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Informações Financeiras sobre os Riscos Relacionados ao Clima: uma revisão da literatura


Financial Information on Climate-Related Risks: a literature review

Información Financiera sobre Riesgos Relacionados con el Clima: una revisión de la literatura

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PALAVRAS-CHAVE
Riscos Climáticos,
Divulgação,
Informações
financeiras.

Resumo: A pesquisa teve como objetivo mapear a literatura sobre a divulgação de informações financeiras sobre os riscos relacionados ao clima, identificando os principais temas abordados, lacunas na pesquisa e tendências futuras. Realizou-se uma revisão sistemática da literatura combinada com uma análise bibliométrica. Foram analisados 55 artigos, coletados das bases de dados Web of Science e Scopus. Este artigo contribui com a análise sistematizada de um tema cada vez mais presente na rotina das organizações, e foco das discussões a partir do Acordo de Paris de 2015. O estudo revelou que a disseminação do conhecimento sobre o tema é recente, mas evidencia importantes achados, como a falta de padronização dos indicadores e mecanismos robustos de acompanhamento de desempenho ambiental organizacional, destacando a importância de novos estudos. A transparência nas informações disponibilizadas também é um tema relevante no campo de discussão para o aperfeiçoamento dos métodos, assim como a falta de regulamentação para a obrigatoriedade de divulgações financeiras sobre os riscos climáticos. Lacunas de pesquisa foram evidenciadas, sendo divididas em: indicadores, gestão de riscos, qualidade das informações, ativismo dos investidores e regulamentação. Cinco temas principais emergiram do mapeamento, com ênfase aos estudos relacionados ao alinhamento das organizações às orientações da TCFD. Proposições foram sugeridas em cada um dos temas discutidos. A investigação constatou que houve um progresso relacionado a transparência na divulgação dos dados das empresas, porém está muito longe



de ser um resposta adequada aos desafios para o alinhamento das finanças relacionadas ao clima.

KEYWORDS

Climate Risks, Disclosure, Financial Information.

Abstract: *The research aimed to map the literature on the disclosure of financial information related to climate risks, identifying the main themes addressed, research gaps, and future trends. A systematic literature review combined with a bibliometric analysis was conducted. A total of 55 articles, collected from the Web of Science and Scopus databases, were analyzed. This article contributes to the systematic analysis of a topic that is increasingly present in the routine of organizations and a focus of discussions since the 2015 Paris Agreement. The study revealed that the dissemination of knowledge on the subject is recent but highlights important findings, such as the lack of standardization of indicators and robust mechanisms for monitoring organizational environmental performance, emphasizing the importance of new studies. Transparency in the information provided is also a relevant topic in the field of discussion for the improvement of methods, as well as the lack of regulation for mandatory climate risk financial disclosures. Research gaps were identified, divided into: indicators, risk management, information quality, investor activism, and regulation. Five main themes emerged from the mapping, with an emphasis on studies related to organizations' alignment with TCFD guidelines. Propositions were suggested in each of the discussed themes. The investigation found that there has been progress related to transparency in companies' data disclosure, but it is far from being an adequate response to the challenges of aligning climate-related finances.*

PALABRAS CLAVE

Riesgos Climáticos, Divulgación, Financial Information.

Resumen: *La investigación tuvo como objetivo mapear la literatura sobre la divulgación de información financiera relacionada con los riesgos climáticos, identificando los principales temas abordados, brechas en la investigación y tendencias futuras. Se realizó una revisión sistemática de la literatura combinada con un análisis bibliométrico. Se analizaron 55 artículos, recopilados de las bases de datos Web of Science y Scopus. Este artículo contribuye al análisis sistematizado de un tema cada vez más presente en la rutina de las organizaciones y foco de discusiones a partir del Acuerdo de París de 2015. El estudio reveló que la difusión del conocimiento sobre el tema es reciente, pero destaca hallazgos importantes, como la falta de estandarización de indicadores y mecanismos sólidos para monitorear el desempeño ambiental organizacional, enfatizando la importancia de nuevos estudios. La transparencia en la información proporcionada también es un tema relevante en el campo de discusión para mejorar los métodos, así como la falta de regulación para las divulgaciones financieras obligatorias sobre riesgos climáticos. Se identificaron brechas en la investigación, divididas en: indicadores, gestión de riesgos, calidad de la información, activismo de inversores y regulación. Cinco temas principales surgieron del mapeo, con énfasis en los estudios relacionados con la alineación de las organizaciones a las directrices del TCFD. Se sugirieron proposiciones en cada uno de los temas discutidos. La investigación encontró que ha habido avances relacionados con la transparencia en la divulgación de datos de las empresas, pero está lejos de ser una respuesta adecuada a los desafíos de alinear las finanzas relacionadas con el clima.*

Introduction

The research agenda on climate change began in the early twentieth century, but only in the last three decades has it gained visibility in academia and society. More recently, it has emphasized the importance of organizational transparency concerning climate-related risks. The sense of urgency has mobilized not only academia but also representatives of the global political environment. Evidence of this is the formalization of the 2015 Paris Agreement when top representatives of 195 countries committed to collaborating on actions to reduce global warming to a maximum of 2°C above pre-industrial temperatures and limit the temperature increase to 1.5°C (United Nations, 2015). Measures aimed at reducing the severe impacts that global warming exerts on various natural systems that ensure life on the planet need to be implemented. The "Climate Value-at-Risk (VaR)" resulting from climate-induced physical damages was estimated by Dietz et al. (2016) at approximately USD 24.2 trillion in financial assets lost by the end of this century, or 16.9% of global financial assets. Reducing emissions and limiting warming to no more than 2°C can influence the climate VaR by approximately 7.7%. However, at the level of individual assets and portfolios, the lack of information on climate risk prevents investors from pricing risk adequately (Monasterolo et al., 2017).

Considering these risks, in 2015, the Financial Stability Board (FSB) - an international body that monitors and issues recommendations on the global financial system - submitted a proposal to the G20 involving creating an industry-led Task Force on climate-related risk disclosure. In 2017, the responsible group published a final report gathering recommendations for companies on climate-related financial disclosures (Financial Stability Board, 2017).

Considering this context, this research aims to map the literature on financial disclosure of climate-related risks, identifying

the main themes addressed, gaps in research, and future trends, answering the following question: what does the literature reveal about the disclosure of financial information related to climate risks? Such information can understand the extent and depth of the impacts generated by organizational activities on the environment, strengthening or undermining their reputation and image.

This research consists of a bibliometric analysis combined with a systematic literature review of 55 articles published between 2015 and 2022, found in the Scopus and Web of Science databases. Five research themes emerged: alignment of guidelines regarding the disclosure of financial information related to climate risks; policies and regulatory systems focusing on low-carbon investments; climate-related risks and their impact on organizations; investors' perspectives on the influence of climate change on business; and bank credit and climate commitments.

The article is structured in 6 sections. In the 2nd and 3rd sections, respectively, an overview of the topic and the research methods employed to answer the central question of the study are presented. In the 4th and 5th sections, the main findings are presented through descriptive analysis and a brief overview of the 5 major research areas revealed by the field. In the 6th section, the research findings are systematically organized for the proposition of a future research agenda.

Theoretical Elements of the Research

Climate Risks and Financial Information

According to the United Nations Framework Convention on Climate Change, climate risk refers to changes in climate directly or indirectly attributed to human activities capable of triggering alterations in the global atmospheric composition. These changes add to the natural climate variability observed over comparable time periods (United Nations, 1992). Global warming, in

turn, refers more specifically to the gradual increase in global surface temperature due to radiative forcing (change in net vertical irradiance) caused by anthropogenic emissions (Carvalho et al., 2011).

The disclosure of reliable information on the impact of climate change on firms' performance has sparked the interest of various groups, especially investors, making studies and discussions on transparency in the disclosure of greenhouse gas mitigation actions and climate risk reports even more urgent. Battiston et al. (2017) expressed concern regarding institutional investors and their respective investment portfolios, considering that in 2015 they accounted for 45% of shares in sectors sensitive to climate policy, such as fossil fuels, public services, energy-intensive industries, housing, and transportation, etc. Additional concern is raised by Carney (2015), who asserts the potential impact of the 'carbon bubble' on a sudden transition in capital markets' value and an indirect impact on financial stability.

In this regard, the Financial Stability Board (FSB) argued that much of the problem

stems from the lack of transparency surrounding assets in sectors relevant to climate policy, as mentioned above. In this context, a Task Force on Climate-Related Financial Disclosure (TCFD) was created with a focus on industry developments. Implementing the TCFD recommendations has been an industry concern and has mobilized political efforts in the area of climate finance (Ameli et al., 2020).

In the TCFD's final report, the Task Force encourages organizations to conduct longitudinal and forward-looking historical analyses when considering the potential financial impacts of climate change, with a greater focus on forward-looking analyses since efforts to mitigate and adapt to climate change have no historical precedents. This is a reason why the Task Force believes that scenario analysis is important for organizations to consider incorporated into their strategic planning or risk management practices (Financial Stability Board, 2017). Table 1 describes examples of climate-related risks and their potential financial impacts.

Table 1
Examples of Climate-Related Risks and Potential Financial Impacts

Type	Climate-Related Risks	Potential Financial Impacts
Transition Risks	Policy and Legal	
	– Increased pricing of GHG emissions	– Increased operating costs
	– Enhanced emissions-reporting Obligations	– Write-offs, asset impairment, and early retirement of existing assets due to policy changes
	– Mandates on and regulation of existing products and services	– Increased costs and/or reduced demand for products and services resulting from fines and judgments
	– Exposure to litigation	
	Technology	
	– Substitution of existing products and services with lower emissions options	– Write-offs and early retirement of existing assets
	– Unsuccessful investment in new technologies	– Reduced demand for products and services
	– Costs to transition to lower emissions technology	– Research and development (R&D) expenditures in new and alternative technologies
		– Capital investments in technology development
		– Costs to adopt/deploy new practices and processes
	Market	

	<ul style="list-style-type: none"> – Changing customer behavior – Uncertainty in market signals – Increased cost of raw materials 	<ul style="list-style-type: none"> – Reduced demand for goods and services due to shift in consumer preferences – Increased production costs due to changing input prices (e.g., energy, water) and output requirements (e.g., waste treatment) – Abrupt and unexpected shifts in energy costs – Change in revenue mix and sources, resulting in decreased revenues – Re-pricing of assets
	<p>Reputation</p> <ul style="list-style-type: none"> – Shifts in consumer preferences – Stigmatization of sector – Increased stakeholder concern or negative stakeholder feedback 	<ul style="list-style-type: none"> – Reduced revenue from decreased demand for goods/services – Reduced revenue from decreased production capacity – Reduced revenue from negative impacts on workforce management and planning – Reduction in capital availability
Physical Risks	<p>Acute</p> <ul style="list-style-type: none"> – Increased severity of extreme weather events such as cyclones and floods 	<ul style="list-style-type: none"> – Reduced revenue from decreased production capacity – Reduced revenue and higher costs from negative impacts on Workforce
	<p>Chronic</p> <ul style="list-style-type: none"> – Changes in precipitation patterns and extreme variability in weather patterns – Rising mean temperatures – Rising sea levels 	<ul style="list-style-type: none"> – Write-offs and early retirement of existing assets – Increased operating costs – Increased capital costs – Reduced revenues from lower sales/output – Increased insurance premiums and potential for reduced availability of insurance on assets in “high-risk” locations

Source: (Financial Stability Board, 2017)

The Task Force also proposed four recommendations related to the areas of governance, strategy, risk management, and metrics and targets. In a recent article, Demaria & Rigot (2021) assert that the recommendations published by the TCFD (2017) will improve the environmental information disclosed by companies, generating greater reliability and enhancing transparency. The next step, the authors add, is to improve its large-scale implementation by providing companies with the operational tools to use it.

Methodological Elements of the Research

In this study, a systematic literature review (Tranfield et al., 2003) combined with a bibliometric analysis was conducted. A visualization of similarities technique

(Bartolacci et al., 2020; van Eck & Waltman, 2009) was used, allowing for an analysis of the problem by outlining an overview of its scientific production, to understand the state of the art of the topic and, thus, identify possible research opportunities.

The bibliographic databases chosen for the review were Scopus and the Web of Science. Although Google Scholar has a broader range of documents, Scopus and the Web of Science provide a more reliable and scalable method for extracting data (Martín-Martín et al., 2018).

The choice to select articles in English is justified as it is the most represented language in the Web of Science and Scopus databases. The documents collected from the databases were merged and processed in the Bibliometrix software (Aria & Cuccurullo, 2017) to exclude duplicates, with the synthesis of the process described in Table 2.

Table 2
Synthesis of the Process

Databases	Terms	Boolean Operators	Restriction Criteria
Web of Science Scopus	("Climate-related Financial Disclosures") OR ("Climate-related AND Financial AND Disclosures) OR ((disclos* OR releas* OR divulg* OR publiciz* OR publish*) AND ("climate-related" AND financ* AND risk*))	AND; OR	Excluded articles that do not present the theme of financial information on climate risks within the context of the abstract.

Source: Prepared by the authors (2022).

The searches conducted in the databases returned 140 documents (71 in Web of Science and 69 in Scopus). After merging the databases, 51 duplicate documents were excluded, narrowing the set down to 89 documents. Of these, 34 articles were excluded after applying the exclusion criterion (Table 2). In the end, 55 articles were analyzed.

A bibliographic coupling of documents was applied for similarity analysis between articles due to the recent nature of the topic (Zupic & Čater, 2014). The software used was VosViewer version 1.6.17 (van Eck & Waltman, 2009). The first article found in the databases is from 2015, and most documents were published between 2021 and 2022. The coupling was performed without considering citation accumulation so that newer works could be included, and with a minimum cluster size of 5 documents (Boyack & Klavans,

2010).

Presentation and discussion of results

Results of the descriptive analysis

The results showed initial discussions published only in 2015, although no temporal criterion was applied to the survey conducted in the Web of Science and Scopus databases, so that the databases would provide all documents, revealing the novelty of this topic for academia. This fact justifies the diversity of journals publishing on the topic and the lack of concentration. The highest occurrence of publications was in 2022 (Figure 1), signaling that this agenda is recent and requires academic attention.

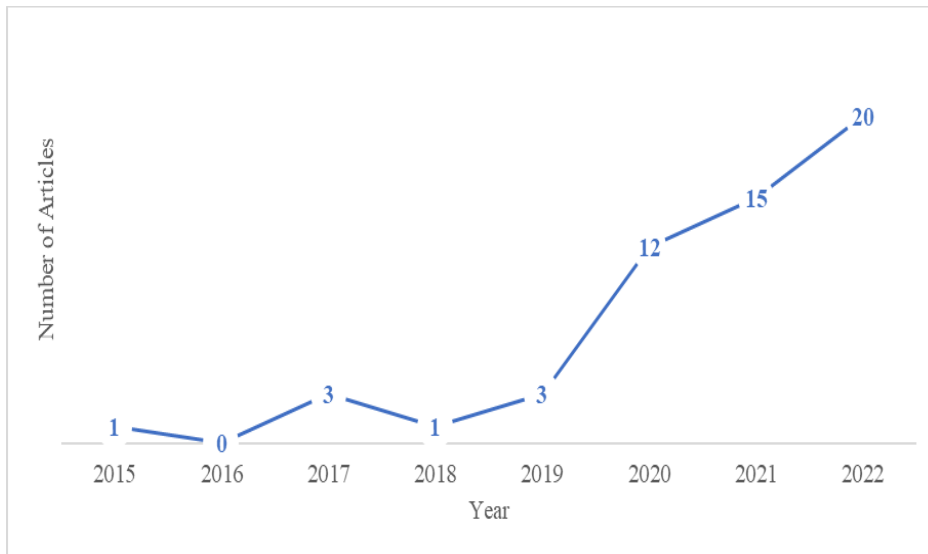


Figure 1 - Article production by year 2015-2021.
Source: Prepared by the authors (2022).

The main journals publishing on the topic can guide researchers in discussions. The data in Figure 2 reveal the journals publishing on the topic. It is noticeable that few journals (6) have more than one article published. Climate Policy stood out with six occurrences in the period. Considering the journal's impact measured by

the H-index, which quantifies scientific production based on citations of works (Hirsch, 2005), the journals with the highest impact on the topic are: Climatic Change, Journal of Cleaner Production, and Business Strategy and the Environment.

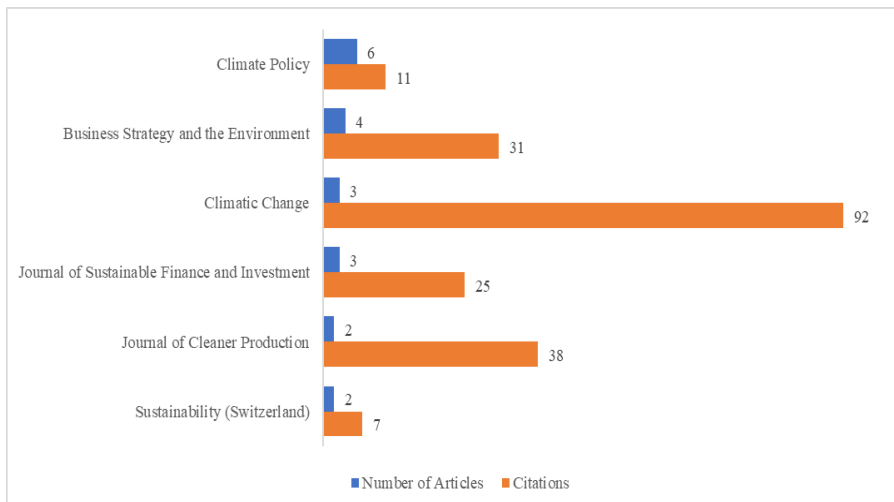


Figure 2 - Number of articles and citations from the main journals.
Source: Prepared by the authors (2022).

The author who stands out for the highest number of published titles is Hugues Chenet, with three articles in the sample. The author is an interdisciplinary climate and sustainability researcher, holding an honorary senior research associate position at University College London (England) and being part of the largest research network on the topic. He recognizes climate-related financial risks (CRFR) as an emerging challenge for central banks and financial supervisors (Chenet et al., 2021).

Figure 3 illustrates the collaboration networks between institutions. The network formed by University College London (England), SOAS University of London (England), University of Oxford (England),

German Development Institute (Germany), School of Environment and Society (Japan), Stockholm School of Economics (Sweden), and the Global Climate Forum (GCF) presents itself as the largest network, with the first institution being the most prominent. Data reveal the leadership of the developed world (England, Germany, Sweden, and Japan), particularly of countries located in Western Europe (England, Germany, Sweden) and institutions that stand out in global rankings. As previously highlighted, among the countries, England leads with 16 publications, followed by Italy (12) and France (7). Some articles stem from investigations carried out by multinational research groups.



Figure 3 - Collaboration networks between institutions
Source: Prepared by the authors (2022).

Results of bibliographic coupling

Figure 4 presents the bibliographic coupling of the 55 articles, resulting in 49 documents with links in 5 clusters (VOSviewer). The size of the circles represents the works with the highest number of citations.

The clusters, which will be discussed subsequently, address the following themes: alignment of guidelines regarding the disclosure of financial information related to climate risks (cluster 1 - red); policies and regulatory systems focusing on low-carbon investments (cluster 2 - green); climate-related

risks and their impact on organizations (cluster 3 - blue); investors' views on the influence of climate change on businesses (cluster 4 -

yellow); and bank credit and climate commitments (cluster 5 - purple).

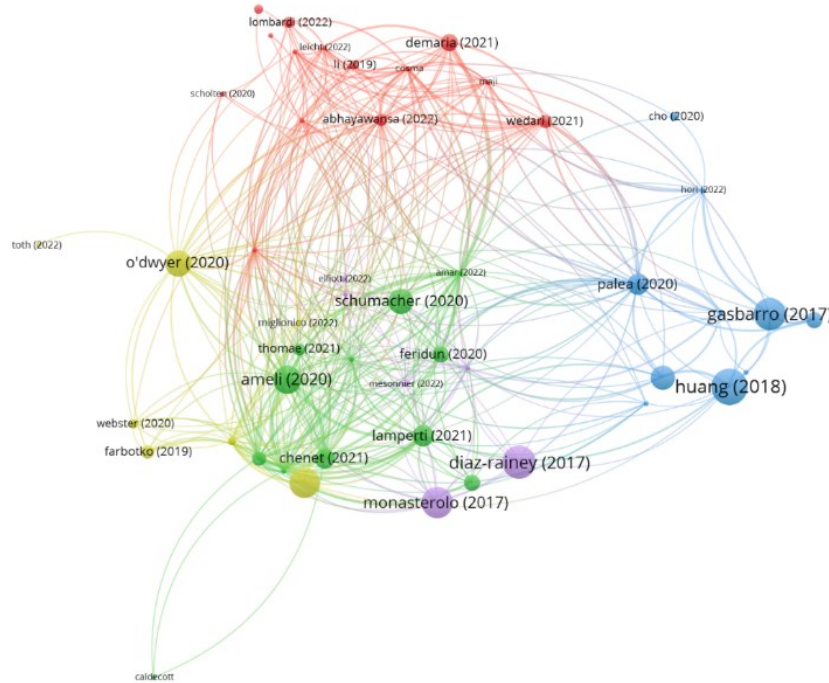


Figure 4 - Document bibliographic coupling
Source: Prepared by the authors (2022).

Alignment of guidelines regarding the disclosure of financial information related to climate risks (cluster 1 - red)

This cluster has the largest number of coupled articles, 14, where the authors emphasize the importance of incorporating qualitative information related to climate risk in financial statements. Scholten et al. (2020) compared four energy companies and found that they do not account for possible changes caused by climate change in their production assets. Propositions of new methodologies to assess the alignment of organizations' disclosure practices with TCFD guidelines are discussed (Demaria & Rigot, 2021; Leicht & Leicht, 2022; Santos & Rodrigues, 2021; Siew, 2020; Wedari et al., 2021). Through the

Climate Compliance Index (CCI), developed and applied in France, a gradual increase in disclosures was found, despite discrepancies between sectors and management areas (Demaria & Rigot, 2021). Banks in Portugal, although already including climate-related financial information in their disclosures, have a long way to go (Santos & Rodrigues, 2021). Other European banks analyzed achieved an intermediate level of compliance, and the existence of corporate social responsibility committees dedicated to sustainability issues is a differential in terms of disclosure (Cosma et al., 2022). Among large Italian companies, several pieces of information necessary for climate-related financial reporting were not appearing (Lombardi et al., 2022). In Germany, considering that disclosure of information is

mandatory, positive results were identified (analyzed period 2018-2020), and the relevance of climate-related information increased and may increase even more in the future (Leicht & Leicht, 2022). In Malaysia, real estate and construction companies failed to achieve an adequate level of alignment with TCFD guidelines and have very poor climate risk-related financial disclosures (Siew, 2020). Other indices compared disclosure with company performance. In Australia, a negative relationship was identified between the disclosure of climate risk-related financial information and environmental performance, highlighting that the data refer to the years 2016 and 2017, a period before the release of TCFD guidelines (Wedari et al., 2021). In the Indian context, in contrast, a positive relationship was found between the disclosure of climate risk-related financial information and performance in energy sector companies (Maji & Kalita, 2022).

The adoption of disclosure practices faces difficulties, due to the lack of a direct process for scenario analysis on climate change (Huiskamp et al., 2022). Ensuring the reliability of non-financial reports is still a goal pursued by researchers, regarding the form and method of evaluation (Bychkova et al., 2021). Mandatory disclosure of financial information on climate-related risks will not necessarily yield the desired outcomes. There are no guarantees that companies will act more sustainably, and there is a risk of disseminating inefficiencies in the financial regulatory system. Moreover, an excessive focus on disclosure could result in the non-application of other more innovative and effective regulatory tools (Stewart, 2020). The disclosure of climate risk-related financial information focuses on "risks" of increasing regulation instead of physical risks, with

scattered information and without an analysis of possible solutions for long-term consequences (Abhayawansa & Adams, 2022).

A proposition identified in this cluster is: the standardization of monitoring indicators through the integration of methodologies organized by recognized international institutions can make the use of disclosed information more comparable.

Policies and regulatory systems focused on low-carbon investments (cluster 2 - green)

The second cluster consists of 12 articles, addressing policies and regulatory systems focused on low-carbon investments. To challenges related to climate risks, transparency alone is not the most appropriate response (Ameli et al., 2020). Central banks and other regulatory institutions should promote policy interventions that encourage greater attraction for sustainable investments. An effective way of alignment climate outcomes (ACO) is to require financial institutions worldwide to comply ACO targets and transition plans (Caldecott, 2020). Regulatory and supervisory expectations were categorized into four main areas: increased board attention to climate risks and integration into the internal governance structure; incorporation of climate risks into strategies and risk management frameworks; identification of material climate-related exposures and disclosure of relevant key metrics; and assessment of the impact of climate risk capital through scenario analysis and stress testing (Feridun & Güngör, 2020). Disclosure, transparency, scenario analysis, and stress testing have limited impact on climate-related financial risks, as efficient price discovery for assets is not possible (Chenet et al., 2021). Thus, stronger regulatory

interventions are needed, considering the potentially catastrophic losses in the long term due to climate change. Increasing transparency and integrating mandatory regulations can transform the sustainable financial sector (D'Orazio, 2021; Schumacher et al., 2020). Disclosure initiatives should be considered as one of several measures that support the low-carbon transition, not the main one, as they are not a central platform for reallocating capital (Ameli et al., 2021). The lack of standardized and internationally accepted taxonomies of green, polluting, and neutral technologies, and associated disclosure requirements, are delaying the shift (D'Orazio, 2021). The combination of using carbon risk adjustment policies (disclosure of information on carbon footprint), green public guarantees (a form of government-backed credit easing), and Green Basel II capital requirements (allocation of weights to different types of assets on banks' balance sheets to account for their relative risk) is a sufficient condition for the sustainable growth path (Lamperti et al., 2021). Suitable and comparable ways to metricate climate risk are needed to ensure that disclosures reflect the assumptions and uncertainties before analyses so that everyone can interpret them correctly (Bingler & Colesanti Senni, 2022).

A proposition for this cluster is: modernizing financial and trade legislation with a focus on sustainability and reducing global warming, led by international organizations, can accelerate the transition to low-carbon markets.

Climate-related risks and their impact on organizations (cluster 3 - blue)

This cluster consists of 10 articles discussing the influence of climate-related risks and their impact on organizations. Companies' adaptation to climate change

involves knowledge and affects the financial performance of organizations. A positive relationship was identified between the absorption of climate knowledge, climate-related operational flexibility, and strategic climate integration, with the return on assets (ROA) (Stechemesser et al., 2015). On the other hand, a better score on sustainability indices does not always mean that companies have better quality (D'Amato et al., 2021). Business continuity is primarily threatened by climate-related physical changes (Gasbarro et al., 2017). The chances of damage caused by extreme events (floods, storms, heatwaves, etc.) are associated with more volatile and lower cash flows and profits (Huang et al., 2018). Some authors have found evidence that higher carbon emissions increase companies' debt costs, and climate-related disclosures mitigate these costs (Kling et al., 2021; Palea & Drogo, 2020; Palea & Santhià, 2022). This occurs in the automotive industry, where carbon emissions have a strong negative relationship with financial performance (Palea & Santhià, 2022), with lower returns on sales and capital inefficiency. Appropriate institutional arrangements could serve as a self-regulation system to stimulate companies to act on climate change (Hori et al., 2022).

In this cluster, the following proposition is observed: encouraging the formation of arrangements between companies and sustainable organizations can improve companies' financial performance and accelerate a self-regulation process with more effective actions on climate change.

Investors' perspective on the influence of climate change on business (cluster 4 - Yellow)

The investors' perspective on the influence of climate change on business is debated in

cluster 4, with 7 linked studies. Investors, particularly institutional ones, should have their viewpoints analyzed. For them, ethical investment is a profitable investment, and climate risk is only relevant if there is a financial component (Christophers, 2019). Investors and shareholders evaluate risks in business models to express their opinions in the market. Disclosing information related to climate risk helps avoid market shocks like those that precipitated the global financial crisis between 2007-2009 (Farbotko, 2019). Investors in the United Kingdom are already exercising their voting power to influence companies in corporate actions aimed at combating climate change (O'Dwyer & Unerman, 2020). Activist investors can allocate resources to polluting companies intending to force changes in the company's management for greater alignment with environmental agreements (Webster, 2020). In Australia, a pension fund was sued for not fulfilling disclosure and due diligence duties related to climate risks (Colombo, 2022). As punishment, it had to pay AUD 57 billion and correct the problems related to disclosure and due diligence, showing the evolution and power of investors to change companies' behavior.

The proposition identified for this cluster is: investors' demands on companies generate greater engagement in sustainability policies and transparency, with effective impacts on actions to combat climate change.

Bank credit and climate commitments (cluster 5 - Purple)

In this last cluster, 6 articles were linked, which investigate how banking institutions have been addressing credit allocation considering their climate commitments.

Climate financing is an important topic to be debated in finance research. However, few journals have addressed the subject (Diaz-Rainey et al., 2017). There is a lack of clarity on how market participation can be measured, considering that various economic sectors emit greenhouse gases (GHGs) (Monasterolo et al., 2017). French industrial small and medium-sized enterprises (SMEs) intensive in carbon have not had difficulties obtaining loans from financial institutions with climate commitments (Mesonnier, 2022), unlike large corporations that must disclose regular reports with their carbon footprint. Among the 10 largest banking institutions in the world that finance the fossil fuel industry, most have recognized their role in mitigating climate change (Elliott & Löfgren, 2022). However, these institutions should do more than voluntary commitments, requiring mandatory disclosures of fossil fuel financing with specific indicators related to these activities. It is worth noting that policymakers should consider how climate risk will affect credit supply and financing costs for companies so that they can take the necessary precautions in advance, maintaining a stable financial environment (Wu et al., 2022).

In this last cluster, the following proposition was observed: granting credit with lower transaction costs for companies with high sustainability indices should be a mandatory policy for all financial institutions worldwide.

Final considerations and topics for future research

Even during the period of the final report publication of the TCFD (2017), Monasterolo et al. (2017) recognized the advances in environmental information disclosed by

companies but argued that even in the presence of more granular and systematic information, the lack of concise and comparable indicators to measure the key economic variables required by market participants for decision-making constitutes an additional information gap that needs to be addressed. With the disclosure of climate risk-related information, the expectation is that investors will migrate from highly polluting (high carbon) assets to assets with greater environmental awareness (low carbon). However, some authors (Ameli et al., 2020; Stewart, 2020) warn that although the achievements regarding transparency in company data disclosure may help, on their own, this is far from being an adequate response to the challenges of aligning institutional climate finance.

The texts by Dietz et al. (2016) and Monasterolo et al. (2017) highlight the influence of industrial activities on climate change. Furthermore, the authors relate the lack of transparency and the lack of information on climate risk as barriers that prevent investors from pricing risk appropriately when they should produce a sustainable analysis of their investments. Recent studies emphasize the need for greater standardization of data (Miglioni, 2022), disclosures (Tóth et al., 2022), and monitoring indicators (Elliott & Löfgren, 2022) related to organizational sustainability.

England stands out as the region that mobilizes the most collaborative research, possibly by co-financing some projects, and was the first G20 country to exceed what was recommended by the TCFD, making it mandatory for large companies to disclose the impacts of climate change by 2025 (Bradford, 2020). In addition to England, New Zealand is

making disclosure mandatory in the country and is expected to be followed by the United States, with Joe Biden's new climate policy (McGrath, 2021).

Although climate risks are discussed in various fields of knowledge and laws impose a more careful behavior on companies concerning their activities, the research data gathered evidence that a discussion on publishing financial reports on climate risks presents gaps for investigation.

Through a critical analysis, we coded the studies and identified the following research gaps:

Indicators: studies involving the formulation and attainment of indicators that can better measure climate risk-related information in financial reports.

Risk management: the need for studies on risk management, including mitigation actions and the alignment of climate outcomes.

Information quality: the development of mechanisms to ensure the quality of information provided to stakeholders, including specific audit processes.

Investor activism: studies that demonstrate the impact of investor activism on the process of disclosing climate-related financial information.

Regulation: studies that address laws and regulations, both from governmental institutions responsible for regulating financial markets and from accounting institutions responsible for the corporate reporting structure.

Table 3 brings together the articles classified according to the presented categorization, where research themes are suggested:

Table 3

Main topics for future research

Topics	Authors
Indicators: concise and comparable indicators to measure the main economic variables required by market participants to make their decisions; system-level data, meaning data from all listed companies and, eventually, large private companies; generation of data and analysis resources needed to properly measure and manage climate-related financial risks; and development of global indicators promoting comparability among banks.	(Caldecott, 2020; Eccles et al., 2018; Monasterolo et al., 2017; Santos & Rodrigues, 2021)
Risk management: how climate change risk is conceptualized and managed to enable reporting in accordance with TCFD recommendations; impact of portfolio strategies, physical risks, or unlisted assets; and managing high disclosure requirements in the context of climate risks.	(O'Dwyer & Unerman, 2020; Thomä et al., 2021)
Information quality: how external verification in sustainability reports is combined with verification in TCFD reports; link between climate disclosure quality and financial performance; the quality of environmental information in terms of relevance, comparing environmental communication with companies' investment practices.	(Demaria & Rigot, 2021; O'Dwyer & Unerman, 2020; Siew, 2020)
Investor activism: analysis of investment choices and investor interactions within the financial system; the involvement of the real estate investor community in governmental and regulatory decision-making; understanding investor expectations about the pace and form of decarbonization patterns, and how they affect investment decisions.	(Ameli et al., 2020; Pike, 2020)
Regulation: For policymakers and regulatory institutions, it would be relevant to monitor actions over time and identify challenges in taking measures beyond measurement; understanding whether adoption and improvements related to sustainability reporting occur voluntarily or through regulation; further developing the environmental accounting framework by complementing it with recommendations offered in the TCFD Report; global financial regulatory response to climate change and the ideal development and implementation of corporate climate-related disclosure regimes (MCDRs); and deeper analysis of possible tools and policies that can be activated beyond central banks, such as in other parts of government (finance ministries, industrial policy, and other public financial institutions).	(Chenet et al., 2021; Cho et al., 2020; Scholten et al., 2020; Stewart, 2020; Thomä et al., 2021)

Source: Prepared by the authors (2022).

The content of the selected articles highlights the existence of gaps that require urgent discussions, particularly considering the global impacts of climate change. Companies that build indicators to transparently communicate their actions for controlling and mitigating climate risks will establish clearer communication with stakeholders. Communication strategies can be developed to meet the demand of activist investors, to provide market security, and maintain the company's reputation over time.

Conclusion

The research aimed to map the literature on the disclosure of financial information about climate-related risks, identifying the main themes addressed, research gaps, and future trends. The study revealed that knowledge dissemination on the topic is recent but reveals important findings, such as the lack of standardized indicators and robust mechanisms for monitoring organizational environmental performance, highlighting the importance of new studies. Transparency in the information provided is also a relevant theme in the field of

discussion for method improvement, as well as the lack of regulation for mandatory financial disclosures on climate risks. Although the first article was published in 2015, it only gained some evidence in the academic community since 2020, with a peak of 20 publications in 2022. The short study time may explain the publication dispersion, and the most prominent researcher has only authored three articles on the topic. This reveals a lack of in-depth research and points to opportunities for creating research networks.

Institutions leading studies on the topic are concentrated in Europe, with an emphasis on England, forming a still modest network that involves University College London, SOAS University of London, University of Oxford, German Development Institute, School of Environment and Society, Stockholm School of Economics, and the Global Climate Forum (GCF). Other countries that have studied the topic conducted isolated research, without much participation in networks, such as in the cases of Italy and France.

The journals that stand out in the number of publications are *Climate Policy*, with six publications, *Business Strategy*, and the *Environment* with four, and *Climatic Change* with three. Despite this, 41 journals had publications, in a sample of 55, which reveals how dispersed the topic is being worked on.

The cluster division by bibliographic coupling of references resulted in five researched themes, with an emphasis on studies related to the alignment of organizations with TCFD guidelines. Research gaps were also highlighted, being divided into five categories - indicators, risk management, information quality, investor activism, and regulation - which can be altered and complemented in future research.

The implications of this work can assist managers and investors in analyzing climate

risk-related financial reports as a company resource, which can be rare and inimitable, as the way the company conducts its operations to mitigate climate risks and how it communicates with stakeholders can add value to its image and reputation, adding value to its assets.

This literature review has some limitations that should be considered when analyzing the results. The selection of articles was based only on two databases, Web of Science and Scopus, and the publication period was limited, which may not adequately cover the evolution of discussions over time. In addition, the article selection process may have generated bias, and the bibliometric analysis may have been influenced by the keywords used in the research.

Despite these limitations, this study provides a useful overview of current trends and gaps in the literature on the topic. This review can serve as a starting point for future research and expanding knowledge on the importance of disclosing financial information about climate-related risks.

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