RGSA – Revista de Gestão Social e Ambiental
ISSN: 1981-982X
Data de submissão: 15/01/2024
Data de aceite: 11/03/2024
DOI: https://doi.org/10.24857/rgsa.v18n8-026
Organização: Comitê Científico Interinstitucional
Editor Chefe: Christian Luiz da Silva
Avaliação: Double Blind Review pelo SEER/OJS

VALUATION OF ENVIRONMENTAL INTANGIBLE ASSETS: A BIBLIOMETRIC AND SYSTEMATIC ANALYSIS

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ABSTRACT

Objective: This paper presents a systematic bibliometric analysis of the literature on intangible valuation, especially environmental intangibles, to analyze the relevance of the subject, the state of scientific knowledge, and research opportunities.

Theoretical Framework: Intangible assets are relevant for companies because they can contribute to higher company valuation. Some research studies have successfully classified the different types of intangible assets and developed models to value companies that include them. However, diverse results have not allowed reaching a consensus on their use in company valuation.

Method: The Knowledge Development Process-Constructivist (ProKnow-C) methodology was used; articles on intangible assets were analyzed with the VOSViewer® software, while an analysis of the articles for environmental assets was performed with the lens.org platform.

Results and Discussion: It was determined that most intangible asset valuation models are empirical and use regressions to perform the valuation. Intellectual capital is one of the intangible assets that has been proposed by more models.

Research Implications: Some opportunities for future research on this topic are identified; these are adjusted to models that consider the main environmental assets and are easily applied by companies.

Keywords: Intangible Assets, Valuation, Bibliometric Analysis, Environmental Assets, Intellectual Capital, Carbon.

VALORIZAÇÃO DE ACTIVOS INTANGÍVEIS AMBIENTAIS: UMA ANÁLISE BIBLIOMÉTRICA E SISTEMÁTICA

RESUMO

Objetivo: Este artigo apresenta uma análise bibliométrica sistemática da literatura sobre a valorização dos intangíveis, em especial os intangíveis ambientais, para analisar a relevância do tema, o estado do conhecimento científico e as oportunidades de investigação.

Referencial Teórico: Os activos intangíveis são relevantes para as empresas porque podem contribuir para uma maior valorização da empresa. Alguns estudos classificaram com sucesso os diferentes tipos de activos intangíveis e desenvolveram modelos de avaliação de empresas que os incluem. No entanto, a diversidade de resultados não tem permitido chegar a um consenso sobre a sua utilização na avaliação de empresas.

Método: Foi utilizada a metodologia Knowledge Development Process-Constructivist (ProKnow-C); os artigos sobre ativos intangíveis foram analisados com o software VOSViewer®, enquanto a análise dos artigos sobre ativos ambientais foi realizada com a plataforma lens.org.

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Resultados e Discussão: Verificou-se que a maioria dos modelos de avaliação de activos intangíveis são empíricos e utilizam regressões para efetuar a avaliação. O capital intelectual é um dos activos intangíveis que tem sido proposto por mais modelos.

Implicações da Pesquisa: Por fim, identificam-se algumas oportunidades de investigação futura sobre esta temática, ajustadas a modelos que considerem os principais activos ambientais e que sejam de fácil aplicação pelas empresas.

Palavras-chave: Activos Intangíveis, Avaliação, Análise Bibliométrica, Activos Ambientais, Capital Intelectual, Carbono.

VALORACIÓN DE ACTIVOS INTANGIBLES MEDIOAMBIENTALES: UN ANÁLISIS BIBLIOMÉTRICO Y SISTEMÁTICO

RESUMEN

Objetivo: Este trabajo presenta un análisis bibliométrico sistemático de la literatura sobre valoración de intangibles, especialmente intangibles medioambientales, para analizar la relevancia del tema, el estado del conocimiento científico y las oportunidades de investigación.

Marco Teórico: Los activos intangibles son relevantes para las empresas porque pueden contribuir a aumentar su valoración. Algunas investigaciones han clasificado con éxito los distintos tipos de activos intangibles y han desarrollado modelos para valorar empresas que los incluyen. Sin embargo, la diversidad de resultados no ha permitido alcanzar un consenso sobre su utilización en la valoración de empresas.

Método: Se utilizó la metodología del Proceso de Desarrollo del Conocimiento-Constructivista (ProKnow-C); los artículos sobre activos intangibles se analizaron con el software VOSViewer®, mientras que el análisis de los artículos sobre activos medioambientales se realizó con la plataforma lens.org.

Resultados y Discusión: Se determinó que la mayoría de los modelos de valoración de activos intangibles son empíricos y utilizan regresiones para realizar la valoración. El capital intelectual es uno de los activos intangibles que ha sido propuesto por más modelos.

Implicaciones de la investigación: Se identifican algunas oportunidades para futuras investigaciones sobre este tema, que se ajustan a modelos que consideren los principales activos del entorno y sean de fácil aplicación por las empresas.

Palabras clave: Activos Intangibles, Valoración, Análisis Bibliométrico, Activos Medioambientales, Capital Intelectual, Carbono.

1 INTRODUCTION

The increasing relevance of intangible asset valuation responds to several studies that have demonstrated how the valuation of intangible accounting information adds value to a company (Andreou et al., 2007; Chen & Ramaboa, 2017; Bagna et al., 2017). Intangible assets refer to consumer information, brand, developed technology, processes, name, reputation, and corporate culture of companies; these assets are a competitive advantage for companies that can

be sustained over time (Hanson, 1988; Manikas et al., 2019). Although this is an interesting topic for accounting and financial research, no consensus has yet been reached on which assets can be classified as intangible and how best to value them.

Among the identified types of intangible assets are those related to intellectual capital, which consists of relational, organizational, and human capital (Atalay et al., 2018a). There are also brands, innovation, and assets directly connected to the organization. Given that they have no physical appearance, their identification and measurement are complex for companies and regulators. Although most accounting standards already consider intangible assets, efforts are being made to seek unanimity and training to correctly assess them (Ciprian et al., 2012). A number of studies have focused on the classification and valuation of intellectual capital (Babajee et al., 2020; Ginesti et al., 2018a; Loyarte et al., 2018a, 2018b; Osinski et al., 2017). However, this heterogeneity makes it difficult to compare companies and their valuation, which requires a multidisciplinary approach.

Intangible environmental assets have become relevant because of the current global situation and the responsibility of companies for pollution and dumping waste. The 2030 United Nations Sustainable Development Goals (UN, 2020) propose various objectives related to economic growth and environmental protection, which include the following: Goal 7, 9,11, 12, 13, 14, and 15.

The ISO 14001:2015 standard is also part of this context. This standard calls for companies to become certified in environmental management systems to demonstrate their commitment to protecting and caring for the environment and managing the environmental risks generated by their operations (ISO, 2015). According to market trends reported by Forbes 2021 magazine, consumers are increasingly demanding that company practices be sustainable and respectful of the environment and resources. Companies must quantify their environmental impact, socialize their sustainable practices with consumers, evaluate their environmental assets, and determine how this affects company valuation. The financial and business sector has not been immune to this trend. Adom et al. (2020) identified the effects of energy efficiency on sustainability issues on increasing bank profits.

According to the aforementioned, some lines of research have been proposed and new opportunities in this area have been created. The keywords used to construct the search equations were method, methodology, valuation, intangibles, assets, and environment.

The Knowledge Development Process-Constructivist (ProKnow-C) methodology was used to identify the gaps, which would enable future research. This study considers consumer awareness of the importance of sustainability and environmental care and increased

commitment on the part of companies to implement policies and organizational changes (Adetoro et al., 2021; Miklosik & Evans, 2021).

Although there is abundant literature on the valuation of intangible assets (Andreou et al., 2007; Atalay et al., 2018a), there is still no consensus on which assets can be classified as intangible and the best way to value them. Moreover, despite the growing relevance of intangible environmental assets within the current context of global warming and increased environmental awareness, comprehensive studies on valuation models of this type of assets for companies are scarce (research gap). This study contributes to the literature by conducting a broad bibliometric and systematic analysis of existing research on intangible asset valuation, with special emphasis on environmental assets. It also identifies concrete opportunities for developing valuation models for intangible environmental assets that are useful to companies (novelty and potential contribution). In this way, this study lays the groundwork for future research focused on standardized comprehensive models for valuation of environmental intangible assets, thus contributing to both academia and business management.

The present study provides a global perspective on the topic of intangible assets, especially environmental issues, by analyzing the documents published in Web of Science (WoS) and Scopus and the results obtained in the lens.org platform. The impact of principal authors, countries, and journals were identified through a bibliometric analysis. The remainder of the study is structured as follows: materials and methods, results of the systematic and bibliometric analyses for intangible assets and those of an environmental nature, research opportunities, and conclusions.

2 OBJECTIVES

The objective of this work was to present a bibliometric and systematic analysis of the literature on intangible asset valuation, more specifically environmental valuation.

3 DEVELOPMENT

3.1 METHODOLOGY

The systematic review of the literature was based on the Knowledge Development Process-Constructivist (ProKnow-C) methodology (Vieira et al., 2019). The VOSViewer® program was used to perform the bibliometric analysis. The ProKnow-C consists of four stages

on which the methodology was performed (Ademar et al., 2015; de Carvalho et al., 2020) (Figure 1).

Figure 1

Knowledge Development Process-Constructivist (ProKnow-C) methodology

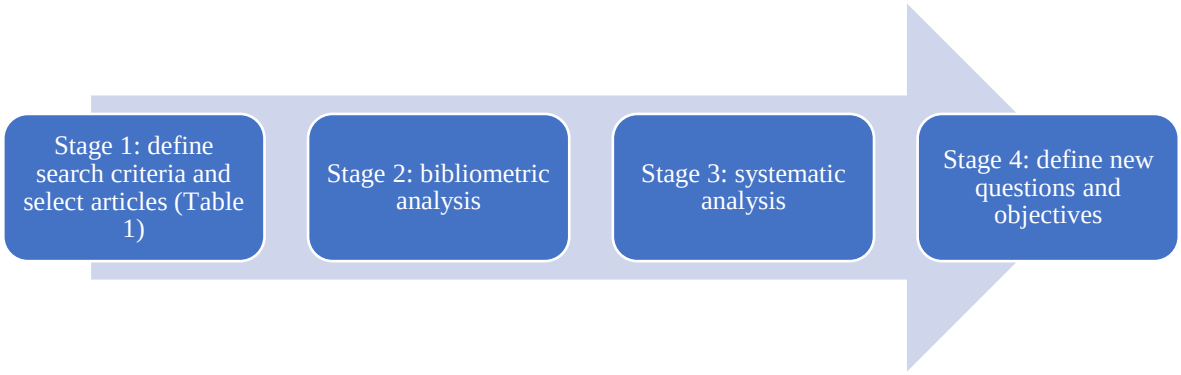


Table 1 shows the search equations used to prepare the bibliographic portfolio, which consisted of two refined search equations with a 16 March 2021 cutoff date in the Scopus and Web of Science (WoS) databases. The materials were screened for the years between 2017 and 2021, inclusively, and those classified as articles were selected. Both databases were analyzed separately with the software because of its technical requirements.

Table 1

Search equations used in the Web of Science (WoS) and Scopus databases

Equation #	Database	Equation
1	Scopus	TITLE-ABS-KEY ((method OR methodology) AND (valuation OR assessment) AND intangible AND assets) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017)) AND (LIMIT-TO (DOCTYPE , "ar"))
2	WoS	TS = ((method OR methodology) AND (valuation OR assessment) AND intangible AND assets) Refined for: YEARS OF PUBLICATION: (2021 OR 2020 OR 2019 OR 2018 OR 2017) AND TYPES OF DOCUMENTS: (ARTICLE) Time period: All years. Indices: SCI-EXPANDED, SSCI, A&HCI, ESCI.

The bibliometric analysis was performed for the initial equations applied in the WoS and Scopus databases. The word environment was excluded because there were only a few articles in both databases, and no significant information was found in the analysis with the VOSViewer® program. This analysis was performed for the unaltered equations to confirm the portfolio of items selected for the analysis of the different methodologies and models used for valuing intangibles. The analyses included co-authorship, co-citation, keywords, and co-

occurrence. Finally, 61 articles were selected, and these were read and used as the basis for the present review. In the case of intangible environmental assets that did not provide significant information with VOSViewer®, these were analyzed using data from the lens.org platform with the following search equation: environmental AND (intangible AND assets) Year Published = (2017 - 2021) Publication Type = (journal article).

In addition, an analysis was performed for the impact factor and Hirsch index (H-index) of the consulted journals. The impact factor was consulted in the Journal Citation Reports (JCR) and the H-index was identified according to the Scimago Journal Rank (SJR).

3.2 RESULTS AND DISCUSSIONS

Two types of bibliometric analyses were performed; one used the WoS and Scopus databases with the VosViewer® software in which published documents related to intangible assets were identified. Meanwhile, the other analysis used the lens.org platform to identify documents related to environmental assets. The analyzed variables in both cases were the number of publications, countries with higher productivity, journals, authors, and bibliometric citation indicators.

Table 2 shows the results obtained for the article search for each of the search equations and applied filters. The first and second filters consisted in eliminating duplicates in both databases and abstracts not related to the research topic, respectively. Finally, 61 articles were obtained after applying the filters, which were used for the present work.

Table 2

Filters applied to the articles found in the search of the Web of Science (WoS) and Scopus databases

Databases	WoS 1	SCOPUS 1
Search equation	Equation 1	Equation 2
Total articles	81	75
First filter: duplicates in the two databases	37	37
Second filter: duplicate articles with abstracts not related to the topic	14	13
Third filter: duplicate articles with abstracts related to the topic	24	24
Fourth filter: articles not duplicated and with abstracts not related to the topic	25	19

Fifth filter: articles not duplicated and with abtracts related to the topic	42	19
Total bibliographic portfolio	42	19

3.2.1 Co-authorship analysis

The co-authorship analysis used the authors as the unit in the equations for both databases. For Scopus, there was a maximum of 25 authors and minimum of 1 author; in this analysis, the largest set of connected elements was 11 (Figure 2). The nodes in the figures indicate the different authors, while the lines represent the different connections between them. In this case, there is a main node corresponding to the author Londoño, who had the highest number of connections with other authors.

For the WoS database analysis, there was a maximum of 25 authors and a minimum of 1 author per document. A maximum of 10 connected elements were obtained and shown in 3 sets. The main node of the first set was the author Stehel, who connected with the second group through the main node and author Marecek, who, in turn, connected a little closer with Machova and Rowland, the two main authors of the third group (Figure 3).

Figure 2

Co-authorship analysis and author connections: Scopus

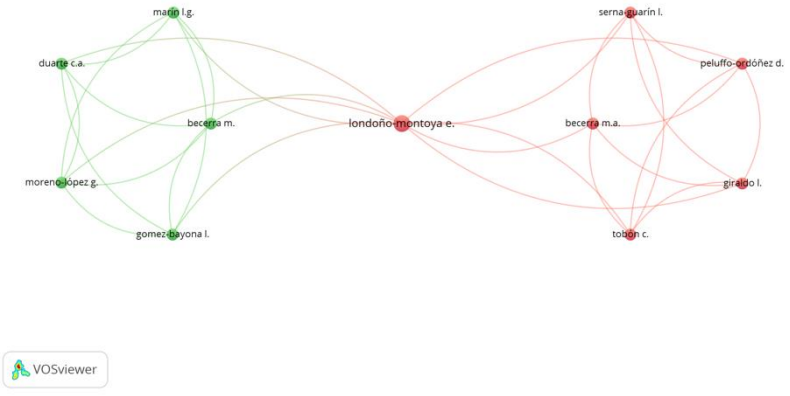
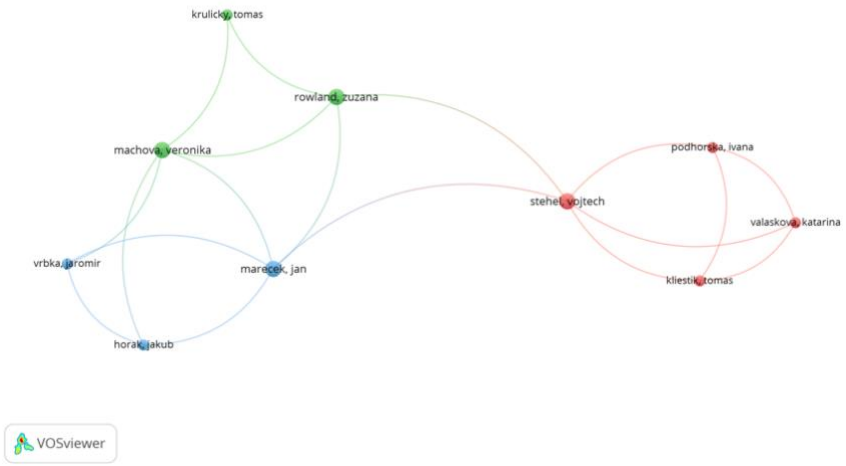


Figure 3

Co-authorship analysis and author connections: Web of Science (WoS).



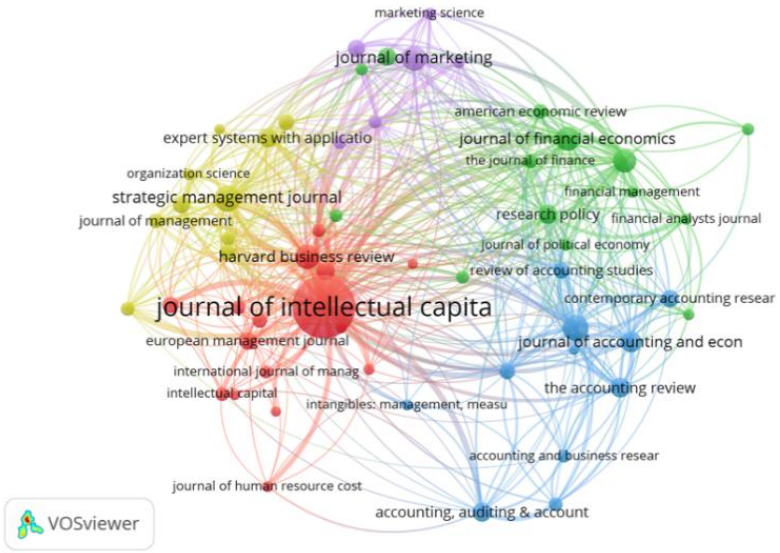
3.2.2 Co-citation analysis

The analysis was performed for the journals. The analyzed nodes indicated the activity and number of published documents, while the distance between documents was the citation frequency. Co-citation showed all those journals cited in the articles of the bibliographic portfolio in both WoS and Scopus. The purpose was to highlight the main journals in which publications on the topic of intangible assets were published and the number of citations they received.

The Scopus search equation revealed 5 main nodes, with the first consisting of 16 journals headed by the Journal of Intellectual Capital with 654 citations, followed by the Harvard Business Review with 101 citations. The second node included 14 journals and the Journal of Financial Economics with 101 citations. The third node consisted of 11 journals and the Journal of Accounting Research with 115 citations and 53 links. The fourth node contained 10 journals and the Strategic Management Journal with 113 citations. Finally, the fifth node included 6 journals and the Journal of Marketing with 104 citations (Figure 4).

Figure 4

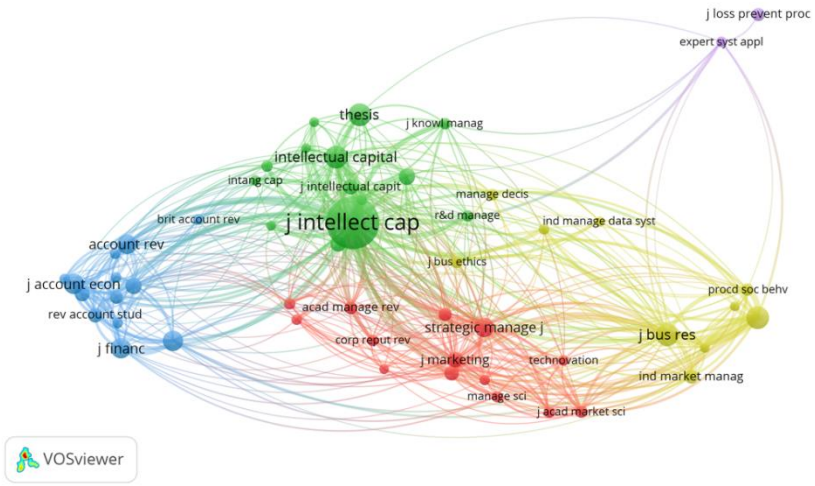
Nodes recorded for the journal co-citation analysis: Scopus



The WoS database showed 5 nodes; the first node included 14 journals and the top 5 for citations were the Strategic Management Journal (37), Journal of Marketing (25), Academy of Management Journal (21), Journal of Management (18), and Academy of Management Review (17). The second node contained 14 journals with citations for the Journal of Intellectual Capital (272), Intellectual Capital (51), Thesis Eleven (51), Sustainability (26), and Harvard Business Review (25). The third node showed 13 journals, including the Journal of Accounting and Economics, Review of Accounting Studies, Journal of Finance, and the Journal of Financial Economics with 43 citations each and Accounting Review with 40. The fourth node included 10 journals with citations for the Journal of Business Research (52), Journal of Product Brand Management (51), Industrial Marketing Management (19), Procedia - Social and Behavioral Sciences (15), and the Service Industries Journal (10). The fifth node consisted of the Journal of Loss Prevention in the Process Industries with 18 citations and Expert Systems with Applications with 11 (Figure 5).

Figure 5

Nodes recorded for the journal co-citation analysis: Web of Science (WoS).



The impact factor and H-index were also analyzed for each journal that appeared in the WoS and Scopus search equations (Table 3). The Journal of Marketing had the highest impact factor and the Service Industries Journal had the lowest. The impact factor in 33% of the journals was greater than 5, which is considered quite high for journals in this area of knowledge. For the H-index, the Academy of Management Journal had the highest value and Thesis Eleven had the lowest. The H-index for the consulted journals was greater than 100, which is above the average of the values for the total number of journals in this area searched in SJR. Of the consulted journals, 92% belonged to quartile 1 (Q1) of the SJR. This reflects the relevance of the journals that were selected for the topic and this systematic analysis.

Table 3

Impact factor and Hirsch index (H-index) of journals in the Web of Science (WoS) and Scopus databases

Journal name	Impact factor (JCR)		Other data		H-Index
	#	Year	SJR	Year	
Journal of Intellectual Capital	4.805	2019	1.184	2019	NR
Harvard Business Review	5.694	2020	0.826	2020	179
Journal of Financial Economics	5.731	2020	11.673	2020	256
Journal of Accounting Research	3.773	2020	6.767	2020	141
Journal of Marketing	9.43	2019	7.799	2020	243
Journal of Accounting and Economics	3.723	2020	6.607	2020	151
Journal of Knowledge Management	4.745	2020	1.841	2020	113
Contemporary Accounting Research	2.026	2019	2.769	2020	99
Accounting Review	3.993	2020	5.678	2020	156
Journal of Finance	6.813	2020	18.151	2020	299
Strategic Management Journal	7.859	2020	11.035	2020	286

Academy of Management Journal	7.525	2020	11.193	2020	318
Journal of Management	8.08	2017	7.491	2020	224
Academy of Management Review	8.365	2020	8.446	2020	270
Thesis Eleven	NR	NR	0.424	2020	28
Sustainability	2.576	2019	0.612	2020	85
Review of Accounting Studies	2.35	2018	4.418	2020	74
Journal of Business Research	4.874	2020	2.049	2020	195
Journal of Product and Brand Management	1.832	2020	0.982	2020	81
Industrial Marketing Management	4.695	2020	2.022	2020	136
Procedia - Social and Behavioral Sciences	NR	NR	0.158	2020	53
Service Industries Journal	1.92	2020	1.177	2020	66
Journal of Loss Prevention in the Process Industries	2.795	2020	0.881	2020	79
Expert Systems with Applications	5.452	2020	1.368	2020	207

JCR: Journal Citation Reports: SJR: Scimago Journal Rank; NR: not reported.

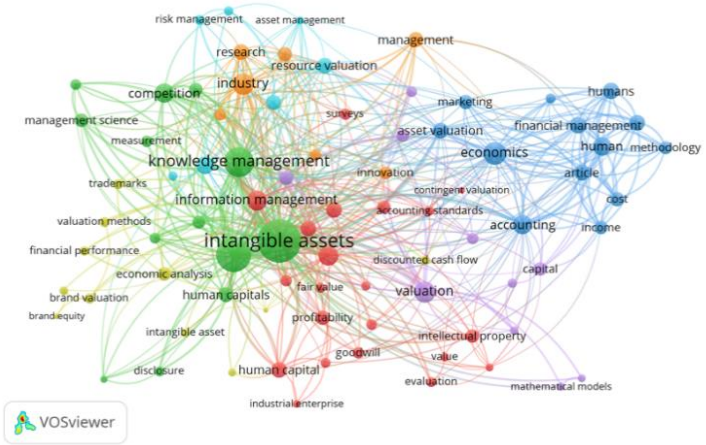
3.2.3 Co-occurrence and keyword analysis

The present study was based on the keywords listed by the authors because this technique counts the number of articles in which two keywords appear together.

In the Scopus equation, 82 words were obtained out of 1,955 words used and with a minimum word threshold of 5 occurrences. The texts showed that as the weight of the word increased, the label and circle increased, and as the distance between nodes became shorter, the relationship between the keywords was stronger. The labels and circles in an article are determined by its weight; the label and circle of the article are larger as weight increases (Roldán, 2019). The strongest word connections and the 500 most representative connections were selected. The most frequently used words were intangible assets, intellectual capital, knowledge management, valuation, economics, accounting, and financial management (Figure 6).

Figure 6

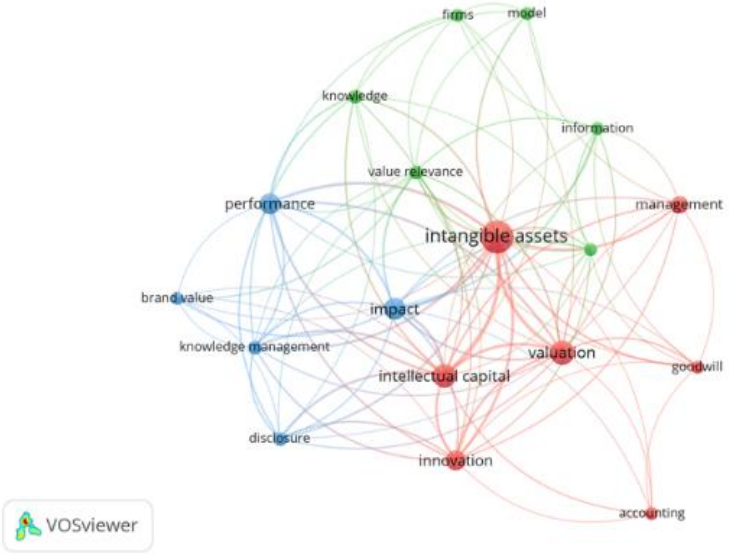
Nodes recorded in the keywords: Scopus.



The analysis of the WoS database resulted in 18 words out of 556 and with a threshold of 5 occurrences. The most frequently used words were intangible assets, valuation, intellectual capital, impact, performance, innovation, whereas the least frequently used were firms, model, information, goodwill, accounting, brand value, and research and development (Figure 7).

Figure 7

Nodes recorded in the keywords: Web of Science (WoS).



It is important to mention the definitions of the keywords used in the systematic analyses. Table 4 shows the two main concepts addressed by the authors in the consulted documents.

Table 4

Definitions of main keywords in the Web of Science (WoS) and Scopus analysis of the search equations

Concept	Author(s)	Definition
Intangible assets	Cavalcanti et al. (2020) (Francioli & Albanese, 2017) Park (2019) Rodionov et al. (2020) Green (2007)	Intangible assets are all assets that are not physical in nature, under company control, and from which future economic benefits are expected. Intangible assets must comply with certain characteristics to be classified as such: they are not of a physical or tangible nature, have a legal existence, are evidence-based, have tangible backing, generate economic benefits, and are subjected to a limited or defined existence over time.
Intellectual capital	Becerra et al. (2020) Hasprová et al. (2018) Osinski et al. (2017) (Lima & Carmona, 2011) Derum & Mysaka (2020)	Intellectual capital is an intangible asset of organizations and consists of human capital, relational capital, and structural capital. This asset represents all those resources related to experience, employee knowledge, organizational processes, skills,

Loyarte et al. (2018)	management tools, and innovation within an organization; it can be measured to increase company value.

Based on these definitions, it can be deduced that there is usually a consensus definition of the concept of intangible assets; however, it is still very general and broad, which leads authors and companies to encounter multiple aspects when valuing them, as shown in Table 4. Intellectual capital is one of the main intangible assets that is valued and results from knowledge transformation. Intellectual capital is highly valued by companies because it is regulated by the International Financial Reporting Standards (IFRS) and the IAS-38 International Accounting Standard (International Accounting Standards Board, IASB, 2004, p. 38), which make its valuation more effective. Another reason is that knowledge-based assets are characterized as being costly to acquire and develop and are difficult to manage; therefore, organizations and researchers strive to find methods that enable them to value intellectual capital to ensure their continuity and economic benefits.

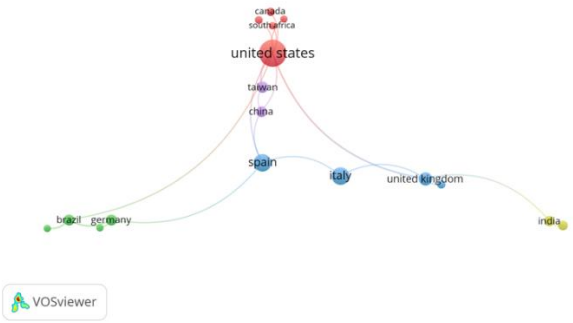
3.2.4 Co-authorship analysis by country

This analysis illustrated the structure of co-authorship and research collaboration between countries; it also showed the collaborative work between research teams. The distance between nodes and their thickness indicated the degree of collaboration between countries. All the analyses recorded a minimum of five documents per country.

For Scopus, 23 articles met the selection threshold and 17 exhibited the strongest connections among the group, including the United States as the main node with 71 articles, followed by Spain and Italy with 30 articles each (Figure 8).

Figure 8

Nodes by country for Scopus



A systematic analysis was performed after the bibliometric analysis, which considered the lens review. This analysis was based on (Viero & Trojan, 2020) and considered the following lenses: approach, uniqueness, identity process, measurement, integration, and management. The lens review according to the ProKnow-C methodology focused on analyzing the selected documents (61 articles) from which the most representative were selected, that is, those corresponding to the first and second quartiles of the total number of article citations. This finally resulted in 6 articles for the WoS and 13 for the Scopus databases.

Table 5 summarizes the main models applied in intangible asset valuation for the articles with the highest number of citations.

Table 5

Summary of the most used models in intangible asset valuation

Authors and year	Methodology	Intangible asset being valued
Ginesti et al. (2018)	Empirical model	Human capital
Jordão & Almeida (2017)	Theoretical empirical model	Intellectual capital
Bagna et al. (2017)	Theoretical empirical model	Brand
Hasprová et al. (2018)	Empirical model	Research and innovation
Ievdokymov et al. (2020)	Theoretical model	Social capital
Podhorska et al. (2019)	Empirical model	Goodwill

Given the results in Table 5, it can be established that most of the models used to value intangibles are empirical; these models are based on linear regressions in most of the analyzed articles. A large number of these documents (47%) focus on the valuation of intellectual/social/human capital as the main intangible asset in companies, followed by

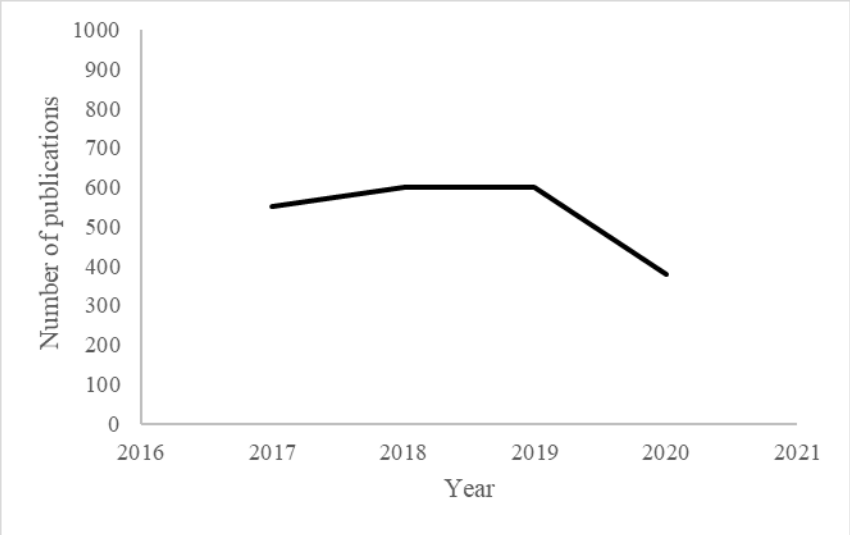
research and development (21%) and brand (16%). This behavior reflects the fact that companies need to rigorously examine their processes and functions to codify business intelligence, simulate processes, model activity, and define attributes aligned with performance. Within the framework of the knowledge era, all this explains the necessity to value the intellectual, social, and human capital of the organization (Andreou et al., 2007). Companies are interested in valuing intellectual capital and knowledge, which directly advance company development, and create the need to also value intangible assets related to research and development (Bandera et al., 2017), which was the second best valued intangible in the reviewed article. As for brand valuation, it is relevant in the current globalization context and urgency to create value, which has been directly linked to the brand. Davison (2009) indicated that approximately 40% of the market value of companies is attributable to the brand.

3.2.5 Intangible environmental assets

Intangible environmental assets were also analyzed with the search equation in the lens.org platform. According to this platform, there have been 2130 scientific article publications on intangible environmental assets in the 5-year period from 2017 to 2021; Figure 9 illustrates this trend. There was a growing trend from 2017 to 2019 for this type of publications; however, there has been a decline in the number of published articles on this topic since 2020. This could be explained by less research due to the COVID-19 pandemic, which has generally affected these processes. Given the importance of this topic in the current context of global warming, the trend is expected to increase again based on the statistical trends provided by the BRE Environmental Assessment Method platform (BREEAM https://breeam.es/), which indicates that the number of companies starting to value their environmental assets has increased by approximately 20% each year.

Figure 9

Publications on the topic of intangible environmental assets in the 5-year period from 2017 to 2021



The countries with the highest number of publications on intangible environmental assets are the United Kingdom with 601 (Figure 10), followed by the United States with 125. This is explained by the high number of regulations regarding environmental issues that the United Kingdom has for companies (Table 6). Companies must quantify the amount of packaging, industrial waste, environmental pollutants, and aquifers they produce, and they must pay certain taxes and fines if the limits established by the government are exceeded. For example, if a company bills more than 2 million pounds per year and handles more than 50 tons of packaging per year, it must register with the environmental regulatory body or adhere to an approved compliance plan. The institution with the most publications on the topic is Durham University in England (Figure 11); it has research centers that cover these topics, including the Durham Energy Institute, Centre for Culture and Ecology, and El Shaarani Centre for Ethical Finance, Accountability and Governance.

Figure 10

The most active countries for publications related to intangible environmental assets in the 5-year period from 2017 to 2021

Table 6

Government-controlled aspects of environmental issues for companies in the United Kingdom

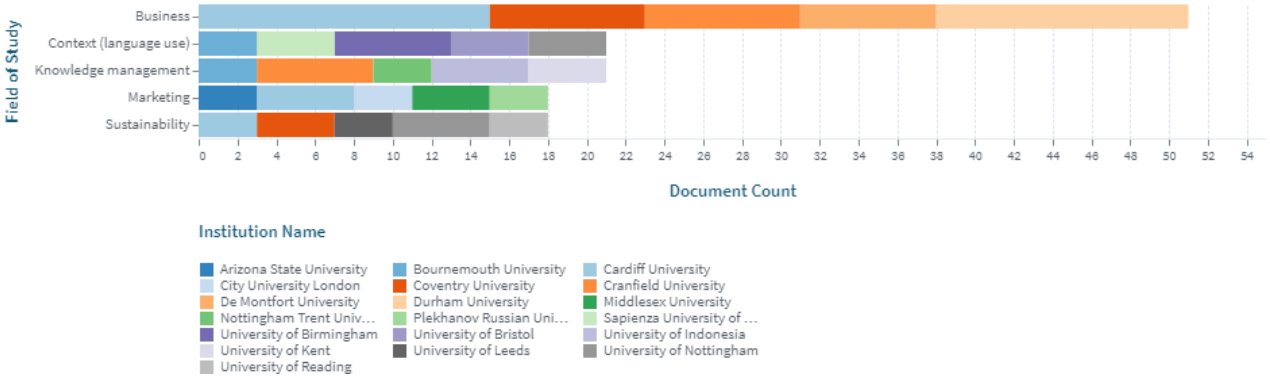
Aspect that is controlled	Explanation
Land use and exploitation: Environmental Protection Act (1974)	Includes regulations regarding environmental conservation, pollution generated by agro-industrial companies, and responsibility for harm to the environment caused by companies. Requires the filing of a planning permit for constructions or modifications to buildings.
Waste management	Responsibility for waste management includes its safe storage and removal by an authorized organization.
Chemical products	British legislation on chemical products covers the use, storage, transport, packaging, labeling, and disposal of chemical products and other substances that can harm the environment. It also covers the necessary qualifications to use certain chemical products and measures to control the risk of major accidents involving hazardous substances
Water and aquifers	It is an offence to discharge any substance into surface or groundwater without the consent of the Environment Agency. The discharge of harmful substances into groundwater, including pesticides, herbicides, and solvents, is controlled by groundwater regulations.
Air: article 2 of Health and Safety at Work etc. Act 1974	Companies have legal obligations regarding air pollution and the creation of a safe work environment.
Noise: Control of Pollution Act 1974	The main legal obligations apply when noise exposure in a company equals or exceeds certain action values, specifically 80 to 85 decibels over the course of the workday or week. There are also values for the maximum or peak noise to which employees can be exposed. However, the main

	objective is control through good practices rather than measurement.
Licenses and permits	Some business activities require special authorizations, such as licenses, permits, and consents. These are usually obtained from the Environment Agency, but local authorities and water companies are responsible for some authorizations. To prevent water pollution, the environmental permits control the discharges in surface and groundwater. The Environment Agency must grant extraction licenses when large amounts of water from surface or groundwater are used.

Retrieved September 29, 2021 from https://www.legislation.gov.uk/all?theme=environment

Figure 11

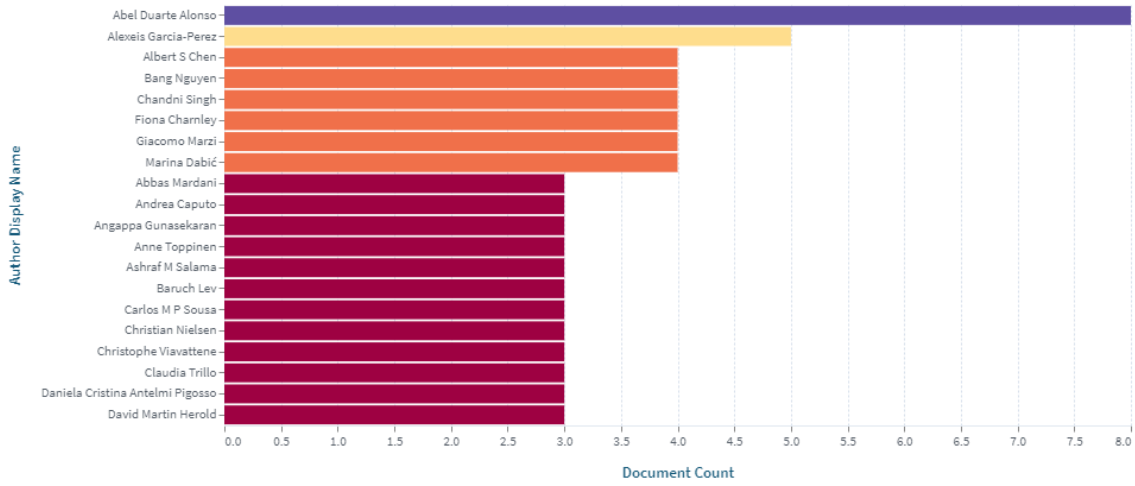
Institutions with publications on environmental assets and fields of study



The most relevant author with the highest number of publications on environmental assets was Duarte Alonso, who had an i10-index of 92 in Google Scholar and 3,585 citations. This author is dedicated to conducting research in wine companies and on sustainability.

Figure 12

Most relevant authors and number of publications on environmental asset topics in the 5-year period from 2017 to 2021.



3.2.6 Relationship between intellectual capital and environmental assets

One of the intangible assets valued by companies is intellectual capital. Although in appearance it differs from environmental asset valuation, some relationships have been established between the two that would allow companies to value both assets. Popescu (2020) indicated that the knowledge of workers is essential when assessing the positive impact of companies, that is, whose principles are consistent with their life projects, especially those related to sustainability and environmental care. In addition, the Internet currently plays a very important role because this is where virtual businesses can promote aspects of innovation and environmental sustainability by using these office automated tools and stimulating within the company values related to good health, recycling, wellbeing, and environmental care, which ultimately have an impact on the happiness of workers and generate enhanced productivity, job satisfaction, and employee retention (Perrini & Vurro, 2010).

3.2.7 Environmental asset valuation

This topic becomes relevant when considering the “Carbon Disclosure Project”, which focuses on the implications and risks of climate change for organizations (operations and stakeholders) (Song et al., 2018).

Several environmental assets have been identified. One of the most valued articles published on the topic is by (Y.-S. Chen & Chang, 2013), who reported the following:

- the productivity and contribution of companies to environmental protection
- employee competence in terms of environmental protection within the company
- quality of sustainable products or services offered by the company
- employee training in environmental protection
- company environmental protection management systems
- innovation in environmental protection
- extent of teamwork cooperation in environmental protection
- managerial leadership in environmental management
- investment in environmental protection facilities
- overall operational processes for environmental protection
- environmental management information systems
- environmental management databases
- environmental knowledge management systems.

Carbon is one of the most evaluated and researched environmental assets. Jiang et al. (2014) proposed a model for valuing intangible carbon emission assets; they highlighted the importance of valuing carbon as an intangible asset because it allows the management and development of company value.

Yuguo et al. (2021) evaluated how low carbon emissions are related to the competitiveness of companies; they proposed a multidimensional valuation approach that includes the realistic, sustainable, and unique value of each intangible carbon asset. Finally, they found that low carbon emissions and their valuation as an intangible asset benefit and improve the competitiveness of Chinese companies that were the basis for their study. Loyarte-López et al. (2020) established a relationship between the environmental effects and R&D activities in a research center and how this can contribute to sustainable development. The authors measured greenhouse gases and calculated the carbon footprint in all the processes of the center related to intangible assets, such as knowledge of the personnel working in the center, projects being executed, and published documents. They also calculated the environmental impact based on ISO 14001:2015; they were able to determine which intangible assets had the greatest environmental impact and the highest carbon footprint so as to create improvement plans that aim to reduce their emissions.

In summary, the most commonly used models for valuing intangible assets are empirical, mainly based on linear regressions (47% of the documents analyzed). The most valued intangible asset is intellectual capital, including human, relational and structural capital

(52% of the studies). It is followed in importance by research and development (21%) and brand (16%).

In terms of intangible environmental assets, the most valued asset is carbon, through carbon footprint and emissions. However, no comprehensive environmental asset valuation models applicable to companies were found.

3.3 RESEARCH OPPORTUNITIES

Although several models were identified for intangible asset valuation, their heterogeneity is evident; therefore, there is no single model that can be applied on a global scale. Up to the search cutoff date, there were no models that had been developed to determine intangible assets of an environmental nature. This creates the opportunity for research to perform these valuations in the current context of the green revolution with the aim of helping companies to identify the possibility of generating value in relation to their environmental practices.

According to Osinski et al. (2017), more empirical models are required to compare the valuation of intellectual capital. It is necessary to develop more innovative models related to new technologies that overcome the current barriers of insufficient financial information of organizations based on traditional methods (Andreou et al., 2007; Atalay et al., 2018b).

There is evidence of some studies of this type applied to different countries; however, it is necessary to develop empirical models that consider variables that are specific to different industries and regions and with more precise indicators adjusted to each particular case, including market volatility and the risks it entails for organizations (Carlbäck, 2019; Cavalcanti et al., 2020; Cordazzo & Rossi, 2020).

Sustainability refers to the management of current resources in such a way that they can be used by future generations; it includes economic, social, and environmental dimensions (Alshubiri et al., 2020; Duarte Alonso et al., 2021). Companies that use sustainability assessment procedures, including the environmental dimension, have a positive effect on the decision making process and are more highly valued (Popescu, 2020). However, there are gaps in environmental asset valuation and how to apply it to companies. Until now the most valued environmental asset is carbon, which is easily evaluated through its carbon footprint, emissions, and environmental impact. However, further research is required to develop comprehensive models for valuing environmental assets that can be applied to companies with the aim of

improving their competitiveness and impact on the market and ensuring sustainable development.

3.4 LIMITATIONS

Although this study performs a broad bibliometric and systematic review of the literature on intangible asset valuation, it has some limitations that open up opportunities for future research:

1. The inclusion criteria focused on valuation models, excluding other complementary approaches to intangible asset analysis. Future studies could adopt broader criteria and include other methodologies.
2. Environmental intangible assets were only analyzed in a cursory manner, identifying this as an area still little explored. Research is needed that focuses exclusively on developing comprehensive models for the valuation of a wide range of environmental intangible assets.
3. The sample was limited to articles in English and Spanish. Expanding to other languages could enrich the findings.
4. The study is based entirely on bibliometric analysis of existing literature. To complement this, empirical studies could be conducted by applying valuation models to real companies.

In this way, future research could address these limitations, generating more comprehensive knowledge on valuation of environmental intangibles and standardized models to be adopted in the business environment.

4 CONCLUSIONS

The objective of the present study focused on identifying the main models of intangible asset valuation (empirical and theoretical models), especially environmental (carbon emission evaluation models). The Knowledge Development Process-Constructivist (Proknow-C) methodology was used to identify 61 articles in the Web of Science (WoS) and Scopus databases and the lens.org platform, which were used to analyze documents that addressed environmental assets.

As for co-authorship, documents included from 1 to 25 authors. The countries with the greatest publication impact on intangible asset valuation were Spain, Italy, the United States,

and Russia. The keywords or concepts that emerged in the systematic analysis included assets, intellectual capital, knowledge management, valuation, economics, accounting, and financial management.

Most intangible assets were valued by empirical models; intellectual, social, and human capital were identified as the most valued assets, followed by research and development and the brand. As for environmental assets, there is evidence that there were some comprehensive models to value them, but most focused on carbon. Thus, a field of research is identified that has the potential for developing models that value other environmental assets. It could be useful for companies choosing to quantify this type of assets given the advantages they can offer at the competitive level, increase company value, and improve communication with stakeholders.

The authors recognize that the study has limitations related to biases in the filtering of articles, language, and access, in addition, the inclusion of other databases and types of publications could be relevant to this topic.

ACKNOWLEDGMENTS

We wish to thank the Universitat de València and the Ayuntamiento de Valencia for the Juan Castelló Doctoral Scholarship and the XV Congreso Iberoamericano de Control de Gestión where this work was presented. We also thank Doctor Iván Andrés Ordoñez Castro for his feedback and recognition of the study. This study was funded by the Corporación Universitaria Remington, Colombia and the Universidad de Valencia, Spain.

REFERENCES

Ademar, D., Vicente, M. R. F., Sandra, R. E., Leonardo, E., & Luis, R. P. G. ccedil alves. (2015). Opportunities for research on evaluation of seaport performance: A systemic analysis from international literature. African Journal of Business Management, 9(20), 704–717. https://doi.org/10.5897/AJBM2015.7833

Adetoro, A. A., Ngidi, M., Nyam, Y. S., & Orimoloye, I. R. (2021). Temporal evaluation of global trends in water footprint, water sustainability and water productivity research. Scientific African, 12, e00732. https://doi.org/10.1016/j.sciaf.2021.e00732

Adom, P. K., Amuakwa-Mensah, F., & Amuakwa-Mensah, S. (2020). Degree of financialization and energy efficiency in Sub-Saharan Africa: Do institutions matter? Financial Innovation, 6(1), 33. https://doi.org/10.1186/s40854-020-00192-3

Alshubiri, F. N., Tawfik, O. I., & Jamil, S. A. (2020). Impact of petroleum and non-petroleum indices on financial development in Oman. Financial Innovation, 6(1), 15. https://doi.org/10.1186/s40854-020-00180-7

Andreou, A. N., Green, A., & Stankosky, M. (2007). A framework of intangible valuation areas and antecedents. Journal of Intellectual Capital, 8(1), 52–75. https://doi.org/10.1108/14691930710715060

Atalay, B., Gokten, S., & Turkcan, M. (2018a). An Overview of Measuring and Reporting Intellectual Capital. In H. Dincer, Ü. Hacioglu, & S. Yüksel (Eds.), Global Approaches in Financial Economics, Banking, and Finance (pp. 369–388). Springer International Publishing. https://doi.org/10.1007/978-3-319-78494-6_18

Atalay, B., Gokten, S., & Turkcan, M. (2018b). An Overview of Measuring and Reporting Intellectual Capital. In H. Dincer, Ü. Hacioglu, & S. Yüksel (Eds.), Global Approaches in Financial Economics, Banking, and Finance (pp. 369–388). Springer International Publishing. https://doi.org/10.1007/978-3-319-78494-6_18

Babajee, R. B., Seetanah, B., & Nunkoo, R. (2020). The determinants of hotel financial performance: An intellectual capital perspective. Journal of Hospitality Marketing & Management, 29(8), 1008–1026. https://doi.org/10.1080/19368623.2020.1703870

Bagna, E., Dicuonzo, G., Perrone, A., & Dell'Atti, V. (2017). The value relevance of brand valuation. Applied Economics, 49(58), 5865–5876. https://doi.org/10.1080/00036846.2017.1352078

Bandera, C., Keshtkar, F., Bartolacci, M. R., Neerudu, S., & Passerini, K. (2017). Knowledge management and the entrepreneur: Insights from Ikujiro Nonaka's Dynamic Knowledge Creation model (SECI). International Journal of Innovation Studies, 1(3), 163–174. https://doi.org/10.1016/j.ijis.2017.10.005

Becerra, M., Londoño, E., Serna, L., Peluffo, D., Tobón, C., & Giraldo, L. (2020). Modelo de capital estructural para Universidades basado en el modelo de fusión. Iberian Journal of Information Systems and Technologies, 29, 465–478.

Carlbäck, M. (2019). Brand Value Attributable to Affiliation (BVAA) – a Method for Measurement in a Consortium Context. 16.

Cavalcanti, J., Amaral, H., Correia, L., & Roma, C. (2020). Do intangible assets matter to financial analysts in the Brazilian stock market? Review of Business Management, 22(Special Issue), 518–538. https://doi.org/10.7819/rbgn.v22i0.4063

Chen, T.-L. G., & Ramaboa, K. K. K. M. (2017). Evidence of mispricing for South African listed R&D firms contributed by accounting conservatism. Intangible Capital, 13(2), 411. https://doi.org/10.3926/ic.880

Chen, Y.-S., & Chang, C.-H. (2013). Enhance environmental commitments and green intangible assets toward green competitive advantages: An analysis of structural equation modeling (SEM). Quality & Quantity, 47(1), 529–543. https://doi.org/10.1007/s11135-011-9535-9

Ciprian, G. G., Valentin, R., Mădălina, G. (Iancu) A., & Lucia, V. (Vlad) M. (2012). From Visible to Hidden Intangible Assets. Procedia - Social and Behavioral Sciences, 62, 682–688. https://doi.org/10.1016/j.sbspro.2012.09.116

Cordazzo, M., & Rossi, P. (2020). The influence of IFRS mandatory adoption on value relevance of intangible assets in Italy. Journal of Applied Accounting Research, 21(3), 415–436. https://doi.org/10.1108/JAAR-05-2018-0069

Davison, J. (2009). Icon, iconography, iconology: Visual branding, banking and the case of the bowler hat. Accounting, Auditing & Accountability Journal, 22(6), 883–906. https://doi.org/10.1108/09513570910980454

de Carvalho, G. D. G., Sokulski, C. C., da Silva, W. V., de Carvalho, H. G., de Moura, R. V., de Francisco, A. C., & da Veiga, C. P. (2020). Bibliometrics and systematic reviews: A comparison between the Proknow-C and the Methodi Ordinatio. Journal of Informetrics, 14(3), 101043. https://doi.org/10.1016/j.joi.2020.101043

Derum, I., & Mysaka, H. (2020). Intellectual Capital Efficiency Management in Professional Football Clubs' Performance: Problems of Assessment. Sport Mont, 18(2). https://doi.org/10.26773/smj.200606

Duarte Alonso, A., Bressan, A., Kiat Kok, S., & O'Brien, S. (2021). Filling up the sustainability glass: Wineries' initiatives towards sustainable wine tourism. Tourism Recreation Research, 1–15. https://doi.org/10.1080/02508281.2021.1885801

Francioli, F., & Albanese, M. (2017). The evaluation of core competencies in networks: The network competence report. Journal of Intellectual Capital, 18(1), 189–216. https://doi.org/10.1108/JIC-01-2016-0014

Ginesti, G., Caldarelli, A., & Zampella, A. (2018a). Exploring the impact of intellectual capital on company reputation and performance. Journal of Intellectual Capital, 19(5), 915–934. https://doi.org/10.1108/JIC-01-2018-0012

Ginesti, G., Caldarelli, A., & Zampella, A. (2018b). Exploring the impact of intellectual capital on company reputation and performance. Journal of Intellectual Capital, 19(5), 915–934. https://doi.org/10.1108/JIC-01-2018-0012

Green, A. (2007). Intangible assets in plain business language. VINE, 37(3), 238–248. https://doi.org/10.1108/03055720710825564

Hanson, W. (1988). Mobilizing invisible assets: Hiroyuki Itami with Thomas W. Roehl, (Harvard University Press, Cambridge, MA, 1987) pp. Xi+186, $20.00. Journal of Economic Behavior and Organization, 10, 457–459.

Hasprová, O., Brabec, Z., & Rozkovec, J. (2018). Intangible assets disclosed by public universities in Czech Republic. Journal of International Studies, 11(1), 67–79. https://doi.org/10.14254/2071-8330.2018/11-1/5

Ievdokymov, V., Lehenchuk, S., Zakharov, D., Andrusiv, U., Usatenko, O., & Kovalenko, L. (2020). Social capital measurement based on "The value explorer" method. Management Science Letters, 1161–1168. https://doi.org/10.5267/j.msl.2019.12.002

ISO 14001:2015, (2015).

Jiang, Y., Fan, L., Yu, Y., & Shi, G. (2014). Research on the Evaluation of Carbon-Intangible Assets in Business Based on Internal Value Network. Low Carbon Economy, 05(04), 172–179. https://doi.org/10.4236/lce.2014.54017

Jordão, R. V. D., & Almeida, V. R. de. (2017). Performance measurement, intellectual capital and financial sustainability. Journal of Intellectual Capital, 18(3), 643–666. https://doi.org/10.1108/JIC-11-2016-0115

Lima, A. C., & Carmona, C. U. (2011). Ddeterminantes da formação do capital intelectual nas empresas produtoras de tecnologia da informação e comunicação. SÃO PAULO, 12(1), 27.

Loyarte, E., Garcia-Olaizola, I., Marcos, G., Moral, M., Gurrutxaga, N., Florez-Esnal, J., & Azua, I. (2018a). Model for calculating the intellectual capital of research centres. Journal of Intellectual Capital, 19(4), 787–813. https://doi.org/10.1108/JIC-01-2017-0021

Loyarte, E., Garcia-Olaizola, I., Marcos, G., Moral, M., Gurrutxaga, N., Florez-Esnal, J., & Azua, I. (2018b). Model for calculating the intellectual capital of research centres. Journal of Intellectual Capital, 19(4), 787–813. https://doi.org/10.1108/JIC-01-2017-0021

Loyarte-López, E., Barral, M., & Morla, J. C. (2020). Methodology for Carbon Footprint Calculation Towards Sustainable Innovation in Intangible Assets. Sustainability, 12(4), 1629-. https://doi.org/10.3390/su12041629

Manikas, A. S., Patel, P. C., & Oghazi, P. (2019). Dynamic capital asset accumulation and value of intangible assets: An operations management perspective. Journal of Business Research, 103, 119–129. https://doi.org/10.1016/j.jbusres.2019.06.014

Miklosik, A., & Evans, N. (2021). Environmental sustainability disclosures in annual reports of mining companies listed on the Australian Stock Exchange (ASX). Heliyon, 7(7), e07505. https://doi.org/10.1016/j.heliyon.2021.e07505

Osinski, M., Selig, P. M., Matos, F., & Roman, D. J. (2017). Methods of evaluation of intangible assets and intellectual capital. Journal of Intellectual Capital, 18(3), 470–485. https://doi.org/10.1108/JIC-12-2016-0138

Park, H. (2019). Intangible assets and the book-to-market effect: Intangible assets and the book-to-market effect. European Financial Management, 25(1), 207–236. https://doi.org/10.1111/eufm.12148

Perrini, F., & Vurro, C. (2010). Corporate Sustainability, Intangible Assets Accumulation and Competitive Advantage. Symphonya. Emerging Issues in Management, 2. https://doi.org/10.4468/2010.2.03perrini.vurro

Podhorska, I., Valaskova, K., Stehel, V., & Kliestik, T. (2019). Possibility of Company Goodwill Valuation: Verification in Slovak and Czech Republic. Management & Marketing. Challenges for the Knowledge Society, 14(3), 338–356. https://doi.org/10.2478/mmcks-2019-0024

Popescu, C. R. Gh. (2020). Sustainability Assessment: Does the OECD/G20 Inclusive Framework for BEPS (Base Erosion and Profit Shifting Project) Put an End to Disputes

Over The Recognition and Measurement of Intellectual Capital? Sustainability, 12(23), 10004. https://doi.org/10.3390/su122310004

Rodionov, D., Perepechko, O., & Nadezhina, O. (2020). Determining Economic Security of a Business Based on Valuation of Intangible Assets according to the International Valuation Standards (IVS). Risks, 8(4), 110. https://doi.org/10.3390/risks8040110

Roldán, N. M. (2019). ESTRATEGIAS PARA COMBATIR LA CORRUPCIÓN DESDE LA RESPONSABILIDAD SOCIAL EMPRESARIAL EN COLOMBIA. 109.

Song, Y., Wang, H., & Zhu, M. (2018). Sustainable strategy for corporate governance based on the sentiment analysis of financial reports with CSR. Financial Innovation, 4(1), 2. https://doi.org/10.1186/s40854-018-0086-0

UN. (2020). The Sustainable Development Goals Report. https://www.un.org/sustainabledevelopment/es/objetivos-de-desarrollo-sostenible/

Vieira, E. L., da Costa, S. E. G., de Lima, E. P., & Ferreira, C. C. (2019). Application of the Proknow-C Methodology in the Search of Literature on Performance Indicators for Energy Management in Manufacturing and Industry 4.0. Procedia Manufacturing, 39, 1259–1269. https://doi.org/10.1016/j.promfg.2020.01.343

Viero, A., & Trojan, F. (2020). Integration of quality tools and multi-criteria methods: A bibliometric and systemic analysis. Gestão & Produção, 27(3), e4358. https://doi.org/10.1590/0104-530x4358-20

Yuguo, J., Asante, D., Dan, C., & Jie, Z. (2021). Evaluation of Low-Carbon Competitiveness Based on a System Evaluation Method: A Case Study of Three Chinese Steel Companies. Mathematical Problems in Engineering, 2021, 1–13. https://doi.org/10.1155/2021/6664216