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Original Research

Intangible Assets: Scientometrics and Bibliometrics using Social Network Analysis

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Abstract

The present study was conducted with a scientometric approach and using the social network analysis method to investigate the relationships in the field of intangible assets. In this regard, the data of 2998 documents conducted between 1979 and 2019 based on the articles indexed in the Scopus database on intangible assets were analyzed using Gephi and Publish or Perish software. The status of scientific productions in this field and the most influential concepts and keywords, researchers, and journals were examined. Research findings show that knowledge management and intellectual capital are essential concepts in this field. Also, value creation, value chain, social responsibility, and trademark are the most valuable subject areas based on the networks. The co-authorship network is discrete, with low density and 58945 citations in all articles. Also, Emerald Publications has published the most significant number of articles in this field. Entering the era of a knowledge-based economy, a large part of organizations' assets is intangible, which confirms the identification and investment in these types of assets. This study shows that intangible assets are closely related to critical social issues such as intellectual capital, knowledge management, and competition. The present study helps researchers in this field explain the investigation process and policies based on the identified areas of influence.

Keywords: intangible asset, scientific map, intellectual capital, scientometrics, social network analysis.

Introduction

In a world where transformations are rampant and, as Toffler puts it, the era of power shifts, the debate over the management of intangible assets as an essential and comprehensive phenomenon has affected the horizons of management. Intangible assets are now the key to success for organizations (Castilla-Polo & Ruiz-Rodríguez, 2017), and Organizations are embarking on a knowledge-based economy (Giju et al., 2010). an economy in which knowledge and intangible assets are the most critical factors in achieving production and gaining a

competitive advantage. They are also the most important source of innovation for organizations (Harris, McAdam, McCausland & Reid, 2013).

Today, transitioning from a traditional economy to a modern and knowledge-based economy has become countries' leading economic growth paradigm. Consequently, the economic approach of countries has changed from source-based to knowledge-based. Therefore, the formation of technology-based businesses, followed by knowledge-based companies, is the driver and engine of countries' economic growth. Under these circumstances, companies seek to create intangible assets to create a sustainable competitive advantage as well as to find new resources and support to differentiate themselves from other companies because, at present, the value of companies is now mainly generated by Intangible Assets and not by "traditional" assets having a tangible form (Volkov & Garanina, 2007). therefore, researchers believe that economic capitals and assets are no longer limited to physical resources and tangible assets, but intangibles, as a contributor to corporate value, become increasingly more critical, and wealth and growth in today's economy are primarily driven by intangible (intellectual) assets (Lev, 2001; Ito, Umeda & Sekiya, 2020). These assets help companies reach and retain customers, build customer loyalty, and enhance a company's brand (OECD, 2008).

Intangibles include all resources that, although lacking physical substance, contribute future benefits to the organization to which they belong. These include know-how, quality management, innovation, consumer trust, and reputation, among other assets (Castilla-Polo & Gallardo-Vázquez, 2016). An intangible asset is a non-monetary asset with no physical appearance that is valuable and can generate future benefits (Keong Choong, 2008). Nakamura (2010) stated that investing in intangible assets today is more important than tangible assets, and it has become increasingly important to represent and report intangible assets in financial statements. Intangible Assets are a company's "weightless wealth" that helps it to obtain real profit. Every company should understand that nowadays, paying much attention to Knowledge Management in general and Intangible Assets especially may help to create and develop its core competencies and thus yield a competitive advantage in the market (Volkov & Garanina, 2007). One of the reasons for the importance of intangible assets is their role in the success of organizations or a business because an organization that can create intangible assets that competitors cannot replicate can also experience sustainable success and play an important role in creating value and improving its position in the market.

Despite researchers' high interest in this topic, According to Kaufman and Schneider (2004), no consensus on one set of terms and definitions - or even a tendency towards one stream - is apparent. Several definitions and terms are still debated, as in many other research fields. Terms used include the following: intangibles, intangible assets, intangible capital, intangible resources, intellectual capital, and intellectual property. Some authors consider these terms synonyms, while others still separate them from each other. Apart from that, some authors do not offer any definition but only separate the basic components, being a part of the concepts referred to above, without claiming completeness (Kaufmann & Schneider, 2004; Volkov & Garanina, 2007).

The literature in this field has expanded with various definitions of intangible assets, with many other terms for this type of asset (Kaufman & Schneider, 2004; Keong Choong, 2008). Many researchers use the term intellectual capital instead of intangible assets. However, both often refer to the same context and content (Bukh, Larsen & Mouritsen, 2001). Petty and Guthrie (2000) argue that historically, the distinction between intangible assets and intellectual

capital has been vague at best, and the delineation between the terms "knowledge management" and "intellectual capital" sometimes seems unclear at times (Petty & Guthrie, 2000). One definition of "intellectual capital" is provided by the Organization for Economic Co-operation and Development (OECD, 2008), which divides intellectual capital into "the economic value of a company's two intangible assets: organizational (structural) capital and human capital." In this definition, the OECD makes an appropriate distinction by locating intellectual capital as a subset of, rather than the same as, the overall intangible asset base of a business. As such, there are items of an intangible nature that do not logically form part of a company's intellectual capital (Kaufmann & Schneider, 2004). According to Holland (2001) and Branswijck and Everaert (2012), in recent years companies' market value has been well above their book value. This difference is also known as intangible asset stock or intellectual capital. Quintero-Quintero, Blanco-Ariza & Garzón-Castrillón (2021) also define intellectual capital as intangible assets that allow an organization to transform a set of material, financial, and human resources into a system capable of creating value for stakeholders

In a study by Steenkamp and Kashyap (2010) on small and medium-sized enterprises, they showed that the same number of SME managers prefer to use the term "intangible assets" as those prefer to use the term intellectual capital. A global survey conducted by Accenture also found that half of the top executives believe managing intangible asset is one of the top three management issues companies face. 94% said that the management of intangible assets (or intellectual capital) is an important management issue, and nearly half (49%) noted that intangible assets are the primary source of wealth for long-term shareholders of their companies.

Given the importance of this field and the fact that a lot of published information is available on intangible assets, which shows the extent of its significance, a review of the literature in this field clearly shows that most research still lacks a theoretical foundation, and research field is still relatively fragmented. Increasing the volume of scientific productions in various specialized areas has made it challenging to review all scientific texts produced by experts. So the use of international scientific indexes and databases that contain a significant portion of valid global information is the fastest way to access information (Hamidi, Asnafi & Osareh., 2008). In this regard, for this research, Scopus database articles on "intangible assets" have been analyzed using scientometrics and social media analysis software such as VosViewer, Gephi, and Publish or Perish (POP).

This research intends to identify and draw the field of intangible assets research with the help of co-word, co-citation, and co-authorship methods with an analytical view and determine the efficiency of this method in identifying and determining scientific and research priorities in this field to Provide information on intangible assets to assist researchers, policymakers, managers, and business owners in using and managing them effectively to create value and ensure sustainable competitive advantage.

To map intangible assets, Scopus Scientific Database research on "Intangible Assets" from the beginning to 2019, using scientometrics and social network analysis software such as VosViewer and Gephi and Publish or Perish (POP) is analyzed and examined to find out the answers of following questions:

1- What is the status of scientific productions in the field of intangible assets?

2- What are the most frequent keywords and the highest co-occurrence of words in this field?

3- What is the analysis of a co-word network based on centrality, density, hub, and clustering indicators?

4- How is co-authorship network analysis?

Literature Review

Studies on intangible assets emerged in the 1980s, and the number of studies jumped in the 1990s. The term "intangible" has various components, such as human assets, organizational assets, information assets, and corporate reputation (Ito et al., 2020). Intellectual Capital (IC) has its roots in the leading-edge economics of the 1930s; the modern implementation of the subject dates back to 1987 and the Swedish Konrad Group's attempt to demonstrate the role of intangible assets in business. In the mid-1990s, it was done on how to use it in business (Pike & Roos, 2011).

With the advent and variety of scientometric techniques, it has become possible for researchers to examine the intellectual structure of their favorite disciplines depending on the method used (Lane, 2010). Quintero-Quintero et al. (2021), while conducting a bibliometric analysis of articles related to intellectual capital, examine the interrelationships between the dimensions of intellectual capital (human, structural, and relational capital) and its impact on the performance of universities and argue that intellectual capital is one of the essential tools for the development and strengthening of public or private organizations and higher education institutions (HEIs) with a high level of intellectual capital contained and trained and innovative human resources, a robust structural capital in organizational, technological, and research process; and relational capital with academic and research networks with its stakeholders, will be able to influence the academic community and society in general, provides these institutions with better organizational learning, more efficient performance and higher quality in their academic and research processes. Of course, this study generally examines intellectual capital on the performance of universities. It does not point out that providing a single formula to calculate the economic value of intellectual capital is almost impossible and requires the design of a set of quality measurement indicators to recognize the current position of universities in managing intellectual capital.

Bellucci, Marzi, Orlando & Ciampi (2020), using bibliometric and systematic literature analysis of studies published in the Journal of Intellectual Capital (JIC), identified four main streams of research on intellectual capital. These include reporting and disclosure of intellectual capital, research in universities, education, and the public sector, knowledge management and intellectual capital, financial performance and market value. Of course, this study has been done on the research published in this journal for four years, from 2014 to 2018. Due to the continuous changes in various scientific fields and the emergence or elimination of different scientific branches, it needs to be updated with new research.

Dias, Zarelli & Selig (2014) used bibliometric methods to find evidence of the acceptance of the principles of intellectual capital under government management. They found that among the 242 words submitted by the authors of articles directly Related to intellectual capital and government management, the three words, accounting, knowledge and management, have the most repetition, which indicates the importance of these three issues in the field of intellectual capital.

Gnanasekaran and Balamurugan (2016) believe that most of the studies concentrated on patents, and very few studies are available for other areas of intellectual property rights. They

argue that because the growth of a long-term economy relies on the protection of new ideas and investment in technological innovation, the apex bodies for higher education and funding agencies in any country should stimulate institutions and research centers in these kinds of research and put more attention on innovation, quality research, use, and effectiveness of intellectual property rights as one of the components of intangible assets.

Lev (2001) believes that investing in intangible assets is much more risky than investing in tangible assets because intangible assets are affected by vague property rights and the difficulty of depriving foreigners of the use of intangible assets. Bhatia and Aggarwal (2018) aimed to evaluate the impact of investment in intangible assets on the corporate performance of Indian companies, argue that intangible assets, after controlling for firm size, age, leverage, the intensity of physical capital, Market share, risk, industries and dummy year have a positive effect on company performance. A study emphasizing the importance of investing in intangible assets reminds managers to understand and pay special attention to improving their organizations' performance in research and development, advertising, customer relationship management, and human resources.

Steenkamp and Kashyap (2010), while discussing the importance of intellectual capital in SMEs business, inform that the broad assumption that intangible assets are essential and are value drivers of business success is valid for small and medium enterprises, and most Respondents consider intangible asset components to be necessary to the success of their business. Petty and Guthrie (2000) also emphasize the critical theoretical and empirical contributions to the measurement and reporting of intellectual capital, stating that without a better understanding of how and why organizations develop intellectual capital, we are unaware of ways and means of improving intellectual capital, and We cannot have a proper dialogue with the aim of enabling progress in the development and further management of intellectual capital.

Kaufmann and Schneider (2004), focusing on articles published from 1997 to 2004, critically analyze current trends and differing perspectives on intangible assets. They found that as interest in intangible assets grew, researchers became more interested in intangible assets. The arguments developed within the resource-based view of strategic management, and the increasing knowledge of management accounting became more motivated to measure intangible assets. This study, while stating that in the field of intangible assets, the definitions of most authors - regardless of the term used - include knowledge and some way and refer to some form of economic value that is attached to intangible assets, suggests in this field, many issues have not been considered and further research is provided, including examining potential implications of the stock of intangibles on the economy and social systems of nations and also developing a theoretical framework that can be applied to the management of intangible assets, It will be useful.

Accordingly, by examining the literature in the field of intangible assets, a review of the literature in this field seems necessary. Since the study of research trends is essential to gain knowledge about the dimensions and functions of an area, scientometric analysis as a quantitative method increasingly evaluates research performance and awareness of the status of the scientific output of prominent scientists, institutions and growth. Different scientific disciplines are used to provide a comprehensive picture of them and identify the strengths and weaknesses of those areas. We seek to fill a gap in this area by using a bibliometric study of

research in the field and by conducting co-word, co-citation and co-authorship analysis, giving researchers a better understanding of the knowledge body in this field.

Materials and Methods

Scientometrics can be defined as "the quantitative study of science, communication in science, and scientific policy." What began as Eugene Garfield's idea of creating an index to improve information retrieval in the 1960s and led to the creation of the Science Citation Index (SCI) soon became a new tool in the empirical study of science (Leydesdorff, 2001).

Scientometrics is one of the most important scales for evaluating scientific products. Makias-Chapula argues that "scientometrics indices have become essential for the estimation of the modern state (in line with the latest developments) of a particular subject for the scientific community." scientometrics deals with and overlaps with bibliometrics and information science interests. The terms bibliometrics, scientometrics, and information science refer to the parts of studying the dynamics of the fields as reflected in the production of their sources (Mooghali, Alijani, Karami & Khasse, 2012).

Understanding the impact of scientometrics on the development of academic disciplines is a complex issue of great importance. Its relevance is due to the recent trend to introduce numerical scales of scientific performance to evaluate research activities and facilitate comparison at different levels, for example, among researchers, institutions, or the media. These comparisons usually take the form of ratings designed to "measure" the "quality" of universities, scientists, scientific articles, and journals on a single scale. This development also points to the methodological shift within scientometrics, whose conceptual origins lie in an interpretive analysis of scientific communication aimed at understanding the characteristics of the discourse of academic publishing (Aistleitner, Kapeller & Steinerberger, 2018).

Van Raan (1997) believes scientometrics research is limited to quantitative science and technology studies. It aims at advancing knowledge, technology and science; it is also about social and political issues. He divides the main interests of scientometrics research into four intertwined areas:

(1) Develop methods and techniques for designing, making and using quantitative indicators in essential aspects of science and technology ;(2) development of information systems in science and technology;

(3) The study of the interaction between science and technology;

(4) Investigating the cognitive and socio-organizational structures of scientific domains and development processes concerning social factors (Mooghali et al., 2012).

Social network analysis researchers understand networks as sets of objects called "nodes" connected by one or more relationships called "edge". In the context of social science, nodes can be a wide range of social units, such as individuals, groups, organizations, corporations, governments, and countries (Hubert, 2014).

This applied research has been conducted using common methods in scientometrics with co-word analysis, co-citation analysis, co-authorship analysis and social network analysis. The research community comprises all articles indexed on the Scopus database from 1979 to 2019 on "Intangible Assets". For this reason, the word "Intangible assets" was searched in the titles, abstracts and keywords of English-language articles. After retrieving records related to intangible assets, for co-word analysis, 2998 records were recovered. Of these records, 566

were highly frequent in the first step, considered according to Bradford's law with a frequency of 5 or more.

In the next step, common words were examined using expert opinions, and some words that had no domain-specific meaning in the structure of their respective sciences, such as human beings, education, research methods, developed countries, etc. were removed along with the country names.

Next, keywords with a frequency of 5 and more were included in the final analysis. It should be noted that studies using co-word analysis have used different thresholds to include top keywords in the final analysis. For example, Liu Hu and Wang (2012) limited their analysis to 66 keywords that accounted for about 55% of the total frequency, as well as Hu, Hu, Deng and Liu (2013). They restricted themselves to 181 keywords representing 29% of the total frequency.

Hierarchical clustering and multidimensional scale are commonly used for co-word analysis. Hierarchical clustering can identify clusters of each of the keywords and show the relationships between them. Therefore, each cluster was visited using Vosviewer software. The maps created using the multidimensional scale can also reveal important clusters and their position among other clusters based on the degree of correlation. Therefore, a multidimensional scale map was prepared using Gephi software. Other features of the co-word matrix network such as centrality, density, weight, etc. were measured using Gephi software to find out more about the study area. Publish Or Perish is also one of the most useful software provided by Harzing Company, aiming to facilitate the calculation of citations to scientific articles in "Google Researcher". In addition to calculating the number of citations to an author, or a publication, this software indicators such as h-index, g-index, hc-index, percentage of citations to the author/article, article/author and other citation criteria specifies.

In addition, in co-authorship analysis among the 5,389 unique authors in intangible asset research, it was identified that 47 authors had participated in at least five studies. It was further observed in the co-citation analysis that a total of 58,945 citations were made in all articles.

Results

Findings and metrics, which are obtained using Publish or Perish on the Scopus database, are as follows:

Metrics

Reference date: 2019-10-20 15:35:29 +0330
Publication years: 1979-2019
Citation years: 50 (1979-2019)
Papers: 2998
Citations: 58945
Citations/year: 1178.9
Citations/paper: 19.66

According to the data, the total number of articles reviewed on the subject of intangible assets has been 2998 studies since the beginning, indexed in the Scopus database over the past 50 years, during which 58945 were cited, i.e., 19.66 times per article and 1178.9 Citation per year, which indicates the high quality of the research conducted.

Research trends in the field of intangible assets

The results of the analysis of the studies show that the research and development of scientific products in the field of intangible assets in the Scopus base has been very positive since the beginning, such that in the last ten years, the growth rate of scientific products is 61% of all researches carried out from 1975 to 2019 (Figure 1).

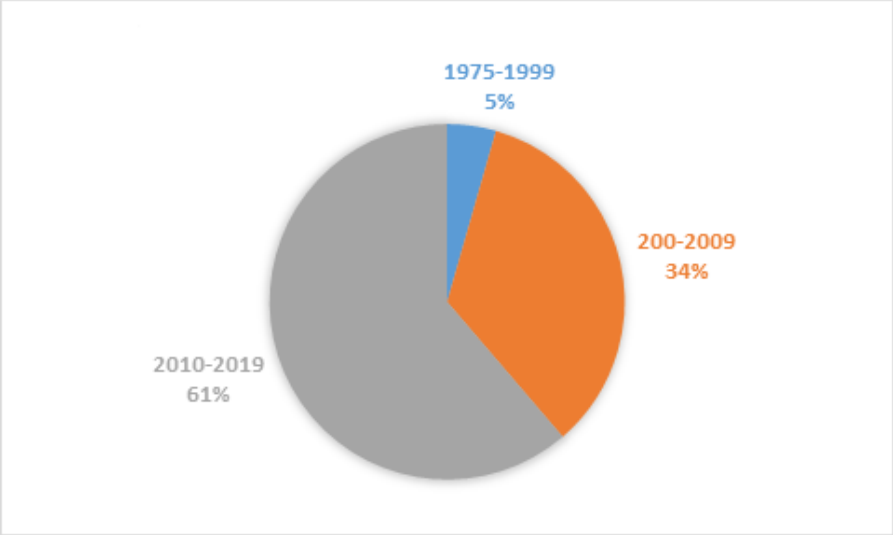

Figure 1: Papers from 1979 to 2019

Among the most important channels of information exchange in scientific disciplines are the scientific journals of each discipline. Therefore, identifying active and reputable journals in any field is particularly important.

A review of data related to the contribution of each journal to the published articles indicates that Springer has the most significant number of articles and research, with 121 articles (Figure 2).

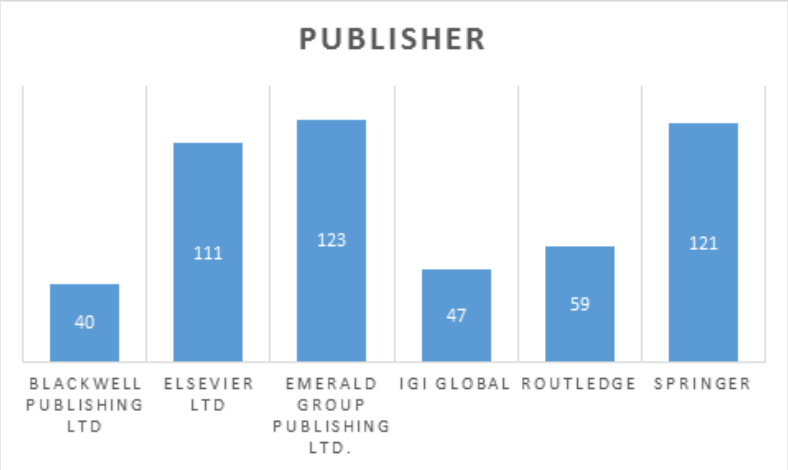

Figure 2: Contribution of each publisher to research

Figure 3 shows that about 77% of the studies were articles.

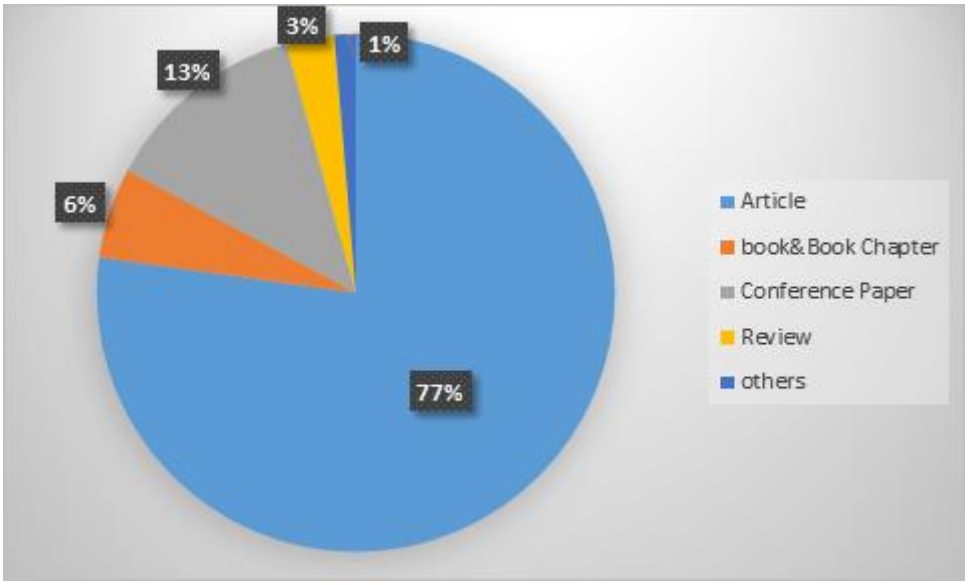

Figure 3: The percentage of the types of research

Word analysis

Keywords in the field of intangible assets

As noted, for the purpose of co-word analysis, by placing inclusion thresholds on keywords repeated at least 5 times, 566 frequent keywords were identified, of which, after eliminating irrelevant items, 364 remained included in the final analysis. The keywords are shown in Table 1 and the degree and weights obtained. For example, the intangible asset has 268 entering edges and 261 outgoing ones, which means it has the highest total grade of 529. This shows the centrality of this concept in the network. Intellectual capital has the next highest number of connections, indicating the closeness of the two concepts to each other. The keywords "intangible assets", "knowledge management" and "intellectual capital" have gained the highest weight in the word co-occurrence network. This result is consistent with a literature review of this article.

Table 1

Keywords co-occurrence network analysis

Label	In degree	Out degree	Degree	Label	weighted in degree	weighted out degree	Weighted Degree
intangible assets	268	261	529	intangible assets	1277	1646	2923
intellectual capital	196	199	395	knowledge management	1052	467	1519
knowledge management	198	167	365	intellectual capital	818	669	1487
competition	39	266	305	competition	52	864	916
innovation	116	136	252	information management	141	352	493
information management	96	140	236	innovation	139	316	455
competitive advantage	30	177	207	competitive advantage	88	363	451

Label	In degree	Out degree	Degree	Label	weighted in degree	weighted out degree	Weighted Degree
management	118	72	190	human capital	73	322	395
sustainable development	180	7	187	knowledge based systems	222	161	383
knowledge based systems	95	89	184	societies and institutions	331	33	364

Using the data in Table 2, it is clear that sustainable development and social entrepreneurship concepts have been repeatedly used in intangible asset research and are closely related to the intangible asset domain. For example, Kujansivu and Ldnnqvist (2007), Berzkalne and Zelgalve (2014), and Mondal and Ghosh (2012) state that intellectual capital is considered to be an intangible asset (Gumelar & Herwany, 2018) and Bontis and Serenko (2007) cite intellectual capital as one of the most important components of intangible assets of a knowledge-based economy. Okamoto, Chen & Li (2008) relate intangible assets to the sum of the knowledge and abilities of all employees that lead to wealth creation for the organization.

The relationship between knowledge management and intangible assets has also been confirmed in many studies. Massa and Testa (2009) regard knowledge and intangible assets as the most critical factors of production and competitive advantage.

The most frequent keywords

After the concept of intangible assets, words such as Intellectual capital, knowledge management, competition, and innovation were widespread in the present study (Table 2). The relationship between innovation and competition with intangible assets is mentioned in many studies. For example, Huang, Lai & Lin (2011) argue that by aligning intangible assets with the innovation process, companies are likely to generate competitive profits.

Table 2
The most frequent words in the co-occurrence network

Keyword	occurrences	Total link strength
Intangible assets	1125	4344
Intellectual capital	468	2036
Knowledge management	336	2068
competition	153	1261
innovation	128	666

Intellectual capital consists of the stock and flow of knowledge available to an organization. These can be regarded as intangible resources, which together with tangible resources comprise the market value of a business. Today, intellectual capital and intangible assets are the key factor in company's profitability and success (Anghel, 2008). Most companies specify intangible assets, and considerable overlap occurs with intellectual capital. Intangible assets may constitute companies' assets (Boekestein, 2006). In today's economy - a knowledge-based economy - the value of goods, services and companies is created not only by tangible assets but mostly by assets based on all kinds of knowledge - Intangible Assets. Results obtained from traditional factors such as labor, land and capital are increasingly dependent on effective

knowledge and management usage.(Volkov & Garanina, 2007). The role of IAs is recognized as central to sustaining the competitiveness of firms and innovation systems. Intangible assets (IAs) are increasingly seen as critical drivers for knowledge creation, innovation and economic growth (Kramer, Marinelli, Iammarino, & Diez, 2011). Intangible assets generate and enhance innovative capability (Huang et al., 2011).

The most related words

The critical "centrality or degree criterion" index is related to the number of edges associated with each node in a network. Therefore, the degree criterion deals with the role of each node in the network. In networks with directed edges, in-degree is the number of edges a node receives, while out-degree is the number of edges each node sends out. The higher the node's in-degree (especially compared to the nodes with a high in-degree), the stronger or more important the node will be (Scott & Carrington, 2011). Table 3 shows the keywords with the highest degree; as is evident, intangible assets and intellectual capital hold the highest degrees, respectively.

Table 3
Words with a high degree of centrality

Label	Degree	Weighted Degree
intangible assets	529	2923
intellectual capital	395	1487
knowledge management	365	1519
competition	305	916
innovation	252	455
information management	236	493
competitive advantage	207	451
management	190	293
sustainable development	187	332
knowledge based systems	184	383

Mapping co-occurrence

We used social network analysis techniques to interpret scientific maps. Because scientific maps have a structure similar to social networks (Guns, Liu & Mahbuba, 2011), after modifying the network and eliminating unrelated nodes such as countries, methodology-related concepts, and so on, the final co-occurrence map was drawn. The map of concepts related to intangible assets arising from the research keywords is illustrated in the general form of word density using VOSviewr software (Figure 5) and degree rank (Figure 4).

VOSviewer software assigns each keyword a density based on frequency, and words with higher frequencies based on co-word analysis will have more densities. The purpose of Gephi software is also to study the correlation of node properties and network construction using visual patterns. Social network analysis metrics such as node degree or betweenness can be used for better computation and visualization.

The longest path in the network, or network diameter, is 6, and the average distance between the two nodes is calculated at 2.03. The network's diameter is measured by the distance of the longest paths in the network with the distance of the shortest paths (in terms of the number

of edges or connections) between two nodes. The shorter the network diameter, the faster the communication speed will be (Cheong & Corbitt, 2009), and in the present network, every two words can be connected through six intermediaries.

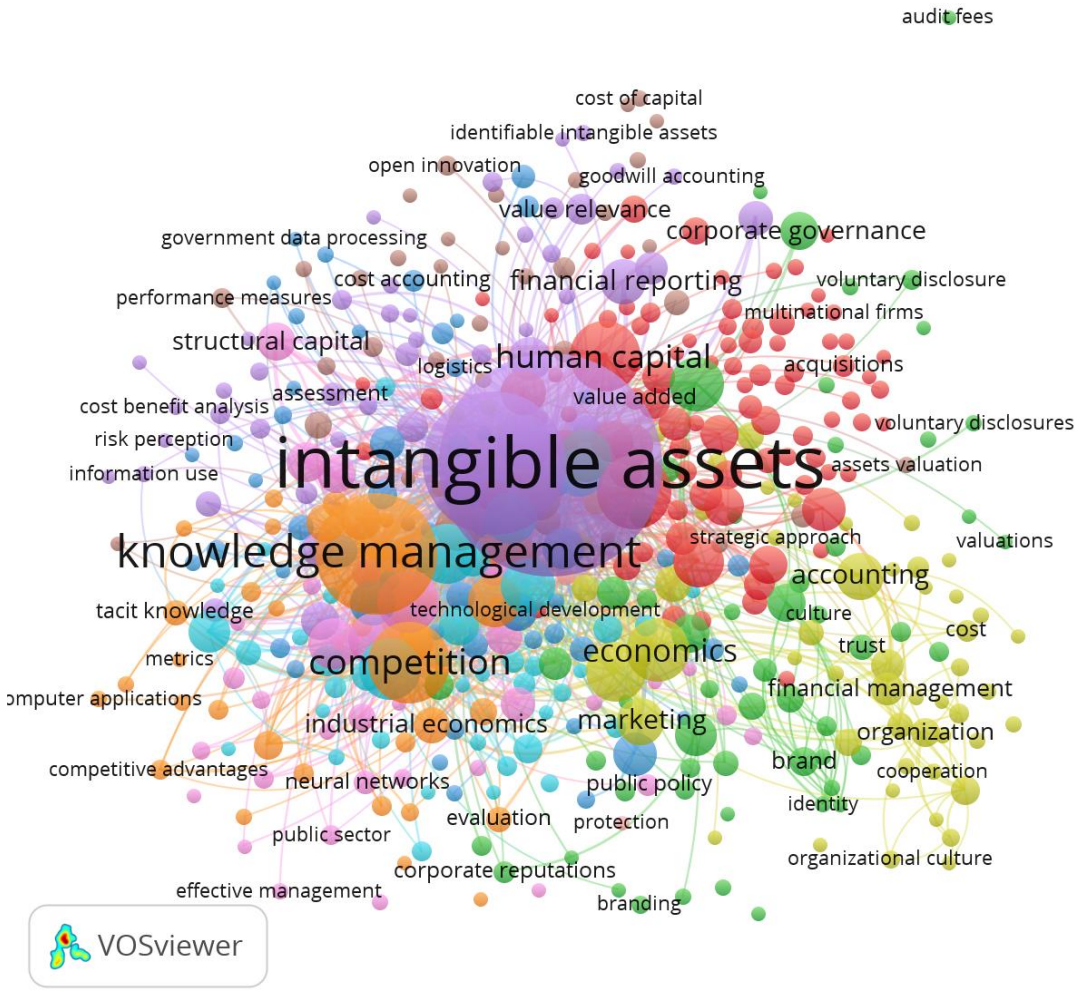

Figure 4: word co-occurrence map

Co-occurrence network analysis

Various indicators for word co-occurrence network analysis can be applied to scientific maps. For example, the size of the network is determined by the number of nodes and the network's density by the number of edges in the network. Centrality is one of the important indicators in network analysis. This index refers to the position of specific nodes within the network, and its types are closeness, betweenness and degree centrality. Degree centrality is the value of each node obtained by counting the number of its neighbors. The number of neighbors is obtained based on the edges to which the node is connected. In a word co-occurrence network, the more centrality degree a word has, the more communication and network it has and the more effective it will be. Closeness centrality is based on the concept of distance and path length. In a network, vertices with the least distance to all other vertices have a higher closeness centrality (Degenne & Forsé, 1999).

In the present study, closeness centrality is the words that link with the least distance (least number of edges) to other words. betweenness centrality also indicates the node's importance

in terms of its location on the map and information transmission over the network. Map analysis shows 345 nodes and 6745 edges on this map. Because the number of edges is more than nodes, the network is continuous.

Centrality

The network nodes' centrality can be studied using degree, betweenness and closeness indices. The degree of centrality for each node in the network is equal to the sum of the edges entering the node, and closeness is the average length of the shortest paths between that node and the other nodes in the network. Betweenness refers to the number of times a node is placed on the shortest paths between every two nodes in the network (Opsahl, Agneessens & Skvoretz, 2010).

Degree of centrality

Centrality is one of the network metrics or indicators useful in analyzing the structure of entire networks and node positions in the network. It measures the number of edges going in or out of a node in a network. The degree of centrality is the number of edges a node shares with other nodes in the network. A subject with the most edges has the highest degree and is the most centralized node (Bródka, Skibicki, Kazienko & Musiał, 2011). Degree centrality can facilitate or prevent the flow of resources between nodes in the network (Estrada & Rodriguez-Velazquez, 2005). As shown in Figure 4, Two nodes or keywords are connected if they share at least one common co-occurrence in this network. The size of each node represents the degree centrality index or the number of co-occurrence of that node with the other nodes in the network. Moreover, the more the co-occurrence of two nodes, the greater the diameter of the link between the two nodes and the bolder the lines that connect them. In the present network, intellectual capital has the highest degree of centrality after the intangible asset keyword, representing the second highest number of connections with other nodes.

Betweenness centrality

Betweenness centrality as a node compatibility feature indicates the node's importance in terms of its position on the map and information on the network. The betweenness centrality index is calculated based on the status of people in the network. The node with the highest betweenness centrality is in the middle of many other nodes, and the edges connecting other nodes pass through it. These nodes have the power to isolate and enhance communication (Newman, 2005).

Analysis of betweenness shows that most keywords have a betweenness of less than 1000, with only eight nodes over 1000. Based on the betweenness analysis results shown in table 4, these are the most important subjects in information transition in the network. In other words, these subjects are considered to be interdisciplinary in the field of intangible assets. The table shows keywords with the highest betweenness centrality.

Table 4
Words with the highest betweenness centrality

Label	Betweenness centrality
intangible assets	11909.46
intellectual capital	4417.272
knowledge management	4212.113
competition	2542.229
innovation	1740.381
information management	1537.941
competitive advantage	1213.811
human capital	1000.643
decision making	990.556
societies and institutions	889.8239

Closeness centrality

How fast an entity on the network can access more entities on that network is explained by closeness. An entity with higher closeness generally has the following characteristics:

It has quick access to other entities on the network;

It has a short path to other entities;

It is close to other entities;

And it has high visibility of what is happening on the network

Closeness is calculated based on the geodesic distance. It measures the distance a node has from other nodes. This index represents the availability (Frank, 2002). According to the graph, most nodes are close to one another and have a closeness between 0 and 1, allowing the information to spread quickly across the network. According to calculations, topics like value creation, value chain, social responsibility, and trademark have the highest impact and closeness centrality (Table 5). Such nodes are less distant from all other nodes and are, on average, closer to all nodes, and in fact, these nodes are more robust in the network (Crucitti, Latora & Porta, 2006; Okamoto et al., 2008). The following table shows the keywords with the highest closeness centrality:

Table 5
Keywords with the highest closeness centrality

Label	Closeness centrality
value creation	1
value chain	1
social responsibility	1
trademark	1
intangible assets	0.963158
intellectual capital	0.82439
knowledge management	0.796791
technology transfer	0.714286
competition	0.712589
tangible assets	0.692308

Co-occurrence network density

Density is one of the indicators used to check the degree of network cohesion. Network density can be defined as a set of edges that connect nodes and prevent the network from breaking (Faust, 2006). Regarding network cohesion, it can be stated that if the interconnection between the nodes or the number of edges between the nodes is low, the network will have low cohesion and many holes in the network. In this case, the network will be discrete, and information flow will be very slow. Conversely, when there is a high number of edges between the nodes and the holes in the network are few, the network is continuous (Faust, 2006; Kohler, Behrman & Watkins, 2001). Analysis of word co-occurrence shows that the network has relatively low cohesion due to its density, which is 0.046. This density indicates that only 4.6% of the potential internal communications in the network is realized. In other words, the number of edges available in the network can be relatively low, resulting in a slow information flow.

The network density also determines the ratio of the number of connections available to the number of connections possible. The co-word density map (Figure 5) shows that the highest density is formed around the two keywords "intangible assets" and "social innovations", and the words farther away from these two have less significance, less occurrence, and fewer neighbor nodes.

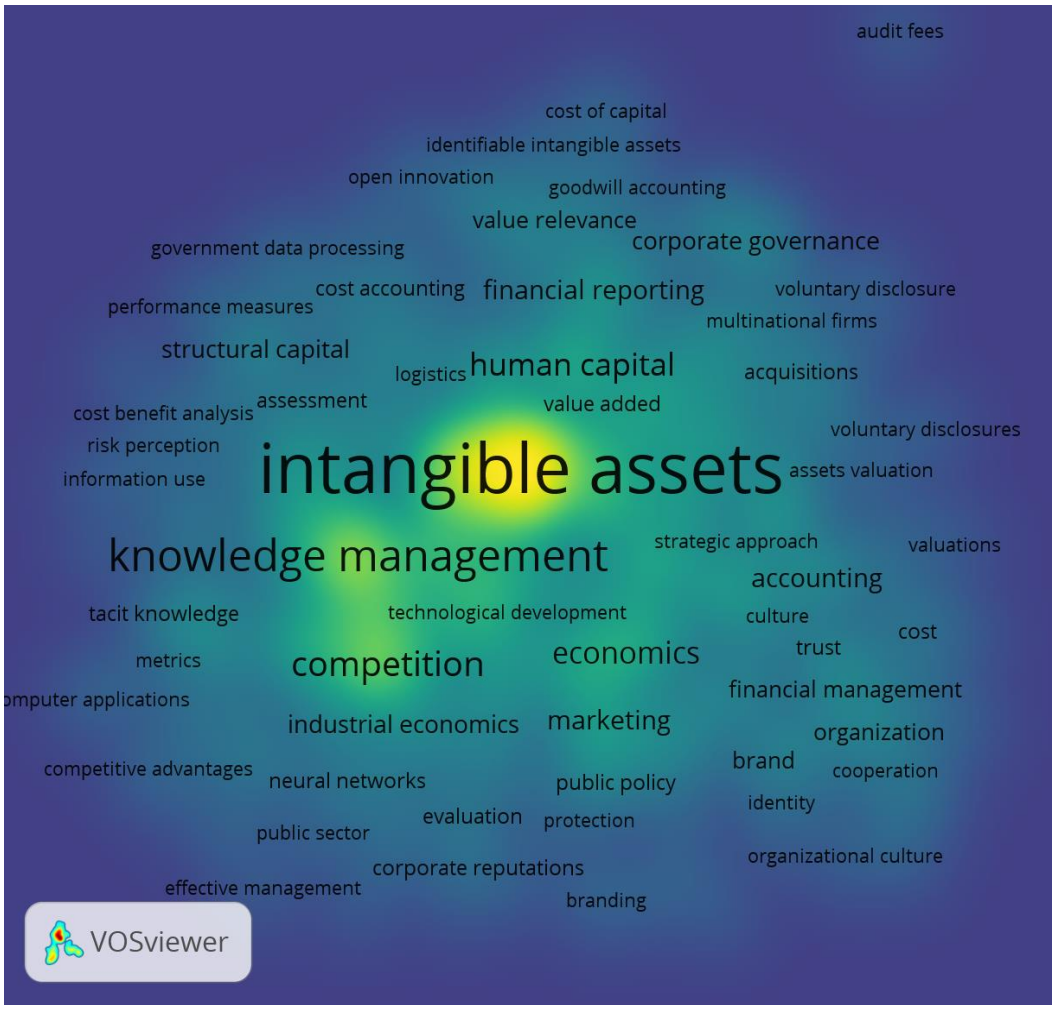

Figure 5: Density-based word co-occurrence network

Hub

Network elements can be categorized into different classes through their participation in the network. For example, they are classified according to how they communicate with other system components. One of the important distinctions that can be made based on their effectiveness is their potential effect on the overall system and their capacity to transmit or process information. High-impact nodes are often referred to as hubs. Identification of hubs is needed to map the different areas that are most interoperable and contribute to system integration. One issue to note is that nodes with high connections also have a more significant shareability factor. The high degree of centrality, relevance, and degree of interconnectedness in structural communication, indicate that they play a vital role in the integration of processes and information flows (Franks, Noble, Kaufmann, & Stagl, 2008). Nodes that act as hubs and connect many nodes. Table 6 shows that nodes of competition, intangible assets and intellectual capital are the most extensive network hubs.

Table 6
Main hubs of word co-occurrence network

Label	Hub
competition	0.27283
intangible assets	0.26415
intellectual capital	0.224412
competitive advantage	0.201576
information management	0.197476
knowledge management	0.192768
innovation	0.178155
decision making	0.149719
human capital	0.144265
information technology	0.136596

As shown in Figure 6, the node and the keyword competition, as one of the most important co-occurrence network hubs, have many links to other nodes, and it also facilitates connection to other nodes, indicating the high importance of competition in the intangible asset domain. It is intangible and shows that intangible assets have a significant impact on the competitiveness of organizations.

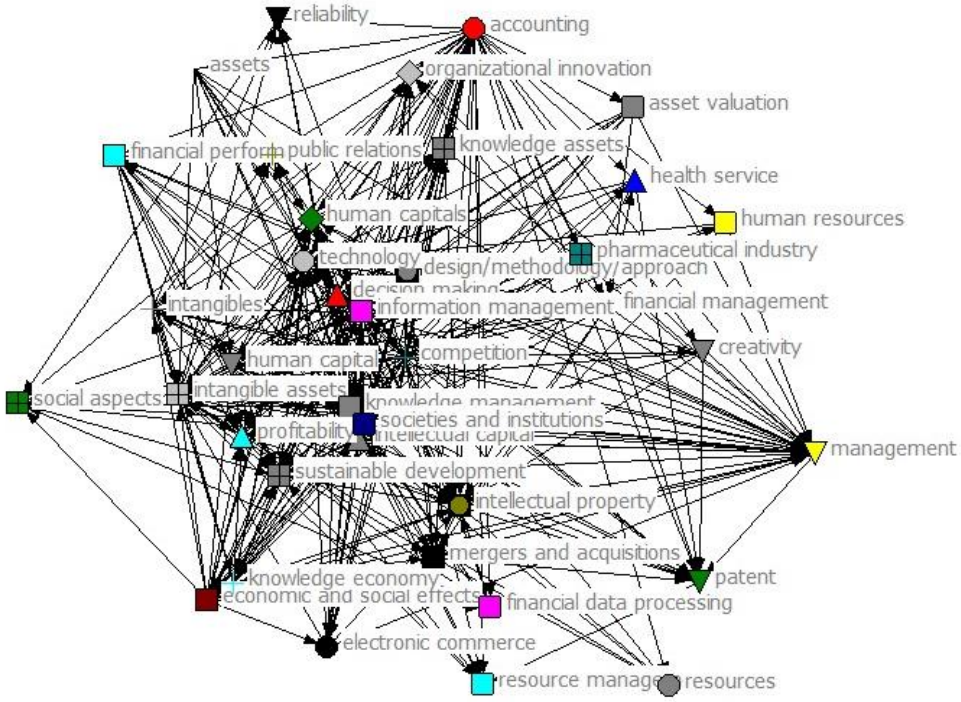

Figure 6: one of the most important co-occurrence network hubs

Cluster analysis

Clustering means categorizing objects in collections without supervision and interference. In this way, clusters are not predetermined, so cluster labels are not available. Clustering refers to finding a structure within a set of unlabeled data; in fact, it is said to be a collection of data points that are similar to one another (Jain, Murty & Flynn, 1999). Classification and clustering are different. In a classification, you assign an object a predefined class, but in a cluster, there is no knowledge of the classes within the data; in other words, the data itself is the source of clusters (Omran, Engelbrecht & Salman, 2007). Consequently, after performing clustering, an expert should interpret the clusters, and, in some cases, it may be necessary to reconsider some of the parameters after clustering. These are the parameters included in the clustering task but are irrelevant or of minor importance and are therefore eliminated, and clustering is performed again (Two Crows Corporation, 1999).

Cluster analysis was performed using Gephi, and 4 clusters of topics were identified and clustered by experts. The "Competitive advantage" cluster is the largest cluster with 185 points and contains clusters related to innovation and competition. The clustering results in Table 7 show the number of clusters, their naming and the percentage of concepts present in each cluster. The clustering shows the automatic structuring of the concepts, and the concepts within each group are the most similar, and all 6 clusters have minor intra-group differences and maximum inter-group differences. In the "intangible asset" cluster, for example, the concepts of sustainability, customer capital, value relevance, and the like are most closely related.

Table 7
Network attributes

Network attributes

Average path length	nodes	Average clustering coefficient	edge	
2.03	245	0.25	6745	
Share of network		Number of nodes	Cluster	#
25%		90	Intangible asset	0
51%		185	Competitive advantage	1
17%		62	Knowledge and intellectual capital	2
7%		26	Assessment	3

The clustering coefficient shows how much the keywords tend to create co-occurring clusters. A clustering coefficient is always between zero and one (Miguel, Chinchilla-Rodríguez, González, & Moya Anegón, 2012). A mean of 0.25 for clustering coefficients for keyword clustering was obtained, indicating that the vocabulary is not randomly formed in a cohesive network, and the coefficient estimates the tendency of network nodes to communicate with each other and form clusters. Moreover, the average distance of the network nodes was 2.03, indicating the nodes' closeness and density of the network.

Authors and co-authors (co-authorship)

There are 5,389 unique authors in the intangible asset area. This is obtained from all of the intangible asset research since the beginning, which is indexed on the Scopus database.

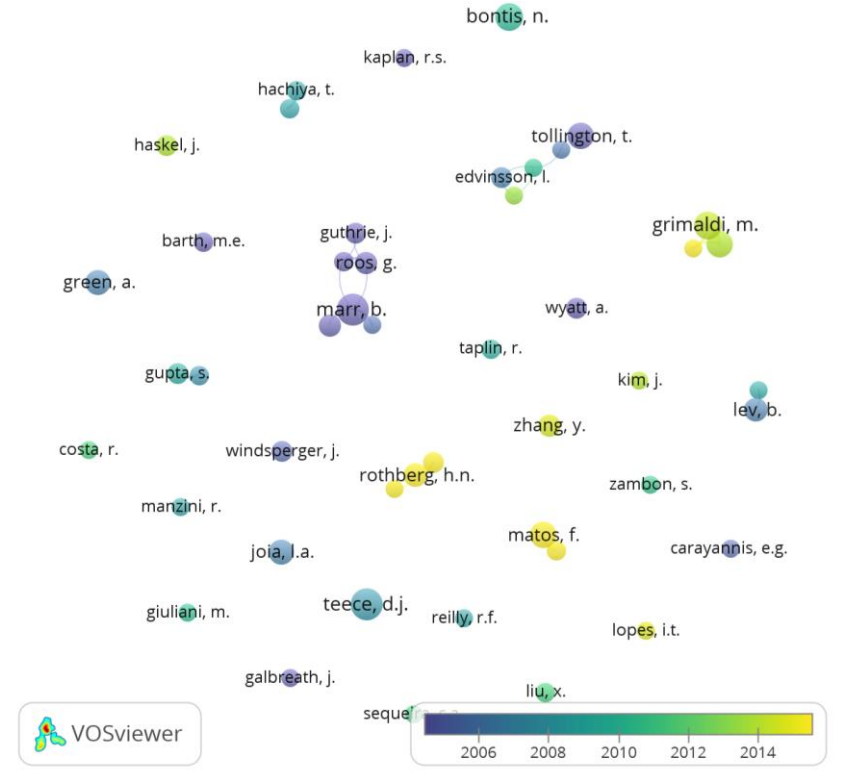

Figure 7: co-authorship map

The co-authorship network of authors contributing at least five works has 47 nodes and 21 edges, indicating a low co-authorship. By computing the co-authorship network density of the

intangible assets network, the value obtained was 0.01. The network density shows the number of edges available in the network concerning the number of possible edges. Network density is a number between 0 and 1. The closer a number is to 1, the more inter-node connections there are in a network. The higher the network density, the more nodes are connected and closer (Mrvar & Batagelj, 2016). Overall, the obtained number indicates that the co-authorship network is discrete and has a low density.

There were 505 single-author studies, 680 two-author studies, and 497 three-author studies, and the rest of the studies had higher author numbers. Careful analysis of the number of authors per article indicates that the dominant authoring pattern in intangible asset research is collective, and only about 25% of the articles have a single author, confirming that scientific and research papers and reports are primarily the results of the work of multiple authors (Andrés, 2009) and that the academic work is increasingly the result of teamwork (Posner, 2009).

Figure 7 shows influential writers, authors' relationships, and important clusters that can be separated. And 30 communities and clusters have been identified from the network of authors who have done at least five studies, with the most co-authorship occurring in cluster 22 with six authors, and 20% of communications in this cluster being related to authors such as Marr, Pike, Roos, Guthri, Chatzk, Schium. The number of documents widely disperses the authors' names. On the science map, authors such as Howlett and Kaltka accounted for the largest share of output in intangible assets, illustrated in Table 8.

Table 8
Prolific authors in the field

Author	Documents
Marr b	15
Teece d	15
Grimaldi m	12
Bontis n	12
Cricelli i	11
Matos f	11
Tollington t	11
Green a	10

Also J.C. Dumay was cited as the author of the most cited article, "Intellectual Capital Measurement: A Critical Approach", in 2008 with 141 citations.

Discussion

The present study was conducted to analyze intangible asset research with the help of scientometrics, co-occurrence, co-citation and co-authorship methods. In response to the first question, the research results showed that the growth of scientific productions in intangible assets has always been positive in the 50 years, and more than 60% of articles were produced in the last ten years. As Kaufman and Schneider (2004) argued, with the increasing interest of organizations in intangible assets, researchers have become more interested in this field. Therefore, the growth of scientific production in this field can be attributed to the increasing importance of intangible assets among organizations and the competitive advantage resulting from it.

In response to the second question, our findings showed that intellectual capital, knowledge management, competition, innovation, competitive advantage and information management are among the most frequent keywords in this field of knowledge. Our findings show that intellectual capital, as one of the keywords and important topics in the field of intangible assets, is one of the important tools for strengthening and developing organizations, which is consistent with the results of Quintero-Quintero, Steenkamp and Kashyap (2021), and Petty and Guthrie because they have also emphasized on a better understanding of how and why to develop intellectual capital for business success.

Bellucci et al. (2020) also concluded that knowledge management is one of the main streams of research in the field of intellectual capital, which is consistent with our findings about the importance of knowledge management in intangible assets because we argued that this keyword is one of the most frequent concepts with a high degree of centrality in the field of intangible assets. According to Dias et al. (2014), the three issues of management, knowledge and accounting have been influential in the area of intellectual capital under government management, and our findings in this field show that knowledge-based systems and management are also important keywords in this field, so our conclusions confirm their results.

Innovation and competitive advantage are other keywords that have become very important among intangible asset researchers. Based on the classification, a significant number of keywords have indicated that this topic shares an opinion with the research of Gnanasekaran and Balamurugan (2016). Because as mentioned, they believed that paying attention to innovation and creating a competitive advantage is one of the components of intangible assets. In response to the third question, we examined co-occurrence networks and calculated the degree of centrality, betweenness centrality and closeness centrality. The results showed that most keywords have a betweenness centrality of less than 1000, and only eight nodes have more than 1000. The keyword "competition", as one of the most important co-occurrence network hubs, has many links to other nodes and facilitates connection to other nodes, indicating its high importance in the intangible asset domain.

The co-authorship network of authors contributing at least five works has 47 nodes and 21 edges, indicating a low co-authorship. The obtained number suggests that the co-authorship network is discrete and has a low density. Also, we presented a comprehensive picture of research in intangible assets by displaying important and highly cited authors and articles in this field so that researchers and policymakers can better understand this field."

Conclusion

In this study, by examining the thematic scattering, we identified the basic issues of intangible assets and, given the growing importance of intangible assets in the world of competition and business, using social network analysis (SNA) and scientometrics. Based on the articles indexed in the Scopus database, we determined the course of the dominant currents in this field and examined research in intangible assets from the beginning until 2019. Analysis of studies in this field showed that research in this field has grown significantly and shows the interest of researchers in this field. The results of this study also indicate the importance of concepts such as knowledge management and intellectual capital, which was confirmed by reviewing the literature on these issues.

Drawing scientific maps of the concept of intangible assets based on research conducted in this field is another result of this research. Keywords such as intangible assets, intellectual

capital, knowledge management, competition and innovation are obtained as nodes with high degrees of correlation in the network. These nodes are significant and facilitate connections and information flow between intangible assets and other domains. Concepts such as value creation, value chain, social responsibility and trademark have the highest degree of centrality in the word network. They are less distant than other nodes. Examination of the synonym network also shows that the network has a relatively low coherence due to the density of 0.046, and the keywords of competition, intangible assets and intellectual capital as the most important hubs of concurrent networks are strongly connected to other nodes and facilitate communication with other nodes. he does. The findings also show that Emerald Publishing has published the most significant number of articles in this field. The results of this study show that intangible assets are closely related to important social categories such as social deprivation, public health, social capital, social policy and social network.

This study adds to the previous descriptive evidence on the importance and contribution of intangible asset components by conducting joint citation analysis on articles in the field of intangible assets and helps to fill the gap left by previous research and give researchers an understanding. It offers a better knowledge of this field and can be useful in understanding the current situation and guiding scientific trends in intangible assets. The present study also helps researchers in social fields, especially intangible assets, to explain the process of studies and policy-making in this field based on identified areas of influence.

Future research orientations on this topic could focus on studying the trends of countries and universities where these case studies appear more regularly. In addition, long-term citation analysis cannot reveal the influential role of recent studies. Therefore, dividing the study period into sub-periods can be useful in discovering the changes and developments of leading research topics over time in intangible assets. The limitations of this research are bibliometric analysis, which is performed only using the Scopus database, so as a suggestion for future research, the inclusion of other scientific databases such as WOS on the subject under study, which can be a basis for further research from this type.

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