Frequency |
|---------------|---------------------------------|-----------|---------------|---------------------------------|-----------|
| 1             | omni-channel                    | 100       | 12            | omni-channel management         | 7         |
| 2             | omni-channel retailing          | 59        | 13            | omni-channel marketing          | 7         |
| 3             | e-commerce                      | 31        | 14            | case study                      | 6         |
| 4             | Retailing                       | 24        | 15            | customer journey                | 5         |
| 5             | multi-channel retailing         | 18        | 16            | CRM                             | 5         |
| 6             | channel integration             | 15        | 17            | digital marketing               | 5         |
| 7             | supply chain                    | 14        | 18            | machine learning                | 5         |
| 8             | Logistics                       | 11        | 19            | mobile commerce                | 5         |
| 9             | consumer behavior               | 9         | 20            | order fulfillment               | 5         |
| 10            | social media                    | 9         | 21            | retail logistics                | 5         |
| 11            | customer experience             | 7         |               |                                 |           |
3. Research Results and Discussions

3.1. Clustering analysis of high-frequency keywords
SPSS is used to conduct cluster analysis on the high-frequency keywords in 21 omni-channel retailing research fields, and the Ward clustering method is used to gather the keywords with the shortest distance between words to generate a vertical tree diagram (as shown in Figure 1). The shorter the distance between words, the higher the frequency of keywords appearing in the same document, which means that the relation of the themes represented by these keywords are closer, and finally 21 high-frequency keywords are subdivided into 6 clusters.

3.2. Strategic coordinate analysis
Clusters in this research field can be obtained through clustering, but the relationship between clusters cannot be identified only by co-word clustering, that is, which are important clusters and which are core clusters cannot be known. Therefore, it is necessary to further clarify the composition, development trend, and change the process of clusters through the strategic coordinate method, and analyze the development context in this field [5]. The strategic coordinate (Law, 1998)[6] is mainly used to describe the internal relation of a certain cluster and the level of mutual influence between fields. In the strategic diagram, the horizontal axis (X-axes) is the centripetal of the cluster, which indicates the degree of correlation between the clusters. The greater the value, the more important the cluster will be in the development of the discipline. The vertical axis (Y-axes) is density, which indicates the closeness between subject words within the cluster. The larger the value, the more mature the cluster becomes[7]. Therefore, according to the clustering results, the density, centripetal, and coordinate values on the X and Y axes of the above 6 clusters are calculated one by one. A strategic diagram is drawn based on the data in Table 2 (as shown in Figure 2). In the strategic diagram, the subject area of each two-dimensional space is divided into four quadrants, i.e. the strategic coordinate diagram, which can reflect the internal research depth of the cluster and the closeness of correlation between the clusters to a certain extent. As can be seen from Figure 2, the above 6 clusters are respectively distributed in three quadrants.
Table 2. Calculation results of strategic coordinates

| Cluster                                      | Density | Centripetal | X value | Y value |
|----------------------------------------------|---------|-------------|---------|---------|
| Cluster A Omni-channel digital marketing     | 2.0     | 2.5         | -3.900  | -5.172  |
| Cluster B Omni-channel digital marketing     | 2.0     | 9.0         | -3.900  | 1.327   |
| Cluster C Research on journey and experience of omnichannel customers | 1.333   | 4.333       | -4.566  | -3.338  |
| Cluster D Research on omnichannel integration and consumer behavior | 12.4    | 11.2        | 6.499   | 3.527   |
| Cluster E Research on omnichannel customer relationship management | 1.0     | 6.5         | -4.900  | -1.172  |
| Cluster F Research on the omnichannel logistics | 16.666  | 12.5        | 10.766  | 4.827   |

Figure 2. Strategic diagram of omnichannel retailing research

(1) The core area of omni-channel retailing research (Quadrant I)

The Cluster D and Cluster F fall in Quadrant I, which indicates that the internal and external connections of the two research topics are relatively close, and they are at the core of the whole research network, so they are the focus and hotspot of the research in this field. They receive attention in the whole discipline of research and are closely related to other researches and tend to mature.

The density and centripetal of Cluster F are the highest among all clusters, which indicates that there are more documents in which the six keywords of omni-channel, retailing, multi-channel retailing, logistics, case study, and retail logistics appear simultaneously, and other clusters often involve these topics. Under the background of omni-channel, logistics service has become a key factor in the transformation process of omni-channel retailing. The method retail enterprises carry out logistics management has become a challenge. Therefore, the research on omni-channel logistics has become an important topic in this field (Hübner et al. 2016; Cao 2015; Ral et al., 2018). Cluster D and Cluster B also involve the above contents. It can be seen from this that Cluster F not only has a close internal relation but also is closely related to the research topics of Cluster D, Cluster B, and other clusters. It is a highly intersecting cluster.

The density and centripetal of Cluster D are second only to Cluster F, which indicates that Cluster D also has relatively close internal and external connections. The research topics in Cluster D include omni-channel retailing, channel integration, e-commerce, order fulfillment, consumer behavior. These topics are often studied and discussed together by researchers, thus forming a relatively close internal connection. Cluster D includes two aspects: omni-channel integration and consumer behavior research. The research on omni-channel integration strategy is mainly carried out from the perspectives of order fulfillment, the impact of channel integration on enterprise performance, the impact mechanism on cross-channel customer retention, and the channel integration effect brought by BOPS. In addition, the omni-channel consumer behavior research mainly studies consumers' omni-channel consumption decision-making characteristics and channel selection preferences (Kokho et al., 2018; Rodriguez et al.,...
Cluster F, Cluster B, Cluster C, Cluster E are also involved in the above contents. It can be seen that although Cluster D is also related to the research topics of other Clusters, it has a closer internal connection and higher research maturity.

(2) Potential areas of omni-channel retailing research (Quadrant II)

The research on the omni-channel retailing supply chain in Cluster B falls in Quadrant II, which indicates that the topic is relatively mature. Although attentions have also been given to the members of Cluster B and they are very active in the discipline field, the centripetal of the cluster is relatively low, which indicates that the internal connection of the cluster is relatively loose and it is easy to be decomposed and evolved into other related clusters and become a branch of discipline research. Therefore, the cluster in this field has potential development space (Donohue 1973). Cluster B includes two keywords: supply chain and machine learning. Scholars mainly use machine learning (Rodriguez et al., 2017), artificial neural network, Bayesian and other methods to construct the omni-channel supply chain service innovation decision-making based on big data and its related factors and the prediction method of the omni-channel retailing supply chain. This cluster is related to Cluster F and Cluster D, but it is less related to Cluster A and other topics and has strong independence. It is a relatively loose and mature field.

(3) Marginal areas of omni-channel retailing research (Quadrant III)

Cluster A, Cluster C, and Cluster E fall in Quadrant III. Compared with other quadrants, the density and centripetal of this quadrant are the lowest, which indicates that its internal structure is loose and has less connection with other clusters. The research is not yet mature and is a marginal topic of the whole research field. This cluster is the point that the research has just begun to pay attention to, and it is also most likely to become a research hotspot through development. When studying this cluster, we should always seek the connection with other clusters, to make the research within the cluster more mature.

Cluster A includes omni-channel marketing and digital marketing, which are two keywords with similar word frequencies. It mainly studies how to use augmented reality, remote experts, digital aids, and other digital technical means to carry out omni-channel marketing. Scholars believe that the new trend of digital marketing communication is omni-channel marketing, which focuses on studying how omni-channel strategy is related to digital phenomena (Kannan et al., 2017; Song et al., 2020). Cluster E is composed of two keywords: social media and CRM. It mainly studies the evolution of social media in the field of business process management under the background of omni-channel, and it believes that different social media tools can be used to realize the transformation to omni-channel management methods. [8].

Cluster C consists of four keywords: omni-channel management, mobile commerce, customer experience, and customer journey. With the development of digital technology and mobile Internet technology, On the one hand, scholars, from the perspective of retailers, have conducted an empirical analysis based on qualitative and quantitative data collection to verify and evaluate how retail enterprises use social media, local and mobile commerce in their omni-channel management strategies and thus to realize omni-channel management. On the other hand, from the perspective of consumers, scholars also have studied the use of specific contact points [9] to subdivide customers in the journey from search to purchase, especially when mobile devices have become a new contact point. Through focus groups, expert interviews, economic decision-making models, machine learning, and other methods, a customer journey framework in the omni-channel environment has been constructed[10]. The existing research seldom combines retailer factors with consumer factors, so the internal connection of Cluster C is loose and the connection with other clusters is less.

In short, the three clusters all focus on the influence of digital technology and digital media on the transformation of the retail industry to the omni-channel retail industry. As digital technology has gradually become a hot research topic, more attention should be paid to the connection with other clusters, making the research mature gradually.
4. Conclusion

The hot research topics of omni-channel retailing researches offer the following three implications for scholars and relevant institutions to carry out studies in this field:

First, in terms of research perspective, global omni-channel retailing research is mainly conducted from the perspective of retailers and consumers. In the beginning, the research mostly analyzed the impact of omni-channel retailing on enterprise performance, omni-channel logistics, and supply chain optimization design from the perspective of retailers, and then studied the impact of omni-channel on consumer channel selection from the perspective of consumers. At present, fewer researches are conducted from the mixed perspective of consumers and retailers. Therefore, in the future, the collaborative performance of the omni-channel will be studied while comprehensively considering the needs of both enterprises and consumers.

Second, in terms of research content, the current international omni-channel retailing research mainly focuses on omni-channel supply chain and logistics, omni-channel integration and management, omni-channel marketing, and consumer behavior. With the development of big data, the Internet of Things, artificial intelligence, 5G, and other technologies and changes in consumer demand, how do retailers realize a seamless connection between omni-channel marketing and the whole process of the customer journey? How do they design channels in a seamless connection? How do they integrate channels, and how do they manage to avoid channel encroachment and bring into play the channel synergy? How can omni-channel retailers provide the best logistics services and realize the efficient integration of supply chain partners? All these questions need to be further discussed. Therefore, in the future, in-depth and interdisciplinary research can be carried out from the aspects of omni-channel retailing operation mechanism, omni-channel consumer decision-making mechanism, omni-channel organization, and management, etc.

Third, in terms of research methods, the initial research on omni-channel retailing mainly focuses on the concept and evolution of omni-channel retailing. The business model and channel integration model of omni-channel retailing are theoretically studied, and qualitative research methods such as case studies or exploratory interviews are mostly used. Later, quantitative research on logistics and supply chain optimization model and prediction is carried out by using questionnaire collection, market operation data, and economic decision models. In recent years, some scholars have also begun to use machine learning, artificial neural networks, quantitative models, and other means to carry out quantitative research. In the future, mixed research methods that combine qualitative research with quantitative research can also be used.

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