Trascender, Contabilidad y Gestión. Vol. 7, Núm. 21 (septiembre – diciembre del 2022).
Universidad de Sonora. Departamento de Contabilidad. México.
ISSN: 2448-6388. Reserva de Derechos 04-2015-04172070800-203.

To disclose or not to disclose? A bibliometric analysis of carbon disclosure

¿Divulgar o no divulgar? Un análisis bibliométrico de la divulgación de carbono

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Recibido: 18 de diciembre de 2021.

Aceptado: 20 de mayo de 2022.

DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178

JEL: M14. Cultura corporativa.

Q56. Desarrollo y medio ambiente.

Abstract

Interest in the problem of climate change has increased throughout the world, mainly in the carbon emissions. The objective of this work is identify authors, articles, journals and findings in the literature of disclosure of carbon. To do this, we use a review approach systematic review of literature using the technique of bibliometric study to identify some aspects relevant in the literature. With software support like VOSviewer and biblioshiny from RStudio, we analyze production by year, authors, articles and magazines more cited. We present the main advances in the knowledge of carbon disclosure, as well as the most used concepts. In addition, we develop conceptualization of carbon

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disclosure proposed by Borghei (2021) focused on six areas and main trends of the field: (i) Answer strategic climate; (ii) Determinants of carbon disclosure; (iii) Carbon Accounting; (iv) Carbon Disclosure Guarantee; (v) Quality of carbon disclosure; and (vi) Consequences of the carbon Disclosure. We reached a consensus on the concept of carbon disclosure, in addition to the mentioned conceptualization of Borghei (2021), we mainly highlight (i), (iv) and (v) for future research in management on the subject of disclosure of carbon.

Keywords: *carbon disclosure, analysis bibliometric, climate change.*

Resumen

El interés en el problema del cambio climático ha aumentado en todo el mundo, principalmente en las emisiones de carbono. El objetivo de este trabajo es identificar los autores, artículos, revistas y hallazgos principales en la literatura de la divulgación de carbono. Para ello, utilizamos un enfoque de revisión sistemática de literatura empleando la técnica de estudio bibliométrico para identificar algunos aspectos relevantes en la literatura. Con el apoyo de softwares como VOSviewer y biblioshiny de RStudio, analizamos la producción por año, autores, artículos y revistas más citadas. Presentamos los principales avances en el conocimiento de la divulgación de carbono, así como los conceptos más utilizados. Además, desarrollamos la conceptualización de la divulgación de carbono propuesta por Borghei (2021) enfocada en seis áreas y tendencias principales del campo: (i) Respuesta climática estratégica; (ii) Determinantes de la divulgación de carbono; (iii) Contabilidad de carbono; (iv) Garantía de divulgación de carbono; (v) Calidad de la divulgación de carbono; y (vi) Consecuencias de la divulgación de carbono. Llegamos a un consenso sobre el concepto de divulgación de carbono, además, de la mencionada conceptualización de Borghei (2021), destacamos principalmente la (i), (iv) y (v) para futuras investigaciones en gestión sobre el tema de divulgación de carbono.

Palabras clave: divulgación de carbono, análisis bibliométrico, cambio climático.

Introduction

In the last couple of decades, interest in the problem of climate change has increased considerably by companies around the world, particularly in the emissions of Greenhouse Gases (GHG), (Delmas et al., 2015; Kolk et al., 2008) of which, carbon emissions are considered the most damaging to the planet carried out by human economic activities (Kolk et al., 2008). However, one of the major problems is that emission reporting is still voluntarily communicated by companies.

These voluntary characteristic contrasts, for example, with financial information, which is mandatory in countries that have adopted quality standards for accounting and financial information, such as the International Financial Reporting Standards (IFRS). These financial standards allow increasing the transparency and comparability of financial information between peer companies, which means that the stakeholders of the companies can make better-informed financial and investment decisions (Chen et al., 2013). In this way, Carbon Disclosure (CD) represents a challenge for researchers in measuring its progress and impacts.

The literature on CD, although recent, is extensive, mostly in developed economies. Its origins can be

detected in the accounting literature where financial reports gave entry to aspects of measurement and reporting of emissions (Ascui, 2014; He et al., 2021; Stechemesser & Guenther, 2012). From this literature, carbon disclosure has emerged as an independent topic but still without clarity of the areas studied, definitions generated, and perspectives used (see exceptions Hahn et al., 2015; Velte et al., 2020).

Therefore, the aim of this work is to identify the main articles, authors, journals, and findings in the CD literature. Hence, a systematic literature review approach is used using the bibliometric study technique to identify some relevant aspects in the literature. In addition, we identify the main advances in the knowledge of the subject focusing on the conceptualization of CD proposed by Borghei (2021). Within the conceptualization proposed by Borghei (2021), there are six key areas, of which we highlight three of them as the most interesting and necessary for deepening management research: (i) Strategic climate response; (iv) Carbon Disclosure Assurance and (v) Quality of carbon disclosure. In addition to this, we present the scientific journals where the greatest contribution about CD is found. Finally, an integrative concept of carbon disclosure is developed based on the literature.

Carbon Disclosure Context (CD)

Based on efforts such as the agenda for 2030 proposed by the United Nations (UN) in which 17 Sustainable Development Goals (SDG) were proposed, efforts have been redoubled to maintain a sustainable world and the achieving of these goals could not be understood without business and government support. However, carbon disclosure is within the so-called non-financial reports and to date, it is a broad report that maintains a voluntary nature in most countries, which is why it is not possible to have accurate, complete, and transparent information by organizations around the world.

This voluntary practice of reporting on their carbon emissions and their reductions arose from the signing of the Kyoto protocol in 1997, which entered into force on February 16, 2005, and its main objective is to promote responses and business actions in the face of the problem of global warming (Lee et al., 2015). The Kyoto Protocol is an outcome of the United Nations Framework Convention on Climate Change (UNFCCC) that is celebrated every year since 1994, whose main objective is to "promote sustainable development by limiting and reducing GHG emissions, with the least possible adverse effects on economic relations, society and the environment, especially in developing countries" (Fernández & Fronti, 2005, p. 2). Currently 192 countries are within the Kyoto Protocol, including Mexico, who ratified it since 2000.

On the other hand, the last international agreement of great importance for carbon disclosure was celebrated in December 2015, at the 21st Conference of Parties (COP21) of the UNFCCC, where the main agreement between the nations that signed it is the to maintain an average increase in global temperature below 2 ° C (Rogelj et al., 2016). This agreement was ratified at the time by 55 parties that represent at least 55% of emissions worldwide. Today, the agreement is ratified by 187 parties out of a total of 197. Finally, in the same year of 2015, the United Nations (UN) approved the 2030 Agenda on sustainable development, which contains 17 Sustainable Development Goals (SDGs), of which the problem of the disclosure of carbon emissions by companies, cities and governments is found in goal number thirteen, called "action for the climate".

Based on these international agreements and the sustainable development agenda, various regulatory bodies around the world began to consider options that would help them control these emissions, as well as to

Vol. 7, núm. 21 / septiembre – diciembre del 2022
DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165

develop regulations for companies to report their carbon-related information (Jaggi et al., 2018). The organizations are clear that one of the most important objectives for companies is to be able to have a favorable carbon performance for the planet, achieving net carbon emissions. This is a long-term objective and the first step to achieve it is to achieve homogeneity in the disclosure of carbon emissions (Córdova-Román et al., 2021).

Method

The objective of this work is to represent through a series of bibliometric analyzes the knowledge that has been generated by the academic community about the carbon disclosure and the role that the private sector has played in the fight for the reduction of carbon emissions. Through a bibliometric analysis, the evolution of knowledge in a specific area or field can be captured in a brief and limited way, using quantitative bibliometric tools and content analysis.

Bibliometrics applies statistical methods to the study of scientific activity in a research field (Zupic & Čater, 2015). Bibliometric analysis combines two main procedures: performance analysis and scientific mapping. In the performance analysis, indicators are mainly seen that provide valuable information on the impact of the topic to be investigated through various types of analysis (e.g., frequency of words, citation analysis, count of publications per unit of analysis, etc.) (Pizzi et al., 2020). On the other hand, scientific mapping is mainly based on first- and second-generation relationship indicators and provides a spatial representation of how the elements of the bibliometric analysis are related to each other.

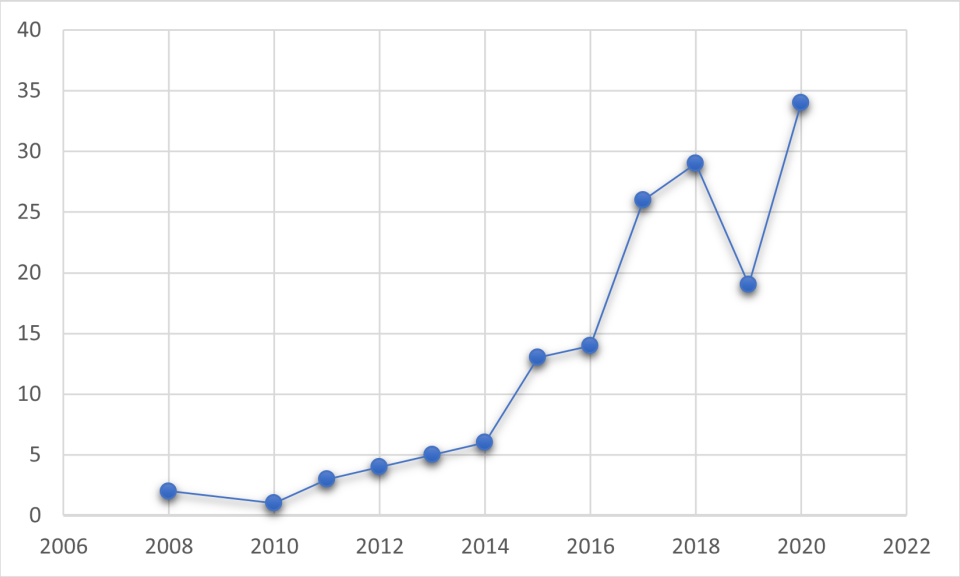
In the present analysis, the production per year, the most cited authors, the most cited papers and the most cited journals were used. These analyzes are the ones that were most appreciated during the course taught by colleagues from the Doctorate in Administrative Sciences. The main tools to obtain these indicators and maps were the VOSviewer software program (Van Eck & Waltman, 2010) and the biblioshiny in RStudio (Aria & Cuccurullo, 2017). The graphics represent a network of elements through circles, the size of which varies according to the importance of the element. The spatial position of the circles and the different colors are used to group the elements.

Descriptive results of the bibliometric analysis.

Through the present bibliometric analysis, it has been possible to better clarify the trend of the study in carbon disclosure by social science researchers, concerned with providing theoretical and practical implications to improve economic and sustainable development.

Graph 1

Production of articles per year



Source: Own elaboration through RStudio.

The first finding that could be found was the way in which the subject has grown year after year since its first appearance in what was in the registry of the data analyzed since 2008, with the only exception in 2019, where the documents published regarding it decreased. the previous year, but by 2020 he again propped up the issue. This statement can be better appreciated in graph 1.

The period analyzed includes from the year 2008, which was the first year in which a publication about carbon disclosure was registered in social sciences, specifically business, economics, administration, and ethics, to the current year, which is 2020. During this period, 178 articles published in different Web of Science (WOS) journals were analyzed. The average citation per article is 19.91 and per year and article is 4.31, which shows the way in which this topic is impacting the scientific community.

The most cited journal in the analysis was Business Strategy and The Environment (614), followed by British Accounting Review (377), Corporate Social Responsibility and Environmental Management (314) and European Accounting Review (307) (Table 1) which represent 51.6% of the total citations, which were 3,123, a fact that allows us to see that much of the discussion on carbon disclosure focuses on them. The density analysis of the journals is represented in Figure 1.

DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165

Table 1

Most cited journals

Journal	Cites	Papers
BUSINESS STRATEGY AND THE ENVIRONMENT	614	31
BRITISH ACCOUNTING REVIEW	377	8
CORPORATE SOCIAL RESPONSIBILITY AND ENVIRONMENTAL MANAGEMENT	314	10
EUROPEAN ACCOUNTING REVIEW	307	2
JOURNAL OF BUSINESS ETHICS	274	6
ACCOUNTING AUDITING \& ACCOUNTABILITY JOURNAL	244	4
ACCOUNTING REVIEW	228	2
STRATEGIC MANAGEMENT JOURNAL	127	1
JOURNAL OF INTERNATIONAL FINANCIAL MANAGEMENT \& ACCOUNTING	126	1
BUSINESS \& SOCIETY	69	2
M\&SOM-MANUFACTURING \& SERVICE OPERATIONS MANAGEMENT	68	1
AUSTRALIAN JOURNAL OF MANAGEMENT	58	2
AUSTRALIAN ACCOUNTING REVIEW	57	3
CONTEMPORARY ACCOUNTING RESEARCH	45	2
B E JOURNAL OF ECONOMIC ANALYSIS \& POLICY	45	1
ECOLOGICAL ECONOMICS	38	1
ACCOUNTING AND FINANCE	37	4
INTERNATIONAL JOURNAL OF OPERATIONS \& PRODUCTION MANAGEMENT	36	1
JOURNAL OF INTERNATIONAL ACCOUNTING RESEARCH	30	3
MANAGERIAL AUDITING JOURNAL	29	1

Source: Own elaboration through RStudio.

On the other hand, among 5 authors, they collected 43.2% of the citations of the total citations collected (4,409), which we can see in Table 2.

Also in figure 1, the density spheres represent the most cited journals in the same way, that the more citations they have, their sphere will become larger and predominant color.

Table 2

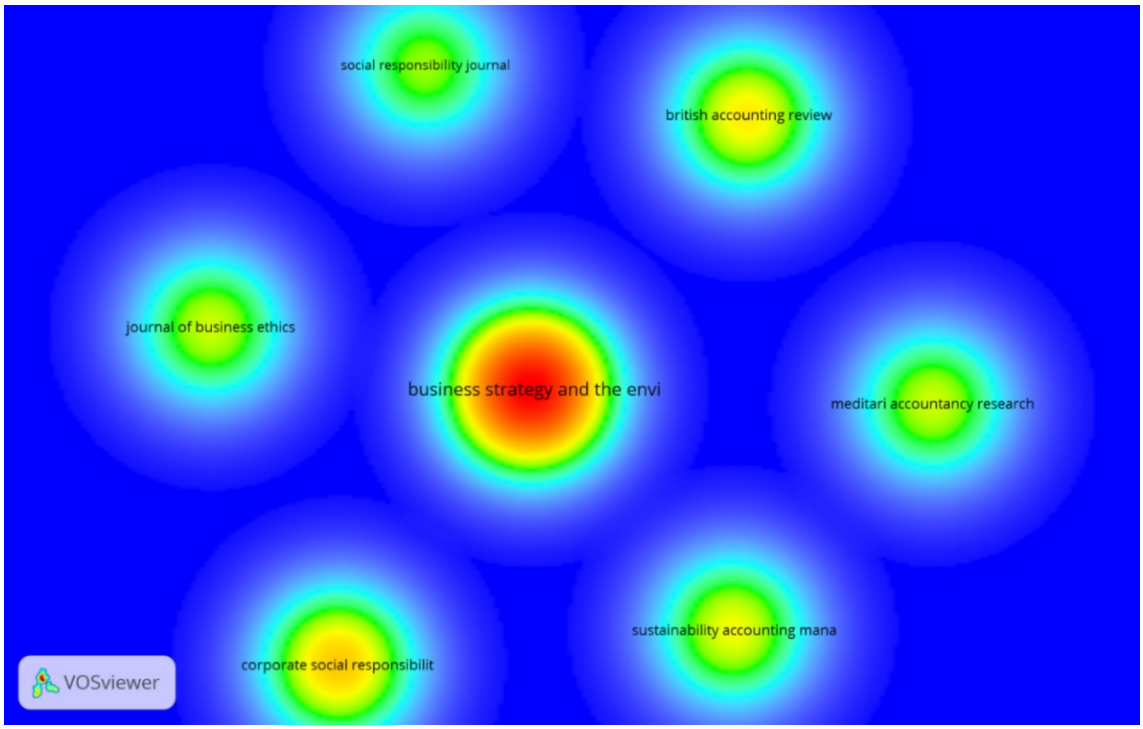
Most cited authors

Author	Cites	Documents
LUO L	499	15
TANG Q	489	14
KOLK A	306	1
LEVY D	306	1
PINKSE J	306	1

Source: Own elaboration through RStudio.

Figure 1

Density diagram of most cited journals



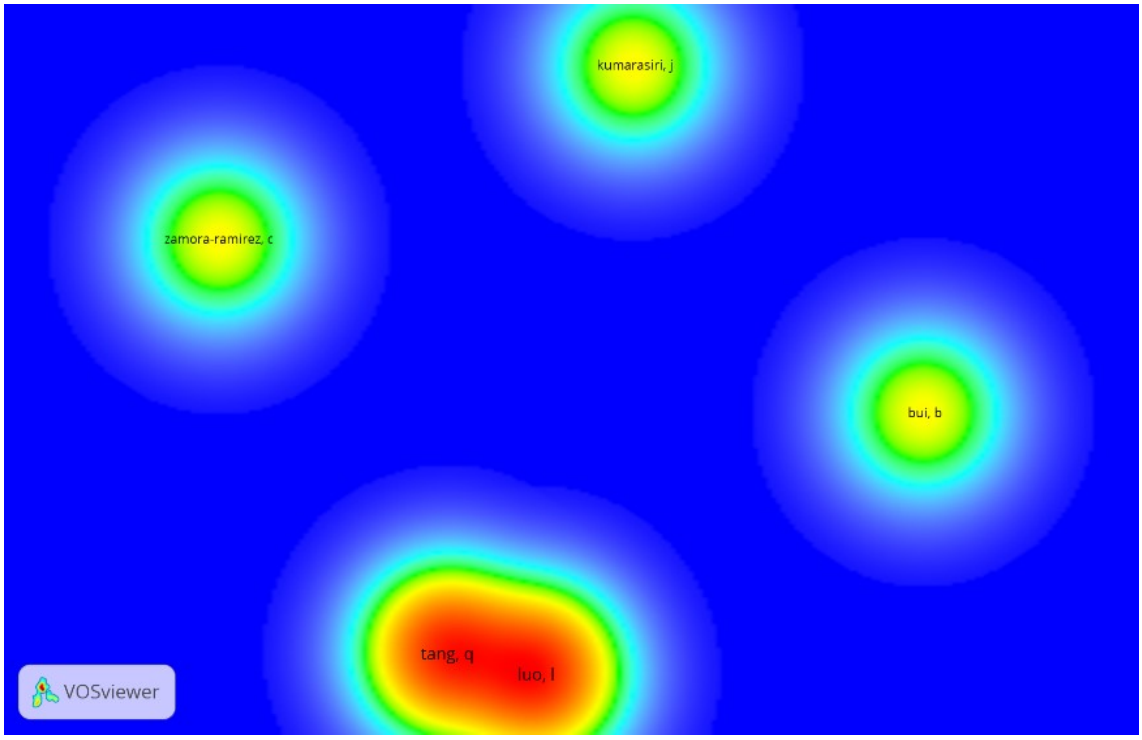
Source: Own elaboration through VOSviewer.

Figure 2 shows the density spheres of the most cited authors. This figure shows the creation of a cluster between the two authors most cited in table 2.

DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165

Figure 2

Density diagram of most cited authors



Source: Own elaboration through VOSviewer.

Finally, another issue to highlight within the bibliometric analysis carried out are the articles that have most influenced the literature on carbon disclosure. The top five most important articles collect a total of 1,050 citations (48%) of the total citations. These articles can be seen in table 3.

Table 3

Most cited articles about carbon disclosure.

Paper	DOI	Cites	Cites per year
KOLK A, 2008,	10.1080/09638180802489121	306	23.538
LIAO L, 2015,	10.1016/j.bar.2014.01.002	231	38.5
MATSUMURA EM, 2014,	10.2308/accr-50629	201	28.714
STANNY E, 2008,	10.1002/csr.175	181	13.923
WEINHOFER G, 2010,	10.1002/bse.618	131	11.909
RANKIN M, 2011,	10.1108/09513571111184751	128	12.8
LEWIS BW, 2014,	10.1002/smj.2127	127	18.143
LUO L, 2012,	10.1111/j.1467-646X.2012.01055.x	126	14
BEN-AMAR W, 2017,	10.1007/s10551-015-2759-1	108	27
STANNY E, 2013,	10.1002/bse.1732	76	9.5
LEE SY, 2015,	10.1002/csr.1321	74	12.333
JIRA CF, 2013,	10.1287/msom.1120.0420	68	8.5
ASCUI F, 2011,	10.1108/09513571111184724	64	6.4
MATISOFF DC, 2013,	10.1002/bse.1741	57	7.125
DEPOERS F, 2016,	10.1007/s10551-014-2432-0	56	11.2
COTTER J, 2012,	10.1177/0312896211423945	56	6.222
BEN-AMAR W, 2015,	10.1002/bse.1840	53	8.833
LI D, 2018,	10.1007/s10551-016-3187-6	51	17
JUNG J, 2018,	10.1007/s10551-016-3207-6	50	16.667
TANG Q, 2014,	10.1111/auar.12010	50	7.143

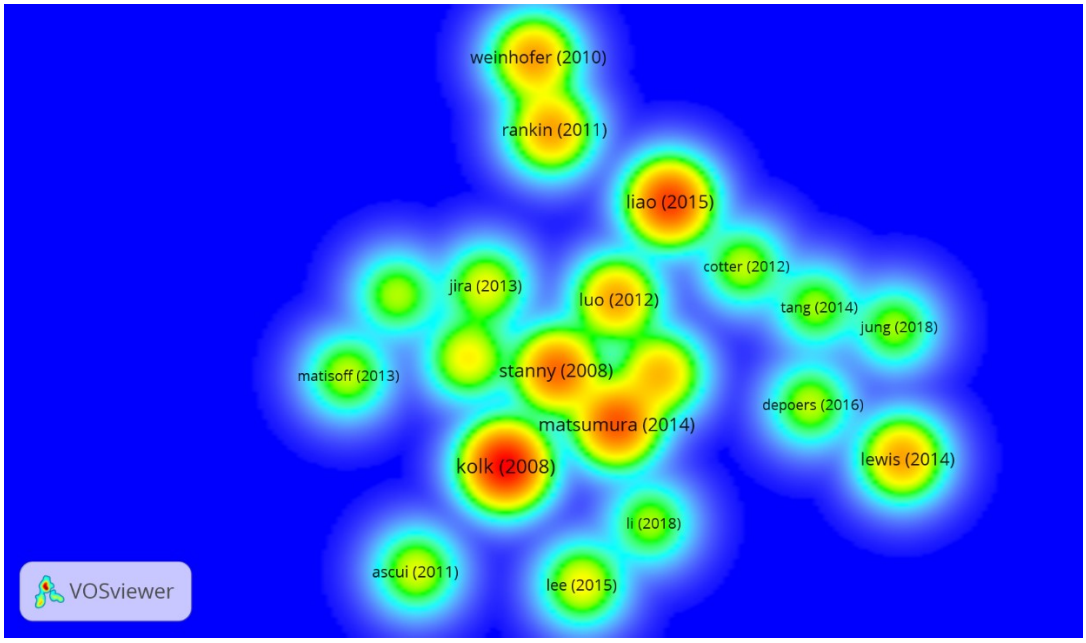
Source: Own elaboration through RStudio.

Figure 3 shows the density map of these articles, among which we can see that 2 clusters were formed, but separately, 2 articles have contributed the most to carbon disclosure (Kolk et al., 2008; Liao et al., 2015).

Vol. 7, núm. 21 / septiembre – diciembre del 2022
DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165

Figure 3

Density diagram of the most cited articles



Source: Own elaboration through VOSviewer.

Advances in the knowledge of Carbon Disclosure

Carbon disclosure has been defined in several ways in the literature, however, there is a consensus in each of the definitions that have been formed on considering the risks, opportunities, benefits, and strategies by companies towards their carbon related information. Table 4 shows three of the most used definitions for the concept of carbon disclosure.

Table 4

Carbon Disclosure Definitions

Author	Definition
(Kolk et al., 2008, P.728-729)	Translate corporate carbon profiles into market opportunity and risk assessments with clear financial implications for companies and investors. In fact, this constitutes the central logic behind the carbon disclosure movement.
(Hahn et al., 2015)	Carbon disclosure involves corporate practices to systematically collect data, measure direct and indirect emissions, and communicate such information to company stakeholders to meet their demands for information and provide guidance on the matter.
(Velte et al., 2020)	Carbon disclosure is an instrument that connects companies with their internal and external stakeholders, and includes information on the carbon performance, strategies, and perspectives of the reporting company.

Source: Own elaboration, 2021.

Through these definitions that, although they have not been many over time, it is possible to appreciate the value that different authors have tried to give to the concept of carbon disclosure, since it is a phenomenon highly related to change climate due to its emphasis on carbon emissions, but it is understood how business responses to the constant pressure of institutions, investors, shareholders and customers, mainly to decarbonize the world economy in order to help society in general (He et al. , 2021).

The importance of carbon disclosure varies depending on the approach in which it is viewed. It is important from the economic point of view mainly because the literature mentions that it can significantly impact the value of companies due to present and future costs on compliance and carbon mitigation can mean liabilities not accounted for by companies (Borghei, 2021; He et al., 2021), as well as it can help companies to obtain government subsidies, as may be the case when it is in mandatory information regimes about carbon management such as the Emissions Trading Scheme of the European Union (EU ETS) (Stechemesser & Guenther, 2012; S. Tang & Demeritt, 2018).

Another reason why carbon disclosure is important is because it allows indirectly observing the behavior of organizations with respect to the information they disclose, since it can be used as a transparency mechanism to influence the decision-making of certain target actors, due to the fact that carbon disclosure is understood as an effective way of governance (Pattberg, 2017), as well as to observe managerial discretion on the content and form that companies decide to report certain non-financial information on a voluntary basis (Hahn et al., 2015), which may have comparability, reliability and veracity problems.

Finally, from the social point of view, corporate carbon disclosure takes on special importance since it is a practice aimed at mitigating emissions of CO^2, which is highly related to climate change, whose consequences are known worldwide (e.g., increase in global temperature, lower levels of precipitation, extreme weather events; droughts, floods, fires, among others) and it is a multidisciplinary phenomenon (Stechemesser & Guenther, 2012).

For this reason, it is important to observe how companies are helping to contribute with lower carbon dioxide emissions to meet the objectives proposed by the Paris Agreement and the Kyoto Protocol. Just as it is important to know if the actions carried out by companies are effective, or if they are only a strategy to avoid scrutiny and continue in search of their own benefits and not that of society.

Carbon Related Concepts

Carbon and its related topics have been the subject of multiple studies in recent years, however, in the literature it can be found that there are terms that continue to be confused with each other since they are used interchangeably, such as carbon accounting, carbon reporting, carbon performance and carbon disclosure (Kolk et al., 2008; Pattberg, 2017; Velte et al., 2020).

Carbon performance

The concept that has caused the least inconvenience because it is more limited is the concept of carbon performance. Carbon performance quantitatively details the GHG emissions of the companies, as well as the measures and strategies contemplated to reduce their level. The most common way to measure carbon

Vol. 7, núm. 21 / septiembre – diciembre del 2022
DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165

performance in the literature is using scopes 1, 2, and 3, which correspond to direct, indirect and supply chain emissions respectively (Velte et al., 2020). Furthermore, carbon performance generally refers to how well companies manage and control their carbon emissions and can be divided into two categories: i. How carbon performance is measured, and ii. The factors that affect the carbon performance of companies (He et al., 2021).

Carbon accounting

Where more confusion begins to exist is in the other three concepts. On the one hand, as with carbon disclosure, various authors have developed an important variety of concepts for carbon accounting. Carbon accounting can have different meanings depending on the person using the term (Ascui & Lovell, 2011). The most important definitions can be found in table 5.

Table 5

Carbon accounting Definitions

Author	Definition
(Ascui & Lovell, 2011, P. 980)	Carbon accounting focuses on the "measurement or monitoring of reductions in carbon dioxide emissions globally, for both mandatory and voluntary research purposes."
(Stechemesser & Guenther, 2012, P. 35)	Carbon accounting includes the recognition, non-monetary and monetary evaluation and monitoring of greenhouse gas emissions at all levels of the value chain and the recognition, evaluation and monitoring of the effects of these emissions on the cycle of carbon in ecosystems.
(Tang, 2017, P. 11)	Carbon accounting is a system that uses accounting methods and procedures to collect, record and analyze information related to climate change and to account and report carbon-related assets, liabilities, expenses, and income to inform decision-making processes of internal managers and external stakeholders.
(Borghei, 2021, P. 15)	Carbon accounting collects, summarizes, and measures carbon emissions data to allow comparisons between reporting periods and facilitate independent reviews for data accuracy and compliance.

Source: Own elaboration, 2021.

As it can be appreciated, there is a consensus in the previous definitions that the main objective of carbon accounting is to measure and recognize the GHG emissions of companies to be able to record them in the accounting books either as assets or liabilities, and thus, to be able to integrate the financial information of organizations into a more complete image.

Another important point to note about carbon accounting is that it has been conceptualized in at least two different ways. On the one hand, Ascui and Lovell, (2011) mention that carbon accounting can be conceptualized among five main processes: i. Carbon physical accounting, ii. Political carbon accounting, iii. Carbon accounting made possible by the market, iv. Carbon financial accounting, v. Carbon social / environmental accounting. On the other hand, He et al. (2021), in a more recent study, break down carbon accounting into six components: i. Accounting for carbon assets and liabilities, ii. Carbon Disclosure, iii. Carbon assurance, iv. Carbon management, v. Carbon performance and, vi. Impact of carbon problems on the capital market. However, it is not the purpose of this

study to focus on the term of carbon accounting nor its components proposed by other authors since we understand carbon disclosure as a more complete concept.

Carbon reporting

The third concept that has been used interchangeably with carbon disclosure is carbon reporting (Kolk et al., 2008). Carbon reporting is about the measurement, monitoring and management of carbon dioxide emissions (Tang & Demeritt, 2018), which although they share characteristics with carbon accounting specifically in measurement, seeks the correct management of emissions to report their progress in mitigating GHG emissions to the organizations' stakeholders. Furthermore, as with carbon accounting and the ways in which it is conceptualized, carbon reporting can be explained by three fundamental reasons or justifications for which carbon reporting is given.

The first is a financial justification since emissions can affect the finances of the company because they are increasingly expensive. The second justification is related to reputation, since, although the financial savings are not significant, organizations will be motivated to report their carbon emissions to demonstrate to their stakeholders (e.g., investors, shareholders, and clients) their commitment with climate change. Finally, a third justification is purely by regulation. Since many of the companies that currently report do so because they are obliged to do so, especially where the reporting scheme is mandatory (e.g., UK). They mainly do it to avoid financial penalties and taxes related to poor carbon management (Tang & Demeritt, 2018).

Despite how interesting it can be to analyze the carbon report alone, the interest of this research is not to delve further into the justifications that motivate companies to carry out this practice. For its part, the central theme of this research is carbon disclosure since carbon disclosure can be seen as an emerging organizational field according to the definition of organizational fields by DiMaggio and Powell (1983, p. 145) in where they describe the conformation of an organizational field as "those organizations that, together, constitute a recognized area of institutional life."

Conceptualization Of Carbon Disclosure

In a recent study, Borghei (2021) finds the following six key research fields in carbon disclosure: i. Strategic climate response, ii. Determinants of carbon disclosure, iii. Carbon accounting, iv. Carbon disclosure assurance, v. Quality Carbon disclosure, and vi. Consequences of Carbon Disclosure. It is due to these key areas in which carbon disclosure can be decomposed that we find this concept as a superior concept to the previous ones mentioned, in addition to the fact that the literature emphasizes more on disclosure than on carbon reporting or accounting.

Strategic Climate Response

Corporate responses to climate change changed dramatically since the 1990s (Kolk et al., 2008). Within the DVC literature there are several works that have addressed strategic climate responses by companies (Bui & Fowler, 2019; Jeswani et al., 2008; Kolk et al., 2008; Kolk & Pinkse, 2004). For example, Kolk and Pinkse (2004) highlight three types of positions in the face of corporate climate change strategies, the defensive position, the opportunistic / hesitant position and the offensive position.

Vol. 7, núm. 21 / septiembre – diciembre del 2022
DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165

While those who adopt a defensive stance are characterized by opposing an organizational climate treaty, those with an offensive stance feel the need to take the first steps towards better emissions mitigation, arguing not only environmental well-being, but also market opportunities and increased legitimacy. Finally, in the middle are those with an opportunistic / hesitant position, who are cautious about the treaties that may arise, but as long as a change does not happen (e.g., a mandatory regime), by themselves they are not proactive regarding this issue.

Adding to the above, Kolk and Pinkse (2004, 2005) analyze the strategies regarding climate change because of the market components that are available to company managers. Likewise, they develop a typology where they highlight that the strategies go in the direction of covering two dimensions: i. The main objective and ii. The form of the organization of companies, where the main objective can be broken down into innovation and compensation, while the form of organization of the company is divided into internal level, vertical level and horizontal level.

Another interesting work in which the strategic responses to climate change of companies were studied, but at the industry level was carried out in Jeswani et al. (2008) for two different contexts (United Kingdom and Pakistan). They categorize companies according to their strategic responses to climate change in four types of clusters: i. Indifferent, ii. Beginners, iii. Emerging and, iv. Actives.

The first type of cluster refers to those companies that are apathetic about environmental issues. In the second type are those organizations that, although they have started some operational activities to reduce emissions, are still at an early stage with respect to environmental management activity. The third type is where there begins to be a significant change for the benefit of the environment, since companies classified as ‘emerging’ are those that do more than ‘beginners’, but even less than ‘active’. Already the 'active' companies are mostly multinational companies concerned about the climate change movement and that undertake a wide range of operational activities to reduce their emissions by making a change in their consumption for renewable energies (e.g., solar, wind, biomass, among others).

One of the great contributions of Jeswani et al. (2008) was to analyze the type of companies in two different contexts, where it states that there is a significant disparity between companies in developed economies compared to those in underdeveloped economies. Their results show that about 75% of the organizations in the underdeveloped country are within the first two clusters, while those in the developed country, only 30% of their companies were in those stages that deal little with climate change, that is, most of these companies in a developed context implement operational activities to combat in a real and effective way the problem of high carbon emissions.

In addition, they mention that some of the factors that affect the strategies of these countries are: i. The influence of stakeholders, mainly the regulatory agencies, owners, and management of the company, and ii. Drivers (e.g., "cost savings", "management commitment", "corporate objectives" and "compliance with regulations") and barriers (e.g., high costs for GHG reduction and lack of financial resources for both contexts, while for the underdeveloped country the greatest barriers are the lack of awareness, the lack of availability of technology, and the absence of government policies).

The strategic responses of a specific industry have also been analyzed. For example, Weinhofer and Hoffmann (2010) developed a generic reference framework on companies CO^2 strategies and specifically analyzed the electricity industry. The framework they developed is broken down into three types of corporate strategies with respect to CO^2: i. Compensation of CO^2, ii. Reduction of CO^2, and iii. Carbon independence. Likewise, they mention that there are several factors that can influence a company to decide what type of strategy to take, for example, the geographical region in which the company operates, the size of the company and the extent to which the current commercial operations of the companies rely on carbon resources.

After analyzing the CDP's electricity industry through the three types of CO^2 strategies, six types of clusters of companies belonging to said industry were identified, which can adopt one or more of the strategies. The six clusters are i. All terrain, ii. Compensators, iii. Replacement compensators, iv. Reducers, v. Replacement reducers, and vi. Preservatives (Weinhofer & Hoffmann, 2010).

On the other hand, Bui and Fowler (2019) complement the strategic responses regarding climate change. They identify five types: i. Avoidance, ii. Operational compliance, iii. Strategic compliance, iv. Strategic differentiation, v. Negotiation and manipulation. The fifth answer is especially important because, in Mexico, as in most developing countries, business policies around carbon disclosure are in a development stage, where companies are more likely to employ strategies manipulation and negotiation to comply with certain institutional and / or economic pressures. When they find themselves in an environment with too much institutional pressure, companies through their managers can adopt a manipulation strategy where they try to control and influence those pressures under which they are exposed, for example, by persuading an institutional agent to become part of their Board of Directors (Oliver, 1991).

Having described the different types of strategic responses that different authors find; it will be important to recap the government responses that have developed over the last couple of decades. One of the first responses to climate change is the EU Emission Trading System (EU ETS) (Kolk et al., 2008). Other of the most common corporate responses to climate change have been of operational and investment type. For example, investments have been made in technologies for a lower emission of CO^2, in solar energy, as well as in a structure that allows companies to evaluate, measure and report their GHG emissions (Kolk et al., 2008).

However, Borghei (2021) mentions that there is not enough clarity on how the specific characteristics of companies can influence their strategic climate response. To date, there is a lack of answers to know how strategic climate responses can build capacity and resilience to climate risk (Borghei, 2021).

Determinants of Carbon Disclosure

The second key area within carbon disclosure is the study of the factors that drive organizations to measure, value and disclose their carbon-related information. Carbon determinants can be understood as "the reasons why some organizations voluntarily disclose their climate actions, while others do not, exploring the "motivations", "drivers" and "barriers" to carbon disclosure. " (Borghei, 2021, P. 8).

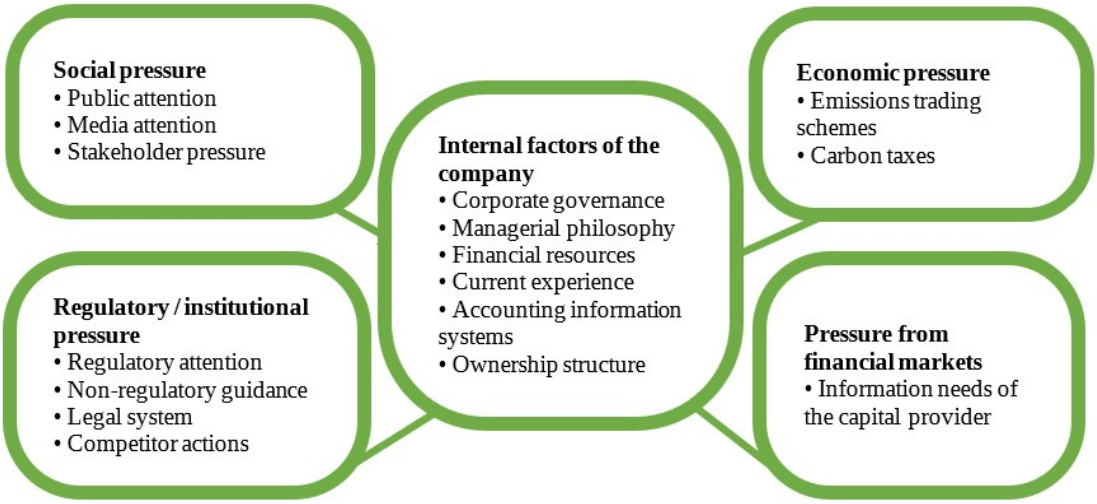
Vol. 7, núm. 21 / septiembre – diciembre del 2022
DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165

Among the most common determinants found in the literature for carbon disclosure can be found economic / financial determinants and governance determinants (Velte et al., 2020). Regarding the economic / financial determinants, the most studied have been financial performance, leverage, cost of capital, market-book ratio, information asymmetry and growth (Hahn et al., 2015; He et al., 2021).

On the other hand, the governance-related determinants most seen in the carbon disclosure literature can be broken down into three: i. Composition and characteristics of the Board of Directors (diversity, independence, size, duality of the CEO, among others), ii. Ownership structure (institutional ownership, managerial ownership, state ownership, among others), iii. Pressure from stakeholders (environmental assurance, media coverage, external audit, among others) (He et al., 2021; Velte et al., 2020). Other determinants of CD can be those related to the environment (emissions, carbon intensity industries) and regulatory (Kyoto Protocol, another specific regulation towards GHGs) (Hahn et al., 2015).

Figure 4

Framework of determinants of carbon disclosure



Source: Figure adapted from He et al. (2021); Luo et al. (2013); Velte et al. (2020).

Carbon Accounting

As mentioned at the beginning of this section, the term carbon accounting has been used interchangeably when referring to carbon disclosure. Its conceptualization, as well as its definition, were discussed in the subsection above called 'Carbon related concepts'.

Carbon Disclosure Assurance

Carbon assurance is an emerging practice within the business world, which, according to Datt et al. (2019), emanates as a dimension of the sustainability assurance and can be defined as:

> A work in which a practicing professional expresses a conclusion designed to improve the degree of confidence of the intended users, other than the responsible party, about the result of the evaluation or measurement of an issue in relation to the criteria (Bui et al., 2021, p. 13).

Three of the most recent and important work on carbon assurance were carried out by Datt et al. (2018, 2019, 2020), where they mention that companies can choose to hire carbon guarantee services due to very different reasons, since carbon assurance is considered a complex and strategic practice. In addition, they argue that the carbon assurance is a response to the legitimacy threats that companies face because of severe climate legislation and an increase in public awareness for the well-being of the environment.

Another reason why organizations choose to hire services of this type is to reduce information asymmetry. The carbon assurance helps companies reduce the asymmetry of information that exists for this issue between management and stakeholders due to its nature of being an independent service, since the information that is disclosed tends to be minimal or different regarding the information that their managers have (Datt et al., 2020; Fan et al., 2021; Shen et al., 2020).

On the other hand, carbon assurance services currently have two main types of service providers, and they are accounting companies (e.g., Big four), and consulting companies (He et al., 2021). Fan et al. (2021) mention that, to provide carbon assurance services, the members of the accounting firms adhere to the International Standard on Assurance Engagements (ISAE) 3410, which stipulates specific guidelines for the guarantee of GHG statements.

It should be noted that the reason for going to an accounting company, or a consulting company depends on the objective that the company wants to achieve. For example, Datt et al. (2020) comment that the reason for hiring an accounting company is because of the independence they offer due to their professional code of ethics, which causes greater credibility and trust in the information that is verified, but on the other hand, a consulting company has the advantage that it can provide better assistance in seeking improvements in carbon management systems due to the high technical knowledge they possess.

In short, the carbon assurance is important especially because companies are offering incentives to their administration to carry out greenwashing practices with respect to their carbon information, to get out of the way of institutional and global pressures on their GHG emissions (Shen et al., 2020). However, in countries where the Monitoring, Reporting and Verification (MRV) stage is not yet fully developed, other tools will have to be developed to identify those companies that carry out greenwashing.

Fan et al. (2021) comment that carbon assurance is emerging as a flourishing market and widespread practice for accounting firms and other consulting organizations and is playing an increasingly important role in managing the business transition to a future free of carbon. Greater efforts are required to empirically investigate carbon assurance, which has been rare to date, mainly because data is limited (Hahn et al., 2015).

Vol. 7, núm. 21 / septiembre – diciembre del 2022
DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165

Carbon Disclosure Quality

In the literature on carbon-related information, there are few studies on how the quality of GHG disclosure has been developed, evolved and improved (Comyns & Figge, 2015). A relevant study on the quality of such information is carried out by Comyns and Figge (2015), in which they measure the quality of disclosure with a self-constructed index based on seven dimensions: i. Accuracy, ii. Integrity, iii. Consistency, iv. Credibility, v. Relevance, vi. Opportunity, and vii. Transparency.

From the social pressures on carbon and GHG emissions in general, companies began to take actions to reduce or offset their carbon footprint. Among these actions are carbon disclosure and performance, however, the quality of both actions carried out by companies is unknown to stakeholders.

As Pitrakkos and Maroun (2019) well mention, 'quantity' is not the same as 'quality', which is why they conducted a study to measure the quality of the carbon information reported by companies listed on the Johannesburg Stock Exchange, in where they measured the quality of their information through eight characteristics of their reports, among them: i. A density index, ii. Attribute, iii. Management orientation, iv. Integrated, v. Assurance, vi. Strategy, vii. Legibility and viii. Repetition. In the study, they found that the quality of their disclosures is compromised depending on the level of carbon risk companies are exposed to, and the amount of disclosure varies according to the legitimacy strategy they use.

Consequences of Carbon Disclosure

The consequences and determinants of carbon disclosure have been studied interchangeably on many occasions, making it somewhat confusing to identify when some variables are used as consequences and when as determinants. The CD by companies has been studied from the perspective of financial performance variables such as return on equity (ROE), return on assets (ROA), Tobin's Q, return on sales (ROS), among others, having inconclusive results.

On the one hand, it is reported that the reduction of carbon emissions results in a significant increase in the financial performance of companies (Gallego-Álvarez et al., 2015; Velte et al., 2020), generating greater value for the public investor, showing that with sustainable activities it is possible to economically reward the investments received; Moreover, different studies have shown that carbon emission reductions have unprofitable results for companies in the short term and, therefore, poor financial performance (Delmas et al., 2015; Ganda & Milondzo, 2018).

Other authors mention that companies can have consequences on their cost of capital depending on whether they voluntarily report on their carbon performance. The results have been similarly mixed on this variable, since there are authors who mention that the cost of capital and carbon disclosure maintain a negative relationship, where public companies use carbon disclosure to predispose the market and thus, obtain a lower capital cost rate (Lemma et al., 2019).

A different way of looking at it is that companies that practice carbon disclosure benefit from lower rates on their cost of capital, which helps them in their financial transactions. Different authors find that the disclosure of carbon emissions affects the cost of capital of companies since it increases when the company discloses carbon emissions, thus causing it to be more expensive to obtain financing and, therefore, make it more complicated the achievement of their corporate strategies (Peters & Romi, 2014).

In addition to variables of financial performance and cost of capital of companies, carbon disclosure also influences the asymmetry of information between agents and stakeholders. The CD is of great importance for financial markets since reporting on carbon emissions reduces the volatility of the price of companies' shares; Similarly, reporting such information with quality is closely related to an increase in the liquidity of the stock market (Borghei et al., 2018; Krishnamurti & Velayutham, 2018).

Conclusions

Focus on carbon disclosure for business scholars has been increasing in the last twelve years starting in 2008 when the first publication about carbon disclosure was registered in social science, especially for business, economics, administration, and ethics. Till 2020, they were 178 articles published in different WOS journals, with an average of almost 15 papers per year, accompanied by a citation average per article of 19.91. This shows the gradual growth of the term in the social sciences. The leading journals for this topic were Business Strategy and The Environment, British Accounting Review and Corporate Social Responsibility and Environmental, covering 19.6%, 12.07% and 10.05% of the total cites. This shows about where the main knowledge about carbon disclosure is supported.

Through a bibliometric analysis and a literature review we could observe some of the latest advances in the knowledge of carbon disclosure. This analysis reveals how despite of the little attention that researchers have been given to the definition of carbon disclosure, there is a consensus about the term with only three definitions. As an integral definition we can say that carbon disclosure is the corporate practice of systematically collect data, measure direct and indirect emissions (carbon performance) and assess carbon risk with financial implications to communicate strategies and outlooks to their stakeholders to provide guidance on the matter with the only purpose of contributing with the economy decarbonization.

Nevertheless, there is an issue arising around the topic of CD due to some other concepts have been related and used indistinctly with carbon disclosure. For example, there are at least three concepts make it difficult to be clear about carbon disclosure. These are carbon accounting, carbon performance, and carbon reporting (Kolk et al., 2008; Pattberg, 2017; Velte et al., 2020). It will be important for the advancement in knowledge on issues related to corporate carbon to learn to differentiate the terms mentioned above.

Finally, we highlight the conceptualization of Borghei (2021) as one of the main advances in the literature of carbon disclosure, where she finds six key research fields: i. Strategic climate response, ii. Determinants of carbon disclosure, iii. Carbon accounting, iv. Carbon disclosure assurance, v. Quality Carbon disclosure, and vi. Consequences of Carbon Disclosure. We believe that advances in future lines of research should focus on these components of carbon disclosure, especially when analyzing three of the six key areas.

The first one, when analyzing the strategic climate responses of different industries and different contexts since they can vary greatly in both scenarios. The second of these that has emerged in the last couple of years is on the assurance of carbon disclosure by accounting and non-accounting companies and seeing if it meets its objective of providing credibility and transparency for the contexts where it can be applied. Finally, the quality of carbon disclosure is an important issue in most countries, as carbon disclosure continues

Vol. 7, núm. 21 / septiembre – diciembre del 2022
DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165

to be voluntary, and the quality of this practice can be affected through greenwashing.

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Vol. 7, núm. 21 / septiembre – diciembre del 2022
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Pp. 143-165

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Vol. 7, núm. 21 / septiembre – diciembre del 2022
DOI: https://doi.org/10.36791/tcg.v7i21sept-dic.178
Pp. 143-165