A scientometric analysis of ESG criteria implementation in the construction industry

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Abstract

This article examines the evolution of Environmental, Social, and Governance (ESG) principles, originally rooted in finance, analysing their status and future trends. Through scientometric analysis, it explores the global ESG research landscape, with a focus on the construction industry. The study utilizes Scopus as bibliographic database and VOSviewer and Biblioshiny as processing tools. This comprehensive exploration seeks to deepen the understanding of ESG principles and their integration into the construction sector, including real estate and infrastructure.

Keywords

Bibliometric; Environment; ESG; Governance; Infrastructure; Real Estate; Social

1. Introduction

Governments, investors, and consumers have long recognized the immense influence that corporate entities hold within society. These entities, through their operations and decisions, have influence over various facets of life. From the products and services to the creation of job opportunities, from shaping working conditions to safeguarding human rights, from environmental impact to fostering innovation, education, and training, corporate actions extend into numerous spheres. The cited reasons have prompted world citizens to demand more than mere corporate self-acknowledgment regarding their side effects. Corporate entities are expected to understand the positive and negative impacts they have on society and the environment, and to prevent, manage and mitigate any negative impacts, included in their global supply chains (Hahnkamper-Vandenbulcke, 2021). All of this has led to the need of companies to integrate non-financial factors in their decision-making process. Therefore, environmental, social and governance (ESG) considerations started to be considered when making investment decisions in the financial sector leading to more long-term investments in sustainable economic activities and projects. ESG stands for Environmental, Social, and Governance criteria, which are used to evaluate a company's operations and its impact on society and the environment. The concept originated as a way for investors to consider non-financial factors alongside financial ones when assessing the performance and sustainability of an investment. The acronym ESG, increasingly recognized beyond the realms of finance and 'sustainability,' is composed by three clear terms: Environmental, Social, and Governance. These represent three fundamental dimensions for verifying, measuring, monitoring, and supporting a company or organization's commitment to sustainability. Environmental considerations assess how a company behaves towards the environment, they might include climate change mitigation and adaptation, as well as the environment more broadly, for instance the preservation of biodiversity, pollution prevention and the circular economy. Social considerations are related to social impact and examine the relationship with the local community, individuals, employees, suppliers, and customers, therefore they could refer to issues of inequality, inclusiveness, labour relations, investment in people and their skills and communities, as well as human rights issues. The Governance of public and private institutions pertains to issues of corporate management guided by best practices and ethical principles, including management structures, employee relations, leadership transparency and executive remuneration (Bellini M, 2021). It is evident how through ESG, it's possible to build a corporate reputation upon which gain or lose investors' trust. Companies can adopt various strategies to enhance ESG performance, such as implementing more sustainable practices, promoting inclusion and diversity, embracing transparency and social responsibility policies, and integrating ESG factors into corporate decisions. ESG principles mark a paradigm shift, encouraging stakeholders to question traditional profit-centric models and promote a more holistic approach to evaluating corporate performance. ESG principles supply that holistic view extending sustainability beyond just environmental issues.

The foundational principle of ESG investing has historical roots spanning centuries, evident in religious decrees prohibiting investments linked to slave labour. Moving ahead to the 1960s and 1970s, the call for

divestment from South Africa emerged as an initial step to condemn the apartheid system in the country. Subsequently, numerous other societal issues prompted the adoption of socially responsible investment strategies. The roots of ESG can be traced back to various social movements, growing environmental awareness, and shifts in corporate responsibility that gained momentum in the latter part of the 20th century. However, it took several decades for such initiatives to be structured into precise regulations and methodologies, eventually evolving into the framework recognized today as environmental, social, and governance.

One of the first attempts to offer a framework for sustainability reporting it was the Global Reporting Initiative (**GRI**) founded in **1997**. The GRI is an independent, international organization that helps businesses and other organisations take responsibility for their impacts. Through the GRI Standards, organizations are also able to assess the economic, environmental, and social impacts of their suppliers, aiming to favour suppliers aligned as much as possible with the new sustainability principles. In 2016, GRI transitioned from guidelines to setting the first global standards for sustainability reporting (Global Reporting Initiative, no date). Several years later, in July **2000**, the United Nations Global Compact (**UNGC**) was launched by United Nations Secretary-General Kofi Annan, serving as a call to companies to align strategies and operations with universal principles on human rights, labour, environment and anti-corruption through a set of ten principles. Since then, the Global Compact has continuously assisted businesses in becoming part of the solution against poverty, inequality, and environmental issues. All of this has been achievable solely through ongoing adaptation and alignment with guidelines and objectives developed in the subsequent years. Today U.N.'s Global Compact is composed by more than 12,000 corporates based in over 160 countries (United Nations Global Compact, no date). In response to companies' need for guidelines and recommendations on how to better integrate environmental, social and governance issues in asset management, In January **2004**, Secretary General Kofi Annan wrote to the CEOs of 55 of the world's leading financial institutions inviting them to join in the initiative that led to the development of a report called: **Who Cares Wins** (WCW). The WCW is the first document ever which introduced the mainstream definition of ESG as known nowadays. The report provided several recommendations for integrating ESG issues in analysis, asset management and securities brokerages (Global compact, 2004). From 2004 to 2008, the UN Global Compact sponsored a series of closed-door-invitation-only events for investment professionals, to increase the industry's understanding of ESG risks and opportunities, and to improve integration of ESG into the investment decision making. Each event considered a particular element of ESG mainstreaming, and four more publications of the Who Cares Wins were published from 2005 to 2008 (International Finance Corporation, 2021):

- 2004 – Connecting Financial Markets to a Changing World
- 2005 – Investing for Long-Term Value
- 2006 – Communicating ESG Value Drivers and the Company-Investor Interface
- 2007 – New Frontiers in Emerging Markets Investment
- 2008 – Future Proof? Embedding ESG issues in Investment Markets

In **2006**, the UN Global Compact and the UNEP FI (United Nations Environment Programme Finance Initiative) launched the Principles for Responsible Investment **PRI**, consisting of six principles aimed at fulfilling the UNGC mission to promote ESG considerations (PRI, 2019). In **2014** the European Union adopted the **NFRD** (Non-Financial Reporting Directive). Under the NFRD listed companies, banks, and insurance companies with more than 500 employees must disclose reports detailing their implemented policies concerning non-financial issues such as social responsibility and employee treatment. This marks the inaugural requirement for companies to issue a non-financial statement as well (European Parliament & Council, 2014).

The NFRD provides considerable flexibility, specifically, it does not mandate the utilization of a specific non-financial reporting standard or framework. Therefore, companies have the option to incorporate a non-financial statement within their management report or, under specific circumstances, generate a distinct report. In addition, companies can use international, European or national guidelines to produce their statements such us: the Global Reporting Initiative (GRI). This flexibility underlines the growing necessity for officially recognized and universally accepted guidelines in this domain. The level of awareness of ESG issues among mainstream professionals has greatly improved since the launch of WCW, moreover they have been significantly influenced by various global initiatives such as the 17 Sustainable Development Goals (**17SDGs**), the Paris Agreement, and the European Green Deal (EGD). The 17 SDGs, established by the United Nations in **2015** as part of the **Agenda 2030**, serve as a universal call to action to end poverty, protect the planet, and ensure prosperity for all. The 17 goals establish a comprehensive framework for global sustainable development, addressing a wide range of social, economic, and environmental challenges. Each goal has specific targets aimed at achieving a more

sustainable and equitable world by 2030. ESG factors align closely with these goals, companies that incorporate ESG principles into their strategies consequently align their actions with the sustainable goals. An example of what just said are the: SDG 3-Social factors, SDG 13-Enviromental considerations, SDG 16-Governance. December 12, **2015**, marks another pivotal moment for sustainability and the planet. In Paris, the **Paris Agreement** was signed, achieving the first major universal and legally binding accord on climate change. This represents a strategic decision not only for the ESG trajectory but primarily for the planet. It involves committing to long-term containment of the global average temperature increase well below the 2°C threshold above pre-industrial levels and striving to limit this rise to 1.5°C. In accordance with the Paris agreement in **November 2019** the European parliament set the **carbon neutrality** goal within the 2050. Companies and investors integrating zero carbon goals into their strategies not only align with global sustainability objectives but also strengthen their ESG performance, enhancing their long-term resilience and value creation (AF&PA, 2014). A month later, the same year, in **December 2019** the European Commission has presented the roadmap for a climate-neutral Europe: The European Green Deal (**EGD**) (Attualità Parlamento Europeo, 2019). To overcome these challenges, the European Green Deal will transform the EU into a modern, resource-efficient, and competitive economy, ensuring (European Commission a, 2019):

- No net emissions of greenhouse gases by 2050
- Economic growth decoupled from resource use
- No person and no place left behind

Therefore, the Green Deal promotes a strategy for sustainable development, addresses environmental and social challenges, and requires effective governance to achieve set objectives. Therefore, it not only promotes ESG principles but also reflects the integration of these principles into EU policies and goals. In the context of sustainable finance in Europe, in **July 2019**, a tool was introduced to facilitate companies' financial transparency. Knowing that it is vital to direct investments towards sustainable projects and activities it was necessary to create a common classification system for sustainable economic activities called: "**EU Taxonomy**", realised in the context of the action plan on sustainable finance. As reported on the website of the EU: "The EU taxonomy allows financial and non-financial companies to share a common definition of economic activities that can be considered environmentally sustainable" (European Commission d, no date). Since large and listed companies must make a non-financial report, the EU taxonomy aims to support companies to better understand and report their sustainable investments which are investments contributing to an environmental or social objective. It does not set mandatory requirements on environmental performance for companies but aims to increase investment in projects necessary for achieving goals outlined in the European Green Deal. Therefore, both ESG and EU taxonomy aim to guide investments and corporate decisions towards greater sustainability.

The following year, the European Parliament approved the Corporate Sustainability Reporting Directive (**CSRD**), which came into effect in January **2023**. The main aim is to ensure greater transparency from companies. Specifically, the directive mandates all large EU companies to disclose report concerning the impact of their activities across various sustainability dimensions: impact on people, the environment, and the planet, with particular focus on sustainability-related risks such as climate change. The CSRD introduces rules that address previous shortcomings in existing legislation on the disclosure of non-financial information, thereby enhancing what was initiated by the NFRD in 2014. Companies that fall under the scope of the Corporate Sustainability Reporting Directive (CSRD) have to report in their annual reports to what extent their activities are covered by the EU Taxonomy and comply with the criteria set in the Taxonomy delegated acts (European Commission a, no date). The companies subject to this directive include the so-called "large undertaking" of the EU. Directive 2013/34/EU provides three possible criteria to determine whether a company is to be considered a 'large undertaking': namely the balance sheet total, net turnover, and the average number of employees during the financial year (European Parliament & Council, 2013). On July **2023**, the European Commission adopted the first set of European Sustainability Reporting Standards (**ESRS**), which mandate detailed reporting for EU companies falling within the scope of the CSRD. The standards cover the full range of environmental, social, and governance issues, including climate change, biodiversity, and human rights. They furnish investors with insights to comprehend the sustainability implications of the companies in which they invest (EFRAG, 2022). The ESRS establish a set of specific rules and directives that companies must adhere to in order to communicate their environmental, social, and governance impacts in a coherent and comparable way. This precision and uniformity make ESG aspects clearer, measurable, and comparable among companies. Therefore, the ESRS contribute to providing greater concreteness and tangibility to ESG factors.

The ESG concept was initially born in and directed towards the investment and finance sector. Given the evolving framework, the finance community has become increasingly aware and comprehending of the ESG concept and its implications on financial, non-technical reporting, and disclosure. However, there is still a restricted comprehension of ESG aspects related to technical products.

This challenge arises when ESG investors and financial entities must deal with non-financial organizations. It is evident that each of these two groups approaches ESG with varying levels of commitment, ambition, and motivation, potentially requiring the "translation of ESG dimensions" between them (CPEA EU ESG Working Group, 2023). The construction industry serves as a notable example in this context.

2. ESG in the Construction Sector

In this historical period, inevitably marked by the COVID-19 pandemic, buildings, their importance in daily life, and their fragilities have been under a spotlight, gathering widespread attention (European Commission, 2020). Moreover, buildings are responsible for around 30% of global final energy consumption and 26% of global energy-related CO2 emissions, from both energy consumption and industrial processes (International Energy Agency, 2022). In addition, the construction sector provides 18 million direct jobs and contributes to about 9% of the EU's Gross Domestic Product (European Commission b, no date). All these data underline how the construction industry has a significant and prominent part to play in shaping our homes, towns, and therefore communities. So, whether it's prompted by client and financial institution requirements or the broader society and local communities, the need for evident awareness and proactive measures, in the construction sector, regarding Environmental, Social and Governance performance is clear. The ESG consideration in the construction industry can be declined as following (Allianz, 2022):

- Environmental aspect revolves around topics such as: energy efficiency, carbon emissions, sustainable materials, water consumption, waste management, future proofing design.
- Social aspect focuses on inclusivity, diversity, community impact, accessibility, fair and safe labour practices.
- Governance aspect emphasizes transparency, stakeholder engagement, risk management and internal control

It can be generally asserted that the construction sector can be divided into two main categories: public procurements (infrastructure) and private works (Real Estate), each with its own dynamics, financing models, and regulatory frameworks. The former category, public procurements, typically involve infrastructure projects funded or commissioned by government entities, such as roads, bridges, public buildings, and utilities. These projects aim to serve the broader community and are subject to specific regulations and procurement processes. At the European level, in 2014, the European Commission released the new **Directive on Public Procurement 2014/24/EU** to replace its predecessor. According to this directive, contractors are mandated to consider the environmental, social, and sustainability impact throughout the entire project lifecycle. However, the directive specifies that due to significant differences across sectors and markets, mandatory requirements regarding environmental and social aspects are not established. Instead, only minimum standards and guidelines are set, thereby assigning individual nation-states the responsibility in this regard (European Commission, 2014). The following year, the 17 Sustainable Development Goals, through **Goal 12**, "Promote public procurement practices that are sustainable, in accordance with national policies and priorities," highlighted the non-negligible importance of the public procurement sector. In particular, Indicator **12.7.1** is officially titled as the "Number of countries implementing Sustainable Public Procurement policies and action plans" and it is supervised by the United Nations Environment Programme (UNEP). UNEP gathers biennial data from national governments to assess the progress of Sustainable Public Procurement (SPP) implementation. The key findings from UNEP's monitoring activities are presented in the second edition of the SPP report. The aim of the second edition of the **SPP by UNEP published in October 2021** is to provide an updated and comprehensive overview of global Sustainable Public Procurement practices and advancements. It therefore serves as a valuable resource for policymakers, stakeholders, and practitioners, offering insights and recommendations to further promote and enhance Sustainable Public Procurement initiatives worldwide (United Nations Environment Programme, 2021). A few months before the SPP, in **May 2021**, the European Commission released a communication titled: **"Social Procurement - A guide to considering social aspects in public procurement (second edition)."** This document aims to raise awareness about the potential benefits of socially responsible public procurements and practically explain the guidelines and the juridical system provided within the EU legal framework. It underlines how social aspects can be integrated throughout the entire public procurement process and offers numerous examples drawn from

actual practices implemented across the EU (European Commission, 2021). While the Commission's Communication focuses on social aspects like social justice, diversity, and inclusion, the UNEP's SPP aims to steer public entities toward adopting sustainable and environmentally respectful practices in their procurements. Both these documents reflect the growing interest in the EU regarding the integration of ESG criteria into public procurement processes to promote greater sustainability and social responsibility in public procurement practices.

On the other hand, private projects encompass real estate development, including residential, commercial, and industrial properties. These projects are initiated by private investors, developers, or companies and may involve constructing housing complexes, office buildings, shopping malls, or industrial facilities. Private projects are driven by market demands and profitability considerations.

At the European level, there are fewer initiatives available, primarily due to the driving force of private construction projects guided by market rules. In the real estate sector, reference can be made to the previously mentioned EU Taxonomy (2020). It can be employed in real estate investments to assess their environmental sustainability. One of the main limitations characterizing the construction industry and, more broadly, the assessment of ESG criteria across various investment sectors, is the lack of universal and particularly quantitative assessment systems. As clarified thus far, the ESG landscape is replete with guidelines and suggestions but lacks a common, precise, and quantitative evaluation system. Hence, one of the most used and comprehensive tools in the construction sector is represented by the Global Building Rating systems (**GBRS**). GBRSs measure buildings' sustainability level by multi-criteria assessment that considers both quantitative and qualitative indicators. All the indicators influence the finale score for the certification according to a weighting scale and when not explicitly, all criteria are given equal weights. Qualitative criterion points are assigned whether a specific environmental concern is applied or not, making this form of credit easier to evaluate. Quantitative criteria are those that are based on numerical data and are supported by scientific methodologies. Adding more quantitative indicators to the GBRS, such as Life Cycle Assessment (LCA) studies, can enhance the scientific validity of the credits while encouraging innovation in the design. Since Global Building Rating Systems are a multitude of systems developed by private companies, they unfortunately do not entirely address the quest for a common evaluation system. Moreover, the GBRSs are primarily revolved around environmental matters, mainly energy and climate issues. So, there is the need for a multi-dimensional ESG approach which takes into account the intricate connection between the three core components of ESG. Another issue, maybe related to the GBRSs prospective is that even if certain stakeholders on the supply side in the construction and real estate industry, such as manufacturers of building components and materials, may be familiar with ESG reporting demands, their disclosures often focus more on organizational activities than on the actual "final product" (the building). This means that their reporting may not sufficiently address the ESG aspects of the constructed building. The EU Taxonomy aims to bridge this gap trying to ensure that ESG considerations are integrated into the entire supply chain, from manufacturing to the final product (CPEA EU ESG Working Group, 2023).

3. Aim and methodology

After examining the concrete evolution of regulations over the years concerning ESG aspects, it is equally interesting to explore the same evolution from a different perspective: that of research and scientific publications. The aim of this article is to identify the impact, current state, and future trends of ESG principles. Once these principles have been assessed on a generical prospective, a vertical exploration in the building sector was performed. Both real estate and infrastructure field were investigated. The tool used to carry out the research was the scientometric analysis. Scientometric is a research methodology that utilizes quantitative tools to evaluate and examine the production, dissemination, and impact of scientific publications. The bibliometrics analysis could be enhanced with scientific maps representing the relationship among the data under study (Moral-Muñoz, 2020). Through appropriate bibliometric tools it is possible to reach an in-depth understanding of the evolution of research in a field. Therefore, the methodology not only provides an overview of the quantity of publications in a specific area but also enables the examination of knowledge dissemination, key authors, and contributors, as well as the citation network and relationships among various publications. The utility of scientometric analysis extends beyond the mere quantification of academic works. It provides a methodological framework for assessing the evolution of a field of study over time, revealing emerging interests, knowledge gaps, and future directions. Additionally, it aids in identifying the most relevant and influential publications, facilitating the retrieval of essential information for researchers, academics, and interested parties. Scientometric analysis employs various statistical and computational techniques to process and analyse large amounts of bibliometric data. Among the most common methods are citation analysis, co-citation

analysis, social network analysis, and the identification of the most frequent keywords. This approach allows to observe how ESG issues have been the subject of study, debate, and research in the academic landscape, offering a broader and more profound view of their importance and multidimensional impact in the contemporary world. The steps followed for the current paper can be divided into seven steps, each of which crucial for a comprehensive bibliometric study:

1. **Defining Research Objectives**: The first step consisted of Determine the specific objectives and scope of the bibliometric study (Naveen et al., 2021). Clarify what aspects of research impact, collaboration, trends, or other parameters are aimed to be analyse. The primary aim of this research is to elucidate the current state of ESG principles, originally conceived within the realms of finance and investments. This research attempts to outline the trajectory of these principles, shedding light on their birth, evolution, and permeation across various sectors. With a keen focus on the construction sector, aiming to discern the extent of integration and adherence to ESG principles within both the real estate and the infrastructures industries. Therefore, it is possible to divide the research into three topics. The most relevant about ESG and two more secondary topics characterized by the development of ESG within the Real Estate sector and Infrastructure.
2. **Key-Words Identification**: After conducting an initial comprehensive study on the subject, an identification of the key terms characterizing the topics under analysis has been accomplished. The keywords represent the foundation for conducting the third step and therefore, serves as base for the subsequent phases of analysis and exploration. The chosen keywords are:

- ESG Topic: "ESG", "Environment", "Social" and "Governance"
- ESG + Real Estate Topic: "ESG", "Environment", "Social" and "Governance" and "Real Estate"
- ESG + Infrastructure Topic: "ESG", "Environment", "Social" and "Governance" and "Infrastructure"

3. **Database Query**: the third step involves defining specific search parameters within bibliographic databases to retrieve relevant publication. Therefore, firstly it is necessary to choose the appropriate bibliographic databases based on their coverage and relevance to the research domain. For the aim of the research Scopus (from Elsevier) was used, since it is the largest abstract and citation database and covers a wider range of papers in the field of business and management (Aksnes & Sivertesen, 2019). Once the database is defined it is necessary to develop a well-structured search query using Boolean operators (AND, OR, NOT) which are used to correctly query the database and obtain data as coherent as possible to the research. Therefore, the final step is create a comprehensive and focused query combining the previously selected keywords through the Boolean operators.
   Final queries used on Scopus:

- ESG topic: TITLE-ABS-KEY("ESG" AND ("ENVIRONMENT*, SOCIAL AND GOVERNANCE")).
- ESG + Real Estate Topic: TITLE-ABS-KEY("ESG" AND ("ENVIRONMENT*, SOCIAL AND GOVERNANCE")) AND TITLE-ABS-KEY("REAL ESTATE")
- ESG + Infrastructure Topic: TITLE-ABS-KEY("ESG" AND ("ENVIRONMENT*, SOCIAL AND GOVERNANCE")) AND TITLE-ABS-KEY("INFRASTRUCTURE")

   Through this type of queries Scopus will provides all the texts present in its database containing in their title, abstract, or keywords the words in the brackets. The asterisk following the word "Environment" allows searching for all words that have "environment" as the root, thus simultaneously considering words such as "environment" and "environmental. It is important to underline that the final queries are the result of an iterative process aimed to reach a set of data without incoherent element.

4. **Data Filtering**: during the database query it is possible to set different filters in order to perform an initial screening of the data. The possible filters concern the publication year, subject area, language, and document type which allow filtering the data to remove texts that are not aligned with the ongoing research. The only filter used in the fourth step of this research is the one regarding the subject area. Just the following subject areas were selected: Business Management and accounting, Economic Econometrics and Finance, Social Science, Environmental Science, Engineering. The publication year, language and document type have not been set, as the research aims to provide the most comprehensive view possible, considering the entire scientific production with no limitation regarding years language or type of document.
5. **Exportation and Processing**: Once the data are obtained, it's possible to proceed to the processing phase. To further manipulate the data using external bibliometric tools it is necessary to export them. Scopus allows file exportation in various formats, the appropriate one is selected based on the type of bibliometric tool chosen for the analyses. For this research, two different tools were used: VOSviewer and Biblioshiny. VOSviewer is specialized in visualizing and exploring bibliographic networks, particularly co-authorship, citation, and keyword networks. It helps in identifying clusters, trends, and connections within large datasets, providing a comprehensive overview. Biblioshiny operates

within the R programming environment. It enables the creation of visual representations such as network maps, co-authorship graphs, and keyword clouds which are useful for understanding relationships and patterns within publications. Since it is recent, most of the analysis developed by previous software tools have been incorporated in it, it therefore represents one of the most complete bibliometric software (Moral-Muñoz, 2020). To carry out the analysis using VOSviewer and Biblioshiny the data were exported from Scopus in the ".CSV" format.

6. **Results' Visualization**: both the bibliometric tools used, allow to create visual representation for each type of data processing such us: network maps, co-authorship graphs, and keyword clouds.
7. **Findings' interpretation**: the last step is represented by the interpretation of the visualization findings.

The research was carried out in November 2023. To make the text more readable, the three topics object of the research: ESG in general, ESG related to the Real Estate world and ESG in relation to Infrastructure. From here on they will be referred to as: Topic1 (ESG), Topic2 (ESG + Real Estate), and Topic3 (ESG + Infrastructure). The datasets obtained from the queries previously reported and on which the processing phase was carried out are the following:

Table 1: Starting data

	N° of Doc.	Time span	Sources
Topic1	2298	2007-2023	815
Topic2	28	2008-2023	21
Topic3	41	2014-2023	40

4. Results

3.1. Publication per year

Table 2 illustrates a substantial increase in publications on the ESG topic (Topic1) over the years. Specifically, there's a noticeable surge starting from 2015/2017, with a consistent and steep rise continuing through 2023. This significant increase can be linked to the birth of the 17 SDGs in 2015 and the focus they have brought to issues strictly connected to ESG. Moreover, the substantial increase in publications in 2022 and 2023 suggests a heightened attention and urgency towards these issues, indicating a growing necessity to comprehend, discuss, and address challenges related to sustainability and corporate social responsibility. It is important to underline that as mentioned before the first document in which the "ESG" word appeared was Who cares Wins in 2004. Since Scopus database is specialized in academic and scientific publications it does not include it. As regarding Topic 2 and 3 it is possible to state that despite a few articles in 2014/2015 the official publication production started in 2018. This may be linked to the growing emphasis around those years on carbon neutrality, later declared as an official goal by the European Commission in November 2019. Since the building sector is responsible for 39% of global CO2 emissions (Adams et al., 2019), the issue of CO2 emissions stands as a common concern within the ESG principles and the construction industry. This increased scholarly output could be a response to the escalating attention toward sustainability goals, specifically the imperative to curb carbon footprints within the construction sector.

Table 2: Topics' Annual Production

Year	Articles		
	Topic1	Topic2	Topic3
2007	1	-	-
2008	3	1	
2009	1	-	-
2010	4	-	-
2011	9	-	-
2012	11	-	-
2013	12	-	-

2014	15	-	1
2015	30	2	-
2016	28	-	-
2017	32	-	-
2018	60	2	5
2019	109	1	1
2020	183	1	3
2021	265	4	3
2022	553	6	12
2023	982	11	16

From Table 2, it's evident how the subject of ESG is currently prominent and extensively explored through scientific production. However, a similar level of attention doesn't extend to its implementation within the construction sector. The substantial disproportion of the numbers in the table highlights that, ESG principles are still in their infancy within the realm of construction. This disproportion raises an initial alarm regarding the potential lack of directives, guidelines, and overall attention towards ESG principles within the construction industry.

3.2. Countries' Scientific Production and Collaboration

Table 3 reports the fifteen countries with the highest scientific production in the Topic1 field. In first place there is China (954 documents), in second place there is USA (675) and in the third place there is Italy (470).

Table 3: Countries' scientific production

Topic1	
Country	**N° of Documents**
CHINA	954
USA	675
ITALY	470
INDIA	356
UK	335
AUSTRALIA	262
MALAYSIA	255
SPAIN	233
SOUTH KOREA	194
GERMANY	180
CANADA	166
FRANCE	150
INDONESIA	141
BRAZIL	128

Results reported in Table3 perfectly align with the following graph generated by Biblioshiny about the correspond author's Countries, Figure 1, where "SCP" stands for Single Country Publications and MCP for Multi Country publications.

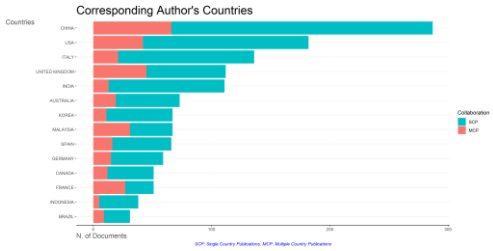

Figure 1: Topic1 Author's countries

Figure 2 shows the collaboration map between countries. The highest frequency of collaboration is between USA and United Kingdom followed by Chin and USA, China and Hong Kong Italy and United Kingdom.

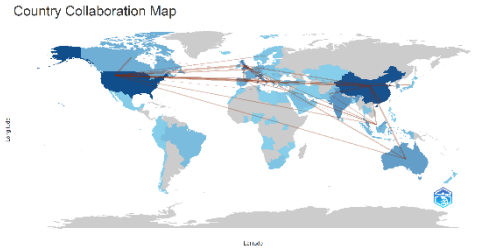

Figure 2: Countries' collaboration

3.3. Co-Occurrence Keywords Network Visualization

A co-occurrence keywords analysis was conducted on topic1, using VOSviewer, including both authors' keywords and index keywords. The minimum number of occurrences of a keyword was settled at 40 and out of 6660 keywords only 44 met the threshold. A .txt file was used to avoid synonymous caused by words that appeared in both singular and plural form, such as: investment and investments, stakeholder and stakeholders, esg score and esg scores. Moreover the .txt file was used also to avoid repetition due to the use of acronyms, such as: csr and corporate social responsibility, sdg and sustainable development goals. Once the analyse is run the software automatically displays a network visualization in which each keyword correspond to a label and a circle. The size of the latter elements is determined according to the weight of the item they represent (Van Eck & Waltman, 2023). VOS stands for visualization of similarities (Van Eck & Waltman, 2006), therefore objects are displayed in such a way that, the distance between any pair of objects reflects their similarity. Lines between items represent links and the thickness of the lines represent the link strength. The colour of an item is determined by the cluster to which the item belongs. Clusters are created by default and each item can belong to only one cluster. Figure 3 shows the Network visual representation of Topic1 (ESG). The map is composed by 43 items, 808 links, a total links strength equal to 6692 and 4 Clusters.

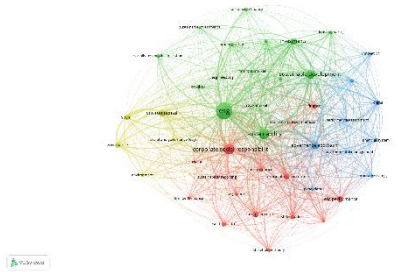

Figure 3: Topic1 - Keywords Network Visualisation

The biggest cluster are the red one, Cluster 1, and the green one, Cluster 2 each composed by 15 items. The keyword with the highest occurrence in **Cluster 1** is Corporate Social Responsibility (CSR), which refers to actions taken by a company at least partially beyond the firm's direct economic interest (Pollman, 2019). Considering both the economic developments affecting the public welfare and the obligation towards nature and human values, the CSR is more than a simple vehicle used to enhance or protect firms' reputation. Therefore, CSR represents an essential starting point towards the ESG principles. The

words following CSR in terms of occurrence are “ESG performance” (occurrence: 148) and “Financial performance” (occurrence: 122). The link between these three keywords is based on the understanding that CSR leads to enhanced ESG performance, which in turn translates into improved Financial Performance. Beyond the words previously analysed within cluster 1, terms like ESG disclosure (occurrence: 92) and Stakeholders (occurrence: 88) emerge, representing a theme strictly linked to CSR communication. A company's strong financial and ESG performance can become pivotal and indicative during decision-making phases, but only if these performance levels are clearly declared and communicated to stakeholders. Without robust ESG disclosure, any efforts by a company to adhere to ESG principles would be rendered futile (Ihlen et al., 2011).

As regarding **Cluster 2,** the most influent keywords are: ESG (occurrence: 784), Sustainability (occurrence: 359), Sustainable development (occurrence: 282), and Investments (occurrence: 165). These word combinations precisely summarize the investment philosophy based on ESG principles, wherein a good investment hinges on a robust economy, which is based on a healthy society, itself contingent upon a sustainable planet. Moreover cluster 2 is full of environment related terms such as: climate change, covid-19, SDG.

Cluster 3 coloured in blue, is composed by 9 items. The word with the highest occurrence is “Governance approach” (Occurrence: 191). The centrality of corporate governance and so of the governance approach in the transition toward sustainability is evident in the United Nations document "Who Cares Wins”. According to which: “corporate governance and risk management systems are crucial prerequisites to successfully implementing policies and measures to address environmental and social challenges”. Corporate governance can be defined as a framework which regulates the exercise of power in the corporation (Caprio et al., 2012). Therefore, the governance approach stands as one of the key features of a company that can be manipulate in order to reach a substantial and social change. The next two words with the highest occurrence are respectively: Environmental economics (occurrence: 59) and Environmental management (occurrence: 44). These terms represent the close correlation between a robust governance approach and a sustainable economy. It's indeed plausible to assert that poorly governed companies cannot be sustainable (Camara & Morais, 2022).

Cluster 4 coloured in yellow is the core of the ESG. It is composed by 4 items each of which represents a pillar of the ESG principle. The keywords of cluster 4 are: Environment/Environmental (occurance:53/194), Governance (occurrence: 101), Social (occurrence: 113).

The same analysis was conducted for Topic 2 and 3. Since the number of total documents was considerable smaller than the one of Topic1, the minimum number of occurrences of a keyword was settled at 3. In the case of Topic2 9 keywords met the threshold as shown in Figure 4. In the case of Topic3, 8 keywords met the threshold as shown in Figure 5.

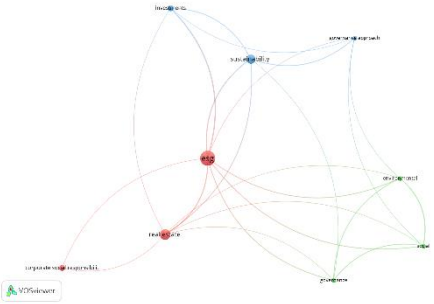

Figure 4: Topic2 keywords map

As regarding Topic2 (ESG + Real Estate) the visualization map is composed by 9 items, 3 clusters, 23 links and a total link strength: 40. If not considering the words “ESG” and “real Estate” the keyword with the highest occurrence is “Sustainability”. Highlighting a sector within real estate characterized by a greater scientific output concerning sustainability topics.

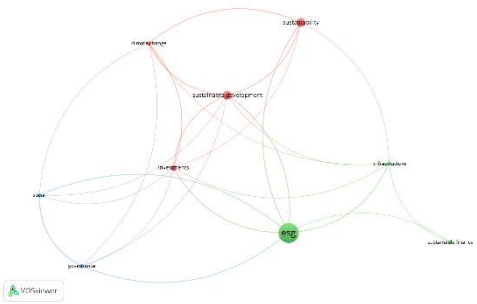

Figure 5: Topic3 keywords map

As regarding Topic3 (ESG + Infrastructure) the visualization map is composed by 9 items, 3 clusters, 25 links and a total link strength: 38. If not considering the words "ESG" the keywords with the highest occurrence are "Sustainable Development" and "Sustainability". Highlighting, once again as the building sector in general is characterized by a greater scientific output concerning sustainability topics. Results on topic 2 and 3 underlined how to date the terms ESG and Sustainability are often used as synonyms. The delineation between Environmental, Social, and Governance (ESG) initiatives and other sustainability frameworks, is frequently blurred. This lack of clarity results in confusion among market participants. Despite ESG being the favoured framework for engaging stakeholders on sustainability matters, a widely accepted definition for the ESG acronym and its boundaries remains elusive. Consequently, ambiguity persists in the utilization of the term and the implementation of its foundational concept across diverse sectors and stakeholder contexts (CPEA EU ESG Working Group, 2023).

3.4. Co-Occurrence Keywords Overlay and Density Visualization

The co-occurrence keywords analysis can be displayed through three different visualizations. The network visualization showed in the previous chapter, the overlay visualization (Figure 6) and the density visualization (Figure 7). The overlay visualization is identical to the network visualization except that, items are coloured differently. In this case, each item is associated to the colour of its average publication year. Whereby default colours ranges go from blue (less recent date) to green to yellow (most recent date) (Van Eck & Waltman, 2023). The map in Figure 6 supports what said in chapter 3.1.

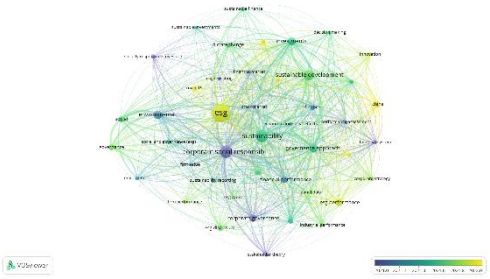

Figure 6: Topic1 - Keywords Overlay Visualisation

In the Density Visualisation, each point has a colour which indicates the density of items at that point. The default colour spectrum spans from blue through green to yellow. Points tend toward a yellow when

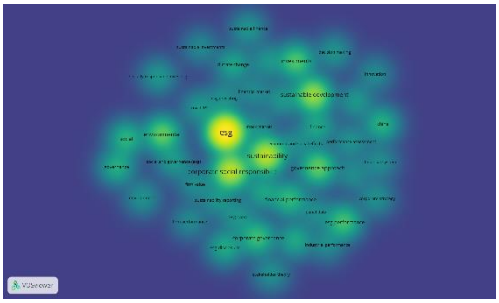

Figure 7: Topic1 – Keywords Density Visualisation

surrounded by a higher quantity of items with increased weights. On the contrary, they lean towards a blue shade when neighbouring items are fewer in number with lower weights. (Van Eck & Waltman, 2023). Figure 7 highlights the relationship between: “ESG”, “Corporate Social Responsibilities” and “Sustainability”.

3.5 Words’ frequency over time

The toll "words frequency over time" in Biblioshiny allows researchers to track and visualize how the occurrence of specific words or themes in publications evolves across different years. Figure 8 shows the evolution over year of the six keywords characterized by the highest frequency. It is interesting to underline that, despite the conducted research was focus on the term ESG not only it is not the term with the highest occurrence, but it started to consistently appear in publications relatively late. That is because ESG investing evolved over time from the earlier concept of CSR (MacNeil & Esser, 2021). The latter term CSR is indeed characterized by a higher frequency, and it also appeared earlier in the scientific production.

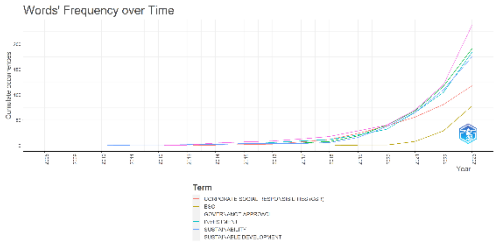

Figure 8: Word’s frequency over time

3.5. Thematic map Evolution

By applying a clustering algorithm on the keyword network, Biblioshiny allows to create thematic maps showing the evolution of bibliographic data over time. It helps visualize how certain topics or keywords have been represented in scholarly publications across different years or periods. Moreover, it is possible to divide the time span in different time slices and to study and plot the topic evolution. The time span is divided according to the distribution of publication per year. The thematic map evolution was carried out on Topic1 (ESG) and it was also used a .CSV file to eliminate synonymous. According to the articles’ annual production (Chapter 3.1), two cutting point: 2018 and 2021, were setting and the time span was divided into two three time slices: Time slice 1 from 2007 to 2018, Time slice 2 from 2019 to 2021 and Time slice 3 from 2022 to 2023. The selected years used as reference in order to divide the timespan under analysis are both characterized by a significant surge in the annual production article. As shown in Figure 9, through this type of analysis is possible to highlight the tendencies of some topics to merge, or of a topic to split into several themes.

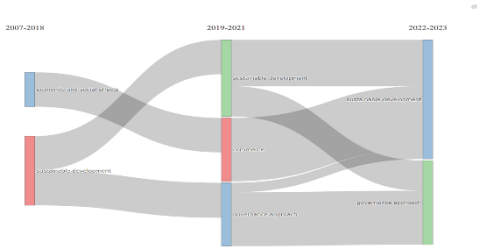

Figure 9: Time slices of the Thematic map Evolution

Considering the initial "time slice," spanning from 2007 to 2018 (Figure 7), a direct influence from addressed objectives and directives at the European and/or global levels becomes evident. As highlighted in the introductory paragraph, notable events within this time frame include the European DIRECTIVE/2014/95/EU Article 19° NFRD, the 17 SDGs, and the Paris Agreement. The European directive might be accountable for the blue cluster, pertaining to Economic and Social effects, while the sustainable goals and/ the Paris Agreement have undoubtedly driven increased interest in sustainability, thus reflecting the presence of the red cluster on Sustainable Development. It's interesting to notice that, even within the initial time slice, the cluster associated with Sustainable Development resides within the bottom right quadrant, indicating its established status as a transversal theme.

Time slice 2, spanning from 2019 to 2021 (Figure 11), once again mirrors the various European and non-European initiatives characterizing the period under examination. As shown in Figure 9, this period is distinguished by three clusters. The Sustainable cluster of Time slice 1 is now divided into two cluster: the sustainable development one and the governance approach. The sustainable development cluster has shifted towards the centre of the graph, thereby transforming into a more central theme. The governance approach cluster appears in the upper left part of the chart representing a new motor theme. The two defining terms within the cluster, Sustainable Development and governance approach, are strictly linked. Their bond can be justified through SDG 12.6.1, elucidating how operating within a sustainability framework necessitates consistent reporting, consequently encouraging companies' responsibility through a good governance approach (SDG 12 HUB, no date). As reported in Figure 6, the Sustainable Development cluster is divided into two distinct clusters: the previously analysed green cluster and the blue cluster, which joined the notions of sustainability with the governance approach. Two

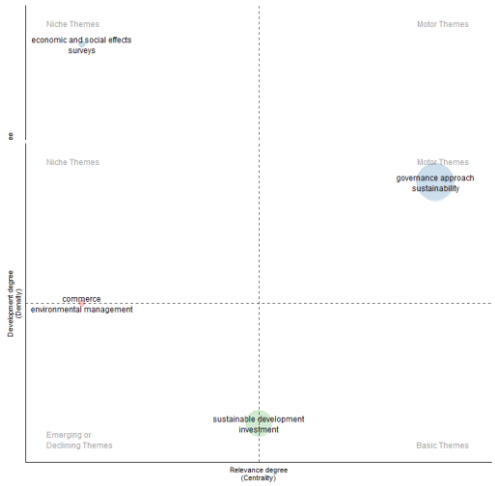

Figure 11: Time slice 2

interdependent terms, whose correlation has been discussed in previously paragraphs. In the Time slice 2, another conspicuous cluster emerges, incorporating the term "Europe." This cluster wholly embodies the European Union's commitment to pursuing sustainability and acting as a leader for other nations in this attempt (European Commission b, 2019)

As illustrated in Figure 6, during time slice 3, all clusters converge into merely two primary themes: Sustainable development and governance approach. Although the reference timeframe includes only two years, they notably represent peak periods of scientific output. It's interesting to observe that among the defining principles of ESG, only the governance approach appears. This focus on the governance approach signifies an evolution towards an correct interpretation of the ESG acronym during the last years.

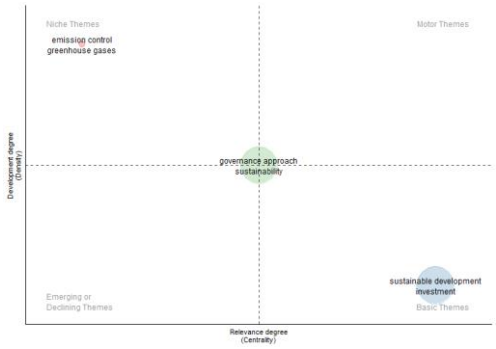

Figure 12: Time slice 3

According to author Camara (2022), the pivotal shift from CSR to ESG involves a true "systematic interaction" between ESG and the corporate governance of companies (and vice versa). This results in a corporate governance assuming the role of an essential tool in pursuing sustainability objectives, thereby shaping itself in alignment with these goals. In essence, corporate governance operates not solely as one of the three investment criteria (ESG), but serves to prepare, adopt, and enforce decisions regarding social and environmental issues.

5. Conclusions

All the introduced regulation and guidelines regarding the understanding, disclosure, and rating of the ESG commitments show a growing demand for sustainable assets among both clients and investors. Similarly, it is evident that companies, considering the construction industry too, are increasingly recognizing their role and responsibilities in adhering to ESG principles. Despite a shared awareness of the importance of prioritizing social and environmental aspects through effective governance approaches, corporate decision-makers are less confident about how they can achieve these priorities. This uncertainty may be attributed to the absence of official and unified regulations and rating systems that would facilitate the evaluation of ESG criteria. A vital step towards a robust sustainability reporting framework in the EU and globally are the European Sustainability Reporting Standards (ESRS), which will be mandatory from January 2024.

Another critical aspect regarding ESG criteria is that, up to now, the predominant focus has been on environmental issues, particularly in addressing the risks and opportunities associated with climate change mitigation. The development of environmental reporting practices and standards is progressing rapidly. In moving forward, it is crucial for companies to broaden their focus beyond environmental considerations and actively engage in addressing social issues. The establishment of comprehensive regulations and standardized rating systems for evaluating ESG criteria can provide the necessary framework to guide corporate decision-makers. By fostering a more holistic and balanced approach to ESG principles, businesses can contribute meaningfully to sustainable development and social equity, aligning their operations with the broader goals of a responsible and ethical corporate landscape.

Author Contributions

Conceptualization, V.V.; data curation, C.P.; formal analysis, C.P. and V.V.; investigation, V.V. and C.P.; methodology, C.A., C.P. and V.V.; resources, C.A., C.P. and V.V.; software, C.P.; supervision, C.A. and V.V.; validation, C.A.; visualization, C.P. and V.V.; writing, C.P.; writing-review & editing, V.V. and C.A. All authors have read and agreed to the published version of the manuscript.

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