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Green FinTech Innovation as a Future Research Direction: A Bibliometric Analysis on Green Finance and FinTech

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Abstract: In alignment with the UN's 17 Sustainable Development Goals and the UN Global Compact's Ten Principles, nations have established platforms for environmental sustainability through financial routes, spotlighting green finance and FinTech. While there have been tangible advancements, academic discourse on these topics remains dispersed and lacks cohesion. Observing the frequent overlap in the implementation of green finance and FinTech, this paper offers a bibliometric analysis of research concerning green finance and FinTech up to 2022. The primary objective of this study is to identify some of the most pertinent research in these fields. The results assist in delineating several future research directions, including a greater focus on the investment facet of green finance, the application facet of FinTech, the regulatory environment in some developing countries, and an emphasis on Green FinTech research based on information from the Web of Science database.

Keywords: Green FinTech; bibliometric analysis; green finance; FinTech

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1. Introduction

A study by the Yale Program on Climate Change Communication (YPCCC) revealed that 33% of Americans are alarmed about global climate change, marking a 15% increase compared to 2017 [1]. To counter the negative effects of climate deterioration, the United Nations (UN) introduced 17 sustainable development goals and the Ten Principles of the UN Global Compact. Environmental protection, climate change, and sustainability are among the focal points. At the 2021 UN Climate Summit COP26 (Since 1995, the UN has been calling annual global climate summits to tackle global climate changes. The meeting was called the Conference of the Parties (COP). In 2021, the 26th Annual Summit took place in Glasgow, United Kingdom), global leaders agreed to expedite the phase-out of inefficient fossil fuels and to halt deforestation. Countries globally are tasked with highlighting sustainable development's importance, executing actionable steps, and aiding organizations in launching green, sustainable projects in reaction to global climate change.

Numerous corporations are strategizing to confront climate risks in line with the UN's directives. Pioneers in this movement include some countries' central banks, which have founded the Central Banks and Financial Supervisors Network for Greening the Financial System (NGFS) and the Sustainable Banking and Finance Network (SBFN) [2]. The NGFS, inaugurated at the 2017 Paris One Planet Summit, began with eight central banks and supervisory authorities but grew to include 121 members and 19 observers by October 2022 [3]. Celebrating its decade-long journey, SBFN serves as a platform for financial sector regulators and industry associations from various emerging markets to exchange knowledge and bolster capabilities pertaining to sustainable finance. Currently, it encompasses 62 member countries, 73 member institutions, and oversees USD 43 trillion in banking assets [4].

Beyond central banks and major financial entities, numerous businesses have been spurred to devise green financial instruments, like green bonds, to back eco-friendly

projects. For instance, during the COP16 (The 2010 UN Climate Change Conference (COP16) is the 16th Annual Summit that took place in Cancún, Mexico) Accord, leaders from developed nations pledged to collaboratively mobilize USD 100 billion annually by 2020 to aid developing nations in climate action through climate bonds. Prompted by this initiative, companies across different nations have made considerable strides in introducing green bonds and concentrating on their environmental, social, and governance (ESG) investment and performance. Growing corporate environmental consciousness has also shone a spotlight on the efficacy of green financing in supporting firms' eco-friendly endeavors. With green financing being a relatively novel concept, much of the research has centered around green bonds. Studies by Tang and Zhang [5] and Flammer [6] suggest companies experience augmented stock prices and institutional ownership post-green bond issuance. There is also a notable improvement in stock liquidity post-issuance, benefiting existing stakeholders. Maltais and Nykvist [7] attribute the swift expansion of the green bond market to the effective alignment between issuers and investors. The allure of green bonds is not necessarily rooted in potential high returns or minimal risks but in the issuer's commitment to green initiatives. However, there are prevalent trust issues surrounding green bond purchases [6], and firms grapple with challenges and elevated costs when processing extensive ESG data [8]. To address these issues, FinTech, which leverages innovative technology to enhance traditional financial service delivery, has been introduced [9,10].

FinTech bolsters systems and fosters trust in procuring green financial instruments. For instance, the integration of the Internet of Things (IoT) with blockchain can transition tangible ESG data into a reliable format [11]. Blockchain characteristics, like distributed networks, decentralization, and smart contracts, can facilitate automated, trustworthy ESG data reporting, subsequently slashing due diligence expenses for investors and the general public. Moreover, utilizing artificial intelligence to track sustainability metrics can diminish a company's financial burdens for environmental and ecological projects [12,13].

In recent times, several nations have made commendable advancements in incorporating FinTech innovation and technology into green finance to cultivate sustainable communities. In Europe, the Green Digital Finance Alliance and the Swiss Green FinTech Network unveiled the world's inaugural Green FinTech taxonomy on 30 November 2021. This taxonomy categorizes Green FinTech solutions into seven categories (The seven taxonomies are green digital payment and account solutions, green digital investment solutions, digital ESG data and analytics solutions, green digital crowdfunding and syndication platforms, green digital risk analysis and insure-tech, greenal digital deposit and lending solutions, and green digital asset solutions). The Monetary Authority of Singapore initiated Project Greenprint in December 2020 to capitalize on FinTech to foster a green finance ecosystem, accumulate funds, oversee sustainability commitments, and evaluate its influence. The Greenprint initiative has tested utility platforms that distribute ESG data, amass ESG data, store vetted ESG data in a blockchain-oriented registry, and establish an open marketplace to bridge FinTech enterprises with green issuers and investors.

Given the escalating prominence of green finance and FinTech in the professional realm, these subjects have also emerged as prominent themes in academic discourse. Nevertheless, despite the growing intersection between these two domains, literature comparisons and analyses regarding green finance and FinTech remain scant. Academics ought to incorporate actual practices into their research, but prior studies on the research landscapes of green finance and FinTech are fragmented. A holistic understanding or conclusion about these dual research areas is essential, highlighting the present practical necessity for FinTech to consistently bolster green finance.

To address previous disjointed efforts in the green finance and FinTech literature, this study uses a bibliometric analysis approach to answer the following research questions: (1) How is the literature on green finance and FinTech evolving? (2) What are the important topics, and how are they organized in both areas? (3) From which countries do the authors who engaged in further research on these two topics originate? (4) What synergies are

provided by these two topics regarding bibliometric results? We adopted bibliometric analysis instead of other similar tools, such as meta-analysis and systematic review, for two major reasons. First, bibliometric analysis is appropriate for topics with a broad scope and large data that do not allow for manual review. Moreover, bibliometric analysis permits both quantitative and qualitative analysis, while meta-analysis only allows for quantitative and systematic reviews to be analyzed qualitatively [14]. Therefore, bibliometric analysis is appropriate for this study. Specifically, we have adopted performance analysis and science mapping to systematically review the previous literature on green finance and FinTech.

The recent literature has witnessed a surge in studies intersecting finance, technology, and sustainability. Darko et al. [15] conducted an exhaustive mixed-methods review of 995 publications, offering a comprehensive overview of green finance trends, such as green bonds, green credit, and carbon investments. Concurrently, works like those by Yang et al. [16] and Alkhwaldi et al. [17] investigated the interplay of FinTech in regional contexts, from China's green finance initiatives to FinTech user acceptance in Jordan post-COVID-19. Furthermore, methodological insights from Muchiri et al. [18] provided a bibliometric perspective post the Paris Agreement, paralleled by Nasir et al. [19] who outlined FinTech's transformative societal and environmental role. However, while these studies offer depth and breadth on green finance or FinTech individually, our research carves a distinct niche. Instead of reiterating green finance's fundamentals, we focus on the synergy between green finance and FinTech's innovative capacities. This approach not only broadens the global green finance perspective but also delves into the dynamism and complexities at their intersection, revealing the untapped opportunities and challenges in this interdisciplinary domain. Our study thereby presents a novel integrated research agenda, positioning itself uniquely in the extensive literature and pushing the boundaries of our understanding of the collaborative potential of green finance and FinTech. We summarize the findings based on the results of bibliometric analysis and provide discussions and conclusions on the future research development of green finance and FinTech, especially the new research stream integrating the two areas, which is of paramount importance.

Section 2 below discusses the methodology adopted in this study. Section 3 provides an integrated discussion of the findings based on the bibliometric analyses of both green finance and FinTech, followed by corresponding research agendas based on the relevant findings. Finally, Section 4 concludes this study.

2. Methodology

We used bibliometric analysis to answer the research questions. Bibliometric analysis refers to the application of a quantitative approach to bibliographic data to gain insights into topics by mapping and visualizing the spatial representation of the interconnection and distinctiveness among different articles and topics [14,20,21]. Thus, we collected literature on these two topics and conducted a performance analysis and science mapping [22–24].

To initiate the bibliometric analysis, we selected the Web of Science (WoS) Core Collection to conduct a keyword search for the literature. WoS offers high-quality peer-reviewed articles and has been widely used in the literature [25]. Moreover, WoS provides better citations than Scopus [26]. Our current bibliometric analysis examines the relationships between keywords or citations, which justifies the selection of WoS. Subsequently, we used keywords to extract two sets of relevant articles. The keywords 'fintech' OR 'finance* technology' were used for the first set, and ('green finance') OR ('ESG' OR 'environment* social governance') for the second set. We imposed specific criteria to identify relevant articles. All papers had to match the following indices: Social Science Citation Index, Science Citation Index Expanded, Emerging Source Citation Index, and Arts and Humanities Citation Index. Additionally, articles had to be published by 2022, written in English, and categorized under Business Finance, Management, Business, or Economics disciplines. This aligns with Zhang et al. [27] who assert that green finance or related topics should be discussed in finance journals. Ultimately, we obtained 776 articles on FinTech and 1428 articles on green finance or ESG (GF/ESG). Our cluster analysis was executed using a qualitative ap-

proach, providing a deeper understanding of the research articles through the exploration of underlying motivations and meanings. This approach also allowed us to recognize any contextual factors influencing the definition of clusters. We used the Bibliometrix package of R, which includes Biblioshiny [28], for performance analysis. VOSviewer 1.6.18 was employed to develop and analyze the visualization networks [29].

3. Findings and Discussion

3.1. Total Publications

Figure 1 displays the publication trends in the FinTech and GF/ESG literature. The publication of FinTech literature began in 1999, a time characterized by intense speculation and investment in internet-related companies during the late 1990s and early 2000s. This era is known as the dot-com bubble, which was marked by the emergence of a slew of innovative internet-based companies. These companies thrived due to the rapid expansion of the internet and the growing number of users coming online. Despite its eventual crash, the dot-com bubble was pivotal in promoting the growth of technological applications and innovations. It resulted in substantial investment in infrastructure, advancements in technology, and fueled the rise of e-commerce. However, the prosperity of Internet technology waned with the burst of the dot-com bubble in the early 2000s. Computer science researchers shifted their focus away from technical applications, and there was diminished research attention in this domain after the early 2000s. The emergence of blockchain in 2015 redirected researchers' emphasis towards the application of technology in finance. The ascent of cryptocurrency further enriched the research environment for FinTech, leading to a noticeable increase in publications after 2015, with a pronounced spike post-2017. Conversely, GF/ESG publications saw steady growth but experienced a sharp rise after 2017. This led to a 38.54% annual growth rate for FinTech publications. In terms of the GF/ESG publication trend, even though the inaugural two publications emerged in 1999, there was an exponential surge from 2016, peaking in 2022. The proliferation of publications pertaining to GF/ESG can be linked to the sustainable development goals (SDGs) and the participation of 192 parties in the Paris Agreement during that time. The annual growth rate of GF/ESG stands at 35.35%.

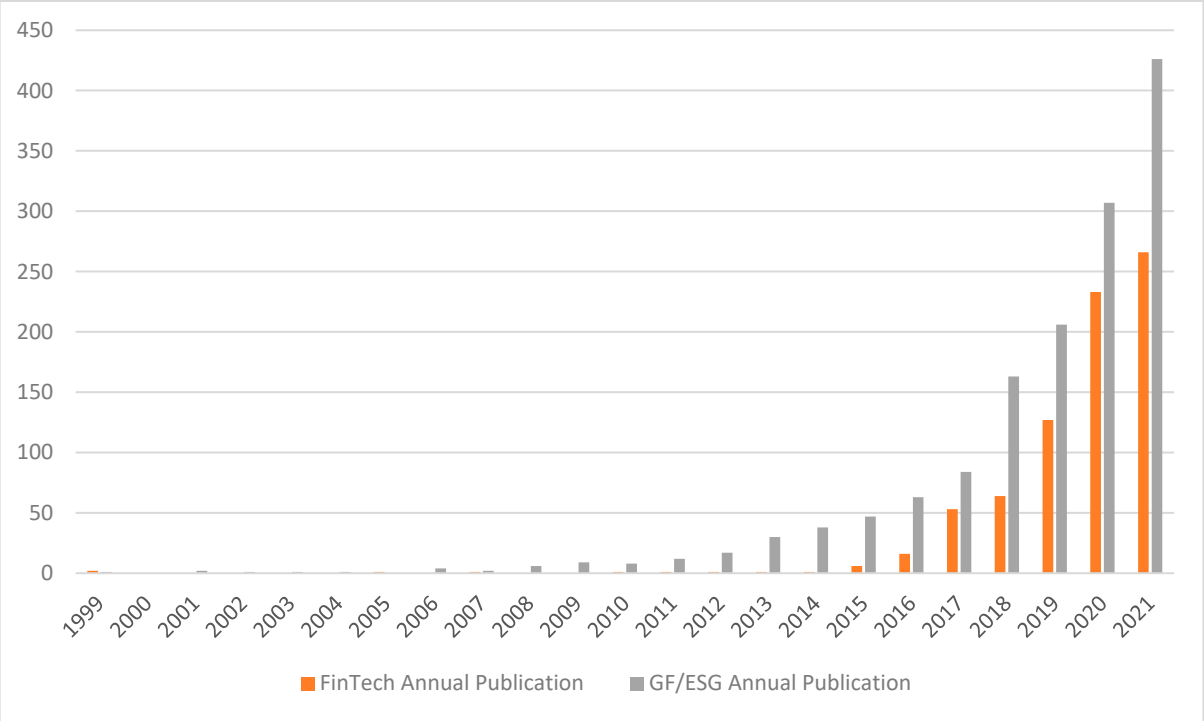

Figure 1. Annual Publication of FinTech and GF/ESG Literature.

3.2. Keywords Analysis

Table 1 lists the top 20 keywords used. In GF/ESG, researchers have focused more on impact issues than on identifying investment opportunities. The *impact*-related keywords *environmental*, *sustainability*, *social*, and *performance* are in the top ten, as they ranked second, third, sixth, and ninth, respectively. The publications with these keywords are all related to the impacts on stakeholders, for example, the environment, company, or society. The *investment*-related keywords, such as *ESG investing*, *financial performance*, and *green bonds*, followed. Researchers in FinTech have focused on the *applications* of the technology. Keywords such as *blockchain*, *banking/bank*, *financial*, and *innovation* are among the top ten. As such, researchers in the FinTech literature are keen to look for novel ways to shape or advance the finance industry's future. The most frequent words for the GF/ESG and FinTech literature show that of the important topics researched in these two domains particularly, GF/ESG researchers were keen on studying the impacts, while the technology of applying FinTech was the main focus of the FinTech literature.

Table 1. The most frequent words for GF/ESG and FinTech literature.

Rank	GF/ESG		FinTech	
	Words	**Occurrences**	**Words**	**Occurrences**
1	ESG	345	Fintech/Financial technology	420
2	Corporate social responsibility	187	Blockchain	48
3	Environmental	141	Banking/bank	42
4	Sustainability	139	Cryptocurrency	41
5	Green finance	104	COVID-19	35
6	Social	87	Peer-to-peer lending	32
7	Corporate governance	76	Financial	28
8	Sustainable development	64	Innovation	28
9	Performance	63	Artificial intelligence	26
10	COVID-19	61	Bitcoin	26
11	Governance	55	China	23
12	Disclosure	48	Machine learning	21
13	ESG investing	47	Risk	21
14	ESG performance	44	Technology	21
15	Financial performance	44	Trust	21
16	Sustainable finance	39	Crowdfunding	19
17	Climate change	37	Finance	17
18	ESG disclosure	31	Finance literacy	17
19	Sustainable reporting	31	Digital finance	16
20	Green bonds	30	Regulation	16

3.3. Co-Word Analysis

The co-word analysis in Figures 2 and 3 offers another perspective for understanding the key topics in the GF/ESG and FinTech literature. It assumes that when an author's keywords cluster together, they should have a thematic relationship with one another [14]. Of the 1428 articles analyzed in the GF/ESG literature, we obtained 3330 keywords, with 137 meeting the minimum threshold of five occurrences. The keywords in Figure 2 primarily fall into four clusters: *investments* (e.g., *corporate sustainability*, *ESG ratings*, and *socially*

responsible investing), *sustainability* (e.g., *environmental, social, and governance*), *reporting and disclosure* (e.g., *financial performance*, *ESG performance*, *disclosure*, and *integrated reporting*), and *impact* (e.g., *sustainable development*, *green finance*, and *climate change*). These results indicate that when scholars in the GF/ESG domain study *corporate sustainability*, they often include discussions of *ESG ratings* and *socially responsible investing* in the *investments* cluster. Similarly, in the *reporting and disclosure* cluster, scholars frequently discuss *financial performance*, *ESG performance*, *disclosure*, and *integrated reporting* together.

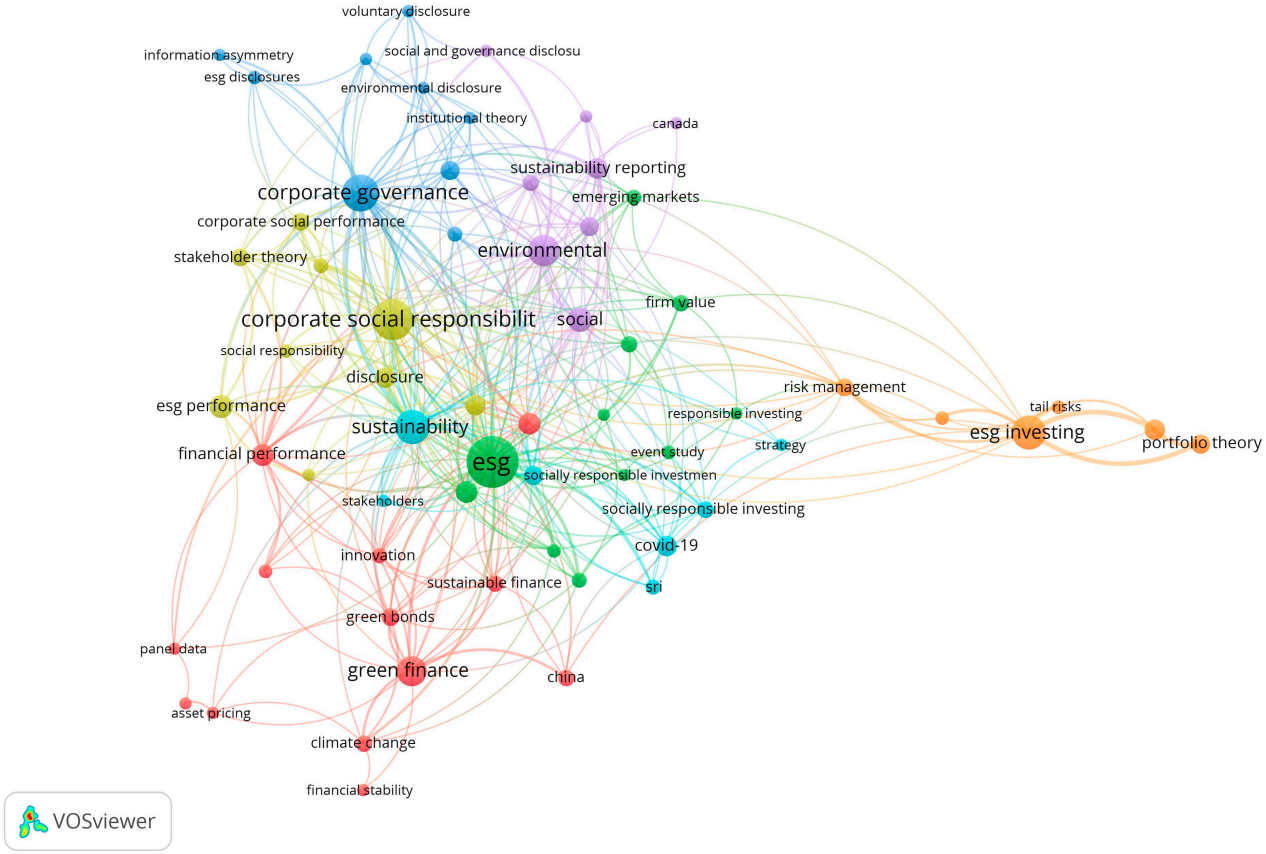

Figure 2. Co-word analysis for GF/ESG literature.

Figure 3 displays the co-word analysis of the FinTech literature. We analyzed 776 articles, and 134 out of 3269 keywords met the minimum threshold of five occurrences. The research topics related to FinTech were further divided into *applications* (e.g., *financial inclusion*, *digital finance*, *P2P lending*, and *digitalization*), *digital assets* (e.g., *cryptocurrencies*, *bitcoin*, and *information asymmetry*), *artificial intelligence and data analytics* (e.g., *machine learning* and *big data*), *innovation* (e.g., *crowdfunding* and *financial innovation*), and *financial institutions and markets* (e.g., *competition*, *Islamic banks*, and *Indonesia*). Thus, FinTech researchers often explore *financial inclusion*, *digital finance*, *P2P lending*, and *digitalization* together when the literature is in the *applications* cluster, while *machine learning* and *big data* often appear together in the *artificial intelligence and data analytics* cluster.

Some implications can be drawn from the results of the keywords and co-word analysis related to GF/ESG. First, scholars should focus on the investment aspect of green finance. Based on the results of the bibliometric analysis, considerable attention has been paid to investigating the impacts of green finance or ESG research, as the keywords related to sustainability, social, and performance were highly ranked. However, topics such as portfolio construction, performance, and ESG integration in the investment realm of green finance should receive more attention.

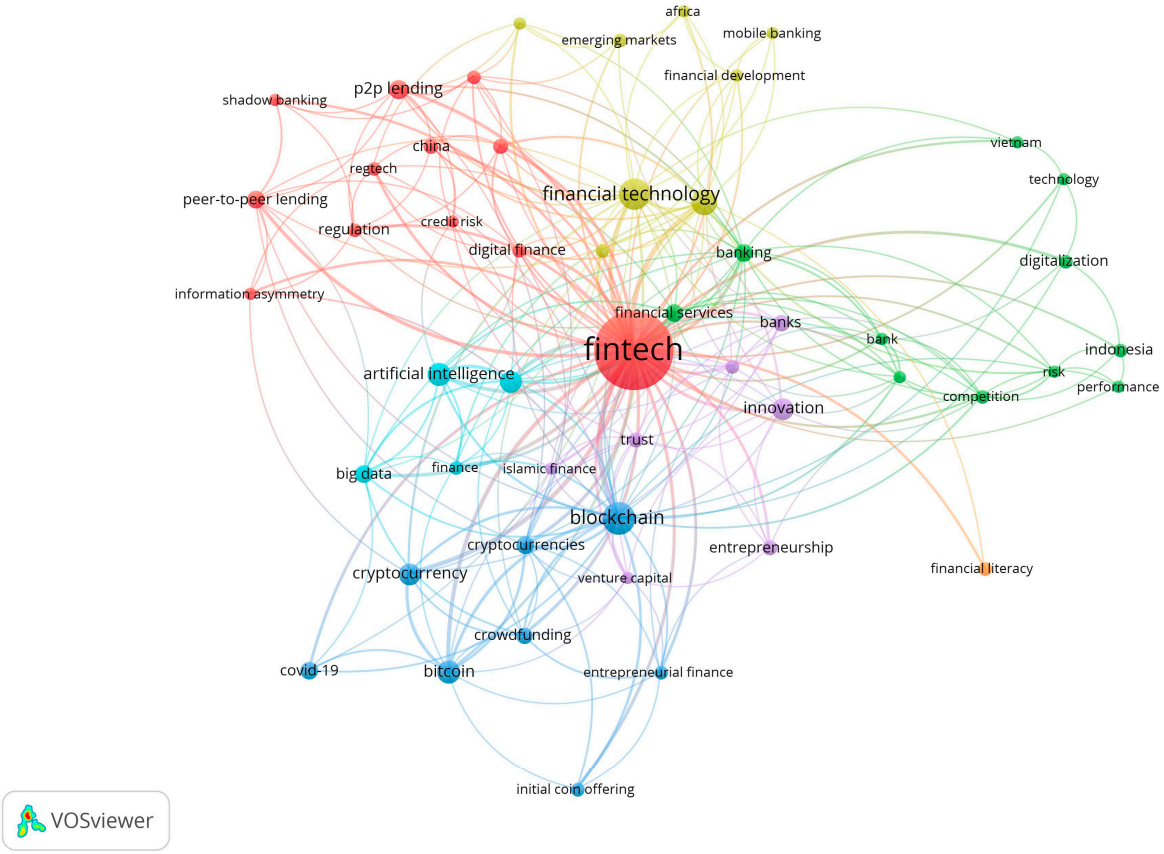

Figure 3. Co-word analysis for FinTech literature.

The *investment* aspect of green finance can be explored from both investor and company perspectives. From the investor's perspective, the focus should be on how a company's participation in green finance and sustainability-related projects might yield abnormal returns. Researchers could investigate the behavioral and sentimental factors influencing investors when selecting companies offering green finance products, such as green bonds or stocks.

From the company's standpoint, the focus is on the intention behind utilizing green financing to gather capital. Scholars have proposed examining a firm's rationale, objectives, or purposes. Some companies might engage in greenwashing to enhance their brand image, potentially boosting their stock prices. Furthermore, the co-occurrence network reveals that ESG investing and socially responsible investments have garnered less research attention in the investment domain.

3.4. Network Analysis of GF/ESG and FinTech

Using network analysis, we further investigated the primary research focus in the GF/ESG and FinTech literature. Betweenness, closeness, and PageRank are three commonly used measures for evaluating centrality in network analysis. Betweenness refers to the ability of a node to carry information between unconnected nodes. High betweenness indicates the importance of the bridging role of the node. Conversely, closeness measures a node's effectiveness in transmitting information to others by being nearer to them [14]. PageRank indicates the prestige of a publication; thus, a high PageRank score suggests that a particular publication is of high quality and is essential to cite [14,30].

Table 2 outlines four major research areas of GF/ESG: *Cluster 1: investments, Cluster 2: sustainability, Cluster 3: reporting and disclosure, and Cluster 4: impact.* Under Cluster 1: investments, the central themes were ESG (betweenness 390.4778; closeness 0.0189; PageRank 0.1181), followed by COVID-19 (betweenness 6.4613; closeness 0.0125; PageRank 0.0220). Most research focused on ESG and COVID-19 themes within investment topics. These

two dominant themes allowed scholars to engage with other topics, such as corporate sustainability or CSR, within the same cluster.

Table 2. Co-occurrence of the author's keywords in GF/ESG literature.

Cluster 1: Investments				**Cluster 2: Sustainability**			
Node	**Betweenness**	**Closeness**	**PageRank**	**Node**	**Betweenness**	**Closeness**	**PageRank**
ESG	390.4778	0.0189	0.1181	Environmental	95.2308	0.0159	0.0710
COVID-19	6.4613	0.0125	0.0220	Social	38.3138	0.0145	0.0535
Corporate sustainability	1.9482	0.0114	0.0085	Governance	13.8548	0.0128	0.0316
CSR	1.7344	0.0122	0.0214	Environment	3.5325	0.0116	0.0123
ESG ratings	0.6194	0.0105	0.0067	Corporate	3.3053	0.0120	0.0157
SRI	0.4496	0.0115	0.0109	Corporate social responsibility (CSR)	0.6084	0.0111	0.0108
Socially responsible investing	0.4291	0.0111	0.0107	Social and governance (ESG)	0.0656	0.0102	0.0081
Sustainable investing	0.3924	0.0110	0.0094	Social responsibility	0.0370	0.0112	0.0087
ESG investing	0.1961	0.0108	0.0064				
Firm performance	0.1759	0.0105	0.0065				
Socially responsible investment	0.1228	0.0110	0.0071				
Cluster 3: Reporting and Disclosure				**Cluster 4: Impact**			
Node	**Betweenness**	**Closeness**	**PageRank**	**Node**	**Betweenness**	**Closeness**	**PageRank**
Sustainability	161.7776	0.0179	0.0714	Sustainable development	16.3449	0.0135	0.0286
Corporate social responsibility	46.3065	0.0156	0.0539	Green finance	11.4905	0.0123	0.0281
Corporate governance	20.1194	0.0137	0.0336	Sustainable	6.7047	0.0127	0.0211
Financial performance	13.3094	0.0125	0.0213	Finance	3.9755	0.0119	0.0160
Performance	8.9259	0.0128	0.0311	Sustainable finance	3.3061	0.0125	0.0193
Environmental performance	2.0024	0.0112	0.0104	Climate change	2.6360	0.0118	0.0143
ESG performance	1.8596	0.0120	0.0142	Investment	2.4620	0.0115	0.0121
Sustainability reporting	1.2672	0.0120	0.0135	Green bonds	2.2689	0.0112	0.0144
Disclosure	1.1188	0.0120	0.0187	Stakeholder engagement	1.6554	0.0119	0.0138
Financial	0.9488	0.0116	0.0125	Development	0.5606	0.0115	0.0114
Integrated reporting	0.8886	0.0119	0.0111	Green	0.5518	0.0108	0.0101
ESG disclosure	0.6497	0.0116	0.0107	China	0.0457	0.0110	0.0090
Corporate social	0.5848	0.0115	0.0116	Innovation	0.0224	0.0114	0.0087
Reporting	0.1393	0.0115	0.0103				

Table 2. *Cont.*

Cluster 3: Reporting and Disclosure				Cluster 4: Impact			
Node	**Betweenness**	**Closeness**	**PageRank**	**Node**	**Betweenness**	**Closeness**	**PageRank**
Firm value	0.1087	0.0112	0.0086				
Stakeholder theory	0.0138	0.0112	0.0099				
Responsibility	0	0.0110	0.0108				

Cluster 2: sustainability centered on environmental (betweenness 95.2308; closeness 0.0159; PageRank 0.0710), social (betweenness 38.3138; closeness 0.0145; PageRank 0.0535), and governance (betweenness 13.8548; closeness 0.0128; PageRank 0.0316). Publications aimed at achieving sustainability primarily discussed environmental, social, and governance aspects. These topics were frequently interconnected with other related concepts, such as social governance and social responsibility.

Cluster 3: reporting and disclosure featured the central themes of sustainability (betweenness 161.7776; closeness 0.0179; PageRank 0.0714) and corporate social responsibility (betweenness 46.3065; closeness 0.0156; PageRank 0.0539). These publications delved into sustainability and CSR disclosure to foster business sustainability. Notably, while CSR disclosure remained optional, the findings revealed connections between themes like financial performance, environmental performance, and ESG performance within the articles.

Cluster 4: impact encompassed themes such as sustainable development (betweenness 16.3449; closeness 0.0135; PageRank 0.0286), green finance (betweenness 11.4905; closeness 0.0123; PageRank 0.0281), and sustainability (betweenness 6.7047; closeness 0.0127; PageRank 0.0211). Publications within this cluster predominantly explored varying impacts, such as the impact of sustainable development and society's sustainability. These topics were often linked with green finance or sustainable finance, among others.

Regarding the FinTech literature, Table 3 identified five clusters. Cluster 1, focusing on applications, highlighted FinTech (betweenness 992.3421; closeness 0.0208; PageRank 0.2824) and financial technology (betweenness 4.5165; closeness 0.0123; PageRank 0.0373) as central themes. Most publications investigated how businesses utilize FinTech to enhance its application, and discussions frequently centered on FinTech, financial technology, financial inclusion, and banking.

Cluster 2, labeled digital assets, spotlighted blockchain (betweenness 8.7153; closeness 0.0128; PageRank 0.0521) and Bitcoin (betweenness 0.5023; closeness 0.0111; PageRank 0.0267). Works in this area pertained to digital assets, notably Bitcoin, and its blockchain-backed applications.

Cluster 3 encompassed artificial intelligence and data analytics. The focus here was on financial services (betweenness 0.8462; closeness 0.0114; PageRank 0.0190) and artificial intelligence (betweenness 0.7923, closeness 0.0112, PageRank 0.0243). The central theme was the role of artificial intelligence in enhancing financial services.

Cluster 4, centered on innovation, showcased crowdfunding (betweenness 1.1920; closeness 0.0114; PageRank 0.0232) as a pivotal innovation in the FinTech literature. Research in this domain frequently discussed crowdfunding as a novel financial approach.

Lastly, Cluster 5 signified financial institutions and markets. The discourse here revolved around competition (betweenness 0.7790, closeness 0.0111, PageRank 0.0136) and performance (betweenness 0.5000; closeness 0.0108; PageRank 0.0094). Scholars often connected discussions of competition and performance, especially concerning Islamic banks.

Table 3. Co-occurrence of the author's keywords of FinTech literature.

Cluster 1: Applications				Cluster 2: Digital Assets			
Node	**Betweenness**	**Closeness**	**PageRank**	**Node**	**Betweenness**	**Closeness**	**PageRank**
Fintech	992.3421	0.0208	0.2824	Blockchain	8.7153	0.0128	0.0521
Financial technology	4.5165	0.0123	0.0373	Bitcoin	0.5023	0.0111	0.0267
Financial inclusion	2.8678	0.0119	0.0324	Cryptocurrency	0.2789	0.0111	0.0245
Banking	1.8884	0.0116	0.0246	Cryptocurrencies	0	0.0108	0.0136
Financial	1.5491	0.0112	0.0187	Information asymmetry	0	0.0108	0.0100
Innovation	1.5478	0.0116	0.0213	**Cluster 3: Artificial Intelligence and Data Analytics**			
COVID-19	1.4451	0.0115	0.0252	**Node**	**Betweenness**	**Closeness**	**PageRank**
Risk	1.1550	0.0112	0.0186	Financial services	0.8462	0.0114	0.0190
Regulation	0.7519	0.0111	0.0177	Artificial intelligence	0.7923	0.0112	0.0243
Digital finance	0.6495	0.0112	0.0166	Machine learning	0.5711	0.0112	0.0215
Technology	0.4260	0.0114	0.0156	Finance	0.2436	0.0112	0.0146
Digital	0.2827	0.0111	0.0118	Big data	0.0657	0.0109	0.0135
Financial literacy	0.1648	0.0110	0.0122	**Cluster 4: Innovations**			
Digitalization	0.1294	0.0109	0.0115	**Node**	**Betweenness**	**Closeness**	**PageRank**
P2P lending	0.0781	0.0109	0.0133	Crowdfunding	1.1920	0.0114	0.0232
Financial stability	0.0483	0.0109	0.0099	Financial innovation	0.0118	0.0108	0.0085
China	0.0379	0.0109	0.0133	Entrepreneurial finance	0	0.0108	0.0107
Financial institutions	0.0313	0.0108	0.0083	**Cluster 5: Financial Institutions and Markets**			
Trust	0.0280	0.0110	0.0123	**Node**	**Betweenness**	**Closeness**	**PageRank**
Peer-to-peer lending	0.0272	0.0109	0.0124	Competition	0.7790	0.0111	0.0136
Financial development	0	0.0108	0.0080	Performance	0.5000	0.0108	0.0094
Risk management	0	0.0108	0.0067	Islamic banks	0.2500	0.0108	0.0082
Management	0	0.0106	0.0060	Bank	0.1716	0.0109	0.0103
Digital financial inclusion	0	0.0106	0.0053	Financial market	0.0652	0.0109	0.0094
Banks	0	0.0105	0.0080	Indonesia	0	0.0106	0.0068
Entrepreneurship	0	0.0105	0.0074				
Corporate governance	0	0.0105	0.0047				
Commercial banks	0	0.0105	0.0042				
Credit risk	0	0.0105	0.0042				

3.4.1. Application Aspect of FinTech

Scholars should continue to focus on *application* topics in the FinTech literature. The bibliometric analysis shows that research in this area has focused on usage in the banking industry, peer-to-peer lending, and financial inclusion, among others. However, researchers could also include innovative approaches to adopting FinTech to facilitate a company's operations. For example, how do companies adopt e-payment systems to facilitate transaction processes? Concerning the co-occurrence network of the FinTech literature, crowdfunding

has received much research attention from the *innovation* aspect, but entrepreneurial finance is also worth studying.

Integrating with another research domain of FinTech, *digital assets* have received considerable attention from researchers. However, it is surprising that cryptocurrency has received very little attention considering the current phenomenon of people conducting cryptocurrency transactions. Thus, researchers have suggested addressing the following research questions: What would be the consideration of accepting cryptocurrency as payment in transactions? Other topics include the use of blockchain to facilitate smart contracts and to increase the security of e-payment systems. Moreover, applications of the IoT connect the *'things'* equipped with technologies, allowing companies to transmit and receive data. With the advancement in 5G and other network platforms, the IoT can be applied to many aspects of company operations.

3.4.2. Regulatory Aspect of FinTech

Based on our results, studies have yet to focus on the regulatory and institutional environment of FinTech applications even though some countries have already developed regulatory measures for FinTech applications. Interestingly, China has become one of the top five countries conducting FinTech research; however, the regulatory framework and institutional environment have always been issues in China. Researchers are recommended to discuss and examine the unique institutional environment of China and some developing countries, including topics such as the roles of FinTech in these countries and special applications of FinTech. Thus, we suggest exploring the regulatory environment in future research.

3.5. Country of Origin

This section examines the countries of origin of the authors engaged in GF/ESG and FinTech research. Table 4 shows that the top five countries of origin of the authors engaged in GF/ESG research are Canada, the US, France, the UK, and China. The results are expected, as the top four countries are founding members of the United Nations, which has put much focus and effort into addressing climate change issues. However, developing countries, such as China and India (ranked fifth and ninth, respectively), also play a significant role in promoting and contributing to green finance research given that their greenhouse gas emissions were 4.8 and 4 times larger, respectively, in 2020 than in 1990 (https://data.jrc.ec.europa.eu/dataset/2f134209-21d9-4b42-871c-58c3bdcfb549 (accessed on 30 August 2023)). Figure 4 shows the collaboration patterns of the co-authors' countries of origin. While the authors from North America and Europe have collaborated in green finance research, the authors from China have also started to collaborate worldwide on GF/ESG topics. Therefore, China is expected to play an important role in this research area.

Table 4. The original country of the authors.

	GF/ESG		Fintech	
Rank	**Country**	**Articles**	**Country**	**Articles**
1	Canada	232	China	205
2	USA	221	USA	132
3	China	171	United Kingdom	50
4	United Kingdom	108	Indonesia	45
5	France	106	Italy	31
6	Italy	103	Germany	29
7	Australia	68	India	27

Table 4. *Cont.*

	GF/ESG		Fintech	
Rank	**Country**	**Articles**	**Country**	**Articles**
8	Germany	63	Malaysia	26
9	India	61	France	24
10	Spain	45	Australia	21
11	Japan	31	Korea	20
12	Malaysia	27	Poland	19
13	Korea	23	Vietnam	19
14	Netherlands	21	Ukraine	17
15	Vietnam	19	Finland	12
16	Sweden	18	South Africa	12
17	Switzerland	15	Canada	11
18	United Arab of Emirates	15	Switzerland	10
19	Pakistan	14	Nigeria	8
20	Poland	14	Japan	7

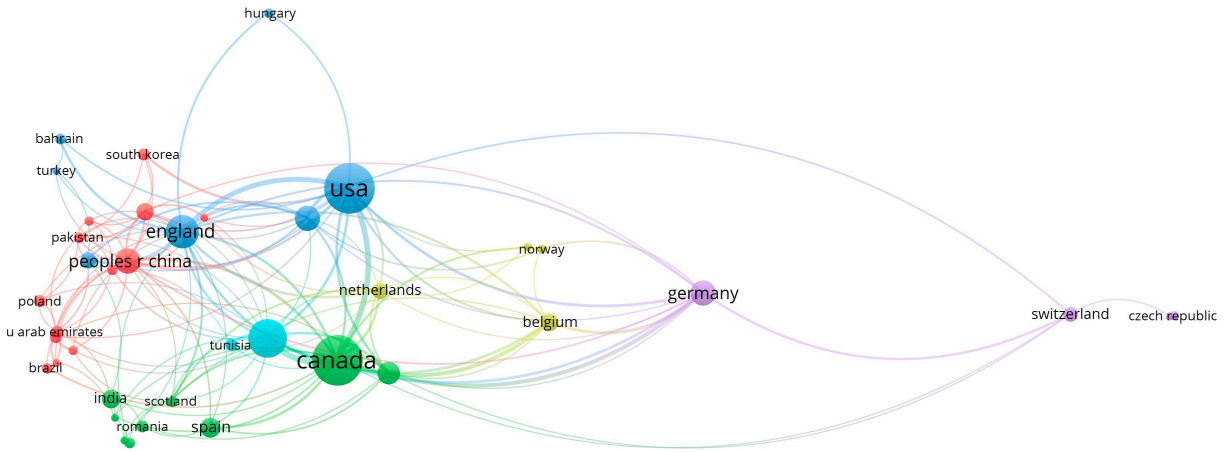

Figure 4. Collaborations of the co-authors' country of origin (GF/ESG).

Table 4 shows the countries of origin of the authors engaged in FinTech research. The top five countries are China, the US, the UK, Germany, and Indonesia. Over the last decade, China has invested many resources into shaping the country's technology ecosystem and fostering some of the world's leading FinTech companies, such as Tencent and Ant Group. It has attracted considerable attention in FinTech research on fueling ecosystem growth. According to the EY Global FinTech Adoption Index (https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/financial-services/ey-global-fintech-adoption-index-2019.pdf?download (accessed on 30 August 2023)), in 2019, approximately 87% of the total population in China actively adopted FinTech in their daily lives, and China ranked first among 27 countries worldwide. Surprisingly, Indonesia, a developing country, ranked fifth. The Indonesian government's proactive offering of significant financial inclusion support might

be the reason for its high ranking (In 2019, the amount of money transferred electronically was USD 9.2 billion in Indonesia (https://www.trade.gov/country-commercial-guides/indonesia-financial-services-financial-technology (accessed on 30 August 2023))). Research collaboration (Figure 5) was mainly observed in the US and in European countries. However, collaborations have also been identified among Asian countries, such as China, Taiwan, Vietnam, and Indonesia. The results show that Asian countries have the capability to conduct FinTech research and become more influential.

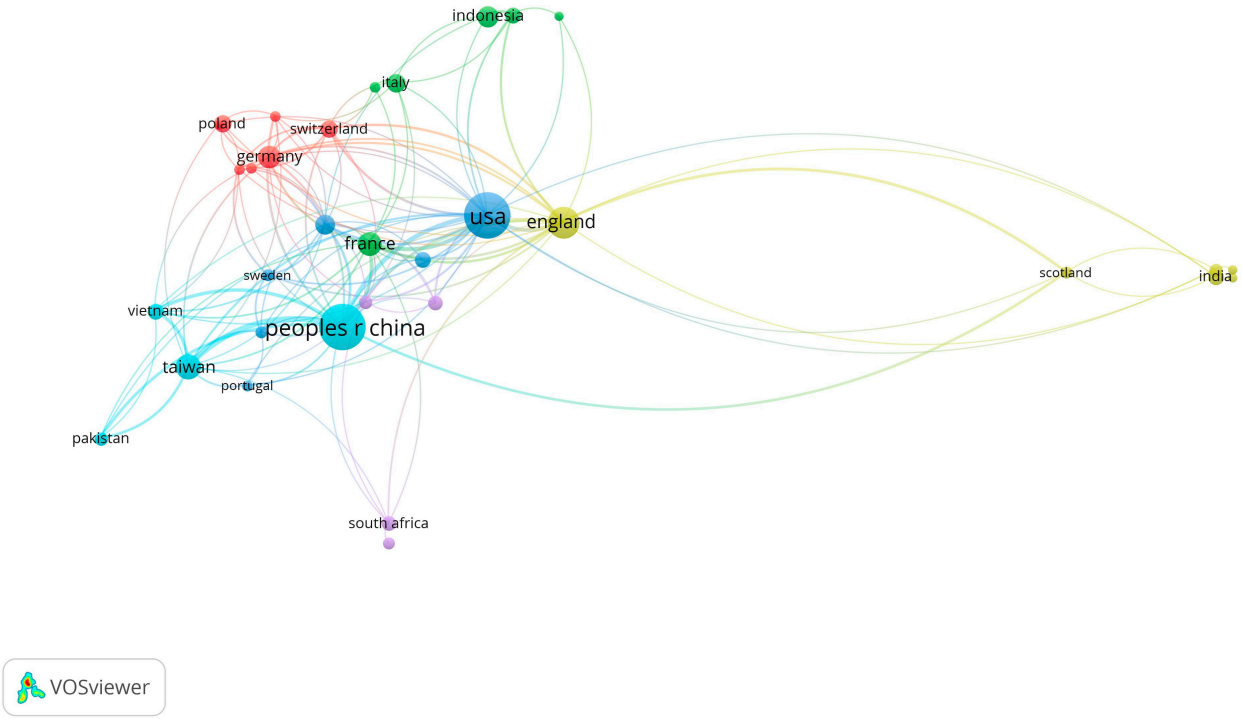

Figure 5. Collaborations of the co-authors' country of origin (FinTech).

3.6. Most Cited Papers

Table 5 presents the publications' rankings according to local citations. Local citations represent the number of citations an article received within the review corpus. Compared to global citations, which denote the number of citations received without any limitation of the review corpus [14], local citations offer a better understanding of an article's influential power within a specific research landscape. Therefore, our discussion is primarily based on the results of local citations. Referencing the results of the most cited paper provides insight into the most influential paper in both the GF/ESG and FinTech fields of study. Table 5 indicates that the top five cited papers were by Fatemi et al. [31], Amel-Zadeh and Serafeim [32], Nofsinger and Varma [33], Broadstock et al. [34], and Galbreath [35]. Except for Galbreath's paper [35], which was published in a non-finance journal, the top four publications were featured in top-tier finance journals. Among all the top-cited papers, when the research topic is related to company performance or investment, the central research theme of the articles tends to be on ESG and COVID-19 [32,34,36–39]. For instance, Broadstock et al. [34] discussed ESG performance during the time of COVID-19 in China, while other top-cited publications mainly examined ESG performance or firm value. Most articles on investment topics revolved around the themes of ESG and COVID-19, aligning with our findings from the network analysis detailed in Section 3.3.

Regarding the most cited publications on FinTech, as illustrated in Table 6, the top five publications were by Buchak et al. [40], Thakor [41], Fuster et al. [42], Tang [43], and Chen et al. [44]. Three of these studies appeared in *The Review of Financial Studies*. Table 6 reveals that when articles focus on FinTech applications, most delve into the theme of how FinTech is employed to facilitate or enhance traditional financial services [40,42,45,46]. For example,

Buchak et al. [40] explored the driving forces behind the rise of shadow banks in the context of FinTech, while Fuster et al. [42] discussed FinTech's role in mortgage lending. This aligns with the insights from our network analysis where the largest cluster of publications in the FinTech literature pertains to FinTech applications.

Table 5. Most cited GF/ESG paper.

No.	Author(s)/Year	Journal	Title	Local Citations	Global Citations	LC/GC Ratio (%)
1	Fatemi et al. (2018) [31]	*Global Finance Journal*	ESG performance and firm value: The moderating role of disclosure	72	199	36.18
2	Amel-Zadeh and Serafeim (2018) [32]	*Financial Analysts Journal*	Why and How Investors Use ESG Information: Evidence from a Global Survey	66	171	38.6
3	Nofsinger and Varma (2014) [33]	*Journal of Banking and Finance*	Socially responsible funds and market crises	59	189	31.22
4	Broadstock et al. (2021) [34]	*Finance Research Letters*	The role of ESG performance during times of financial crisis: Evidence from COVID-19 in China	56	148	37.84
5	Galbreath (2013) [35]	*Journal of Business Ethics*	ESG in Focus: The Australian Evidence	55	110	50
6	Van Duuren et al. (2016) [47]	*Journal of Business Ethics*	ESG Integration and the Investment Management Process: Fundamental Investing Reinvented	53	130	40.77
7	Nollet et al. (2016) [48]	*Economic Modelling*	Corporate social responsibility and financial performance: A non-linear and disaggregated approach	52	193	26.94
8	Velte (2017) [36]	*Journal of Global Responsibility*	Does ESG performance have an impact on financial performance? Evidence from Germany	48	115	41.74
9	Aouadi and Marsat (2018) [37]	*Journal of Business Ethics*	Do ESG Controversies Matter for Firm Value? Evidence from International Data	45	132	34.09
10	Duque-Grisales and Aguilera-Caracuel (2021) [49]	*Journal of Business Ethics*	Environmental, Social and Governance (ESG) Scores and Financial Performance of Multilatinas: Moderating Effects of Geographic International Diversification and Financial Slack	42	120	35
11	Xie et al. (2019) [38]	*Business Strategy and the Environment*	Do environmental, social, and governance activities improve corporate financial performance?	37	158	23.42
12	Krueger et al. (2020) [50]	*The Review of Financial Studies*	The Importance of Climate Risks for Institutional Investors	37	176	21.02

Table 5. *Cont.*

No.	Author(s)/Year	Journal	Title	Local Citations	Global Citations	LC/GC Ratio (%)
13	Baldini et al. (2018) [51]	*Journal of Business Ethics*	Role of Country- and Firm-Level Determinants in Environmental, Social, and Governance Disclosure	36	115	31.3
14	Pedersen et al. (2021) [39]	*Journal of Financial Economics*	Responsible investing: The ESG-efficient frontier	36	90	40
15	Taghizadeh-Hesary and Yoshino (2019) [52]	*Finance Research Letters*	The way to induce private participation in green finance and investment	33	207	15.94
16	Ng and Rezaee (2015) [53]	*Journal of Corporate Finance*	Business sustainability performance and cost of equity capital	29	136	21.32
17	Mervelskemper and Streit (2017) [54]	*Business Strategy and the Environment*	Enhancing Market Valuation of ESG Performance: Is Integrated Reporting Keeping its Promise?	29	104	27.88
18	Stellner et al. (2015) [55]	*Journal of Banking and Finance*	Corporate social responsibility and Eurozone corporate bonds: The moderating role of country sustainability	28	104	26.92
19	Semenova and Hassel (2015) [56]	*Journal of Business Ethics*	On the Validity of Environmental Performance Metrics	28	93	30.11
20	Tang and Zhang (2020) [5]	*Journal of Corporate Finance*	Do shareholders benefit from green bonds	28	152	18.42

Table 6. Most cited FinTech paper.

No.	Author(s)/Year	Journal	Title	Local Citations	Global Citations	LC/GC Ratio (%)
1	Buchak et al. (2018) [40]	*Journal of Financial Economics*	Fintech, regulatory arbitrage, and the rise of shadow banks	74	214	34.58
2	Thakor (2020) [41]	*Journal of Financial Intermediation*	Fintech and banking: What do we know?	51	121	42.15
3	Fuster et al. (2019) [42]	*The Review of Financial Studies*	The Role of Technology in Mortgage Lending	48	112	42.86
4	Tang (2019) [43]	*The Review of Financial Studies*	Peer-to-Peer Lenders Versus Banks: Substitutes or Complements?	45	110	40.91
5	Chen et al. (2019) [44]	*The Review of Financial Studies*	How Valuable Is FinTech Innovation?	35	110	31.82
6	Jagtiani and Lemieux (2018) [57]	*Journal of Economics and Business*	Do fintech lenders penetrate areas that are underserved by traditional banks?	33	78	42.31
7	Anagnostopoulos (2018) [58]	*Journal of Economics and Business*	Fintech and regtech: Impact on regulators and banks	29	93	31.18

Table 6. *Cont.*

No.	Author(s)/Year	Journal	Title	Local Citations	Global Citations	LC/GC Ratio (%)
8	Ozili (2018) [59]	*Borsa Istanbul Review*	Impact of digital finance on financial inclusion and stability	24	208	11.54
9	Foley et al. (2019) [60]	*Review of Financial Studies*	Sex, Drugs, and Bitcoin: How Much Illegal Activity Is Financed through Cryptocurrencies?	20	203	9.85
10	Drasch et al. (2018) [61]	*Journal of Economics and Business*	Integrating the 'Troublemakers': A taxonomy for cooperation between banks and fintechs	18	46	39.13
11	Adhami et al. (2018) [62]	*Journal of Economics and Business*	Why do businesses go crypto? An empirical analysis of initial coin offerings	17	166	10.24
12	Jagtiani and Lemieux (2019) [45]	*Financial Management*	The roles of alternative data and machine learning in fintech lending: Evidence from the LendingClub consumer platform	16	45	35.56
13	Cong and He (2019) [63]	*The Review of Financial Studies*	Blockchain Disruption and Smart Contracts	14	224	6.25
14	Gimpel et al. (2018) [64]	*Electronic Markets*	Understanding FinTech start-ups—a taxonomy of consumer-oriented service offerings	13	67	19.4
15	Chiu and Koeppl (2019) [46]	*The Review of Financial Studies*	Blockchain-Based Settlement for Asset Trading	13	61	21.31
16	Zhu (2019) [65]	*The Review of Financial Studies*	Big Data as a Governance Mechanism	12	38	31.58
17	Begenau et al. (2018) [66]	*Journal of Monetary Economics*	Big data in finance and the growth of large firms	11	40	27.5
18	Zalan and Toufaily (2017) [67]	*Contemporary Economics*	The Promise of Fintech in Emerging Markets: Not as Disruptive	10	31	32.26
19	Ashta and Biot-Paquerot (2018) [68]	*Strategic Change*	FinTech evolution: Strategic value management issues in a fast changing industry	10	32	31.25
20	Stulz (2019) [69]	*Journal of Applied Corporate Finance*	FinTech, BigTech, and the Future of Banks	10	27	37.04

3.7. Co-Citation Analysis

This co-citation analysis can identify similar themes in the literature when they are cited together [70]. The intellectual structure, such as the underlying themes [71], can be revealed for a specific research field [72]. We set the minimum number of citations for a cited reference at 20 for both the ESG/GF and FinTech literature. In the end, we identified 50 and 9 publications that met the threshold for the ESG/GF and FinTech literature, respectively. Both research fields displayed three clusters. Figures 6 and 7, as well as Tables 7 and 8, present the co-citation analysis results for the GF/ESG and FinTech literature, respectively.

Tables 7 and 8 clearly indicate that three clusters emerged for the GF/ESG and four clusters for the FinTech literature.

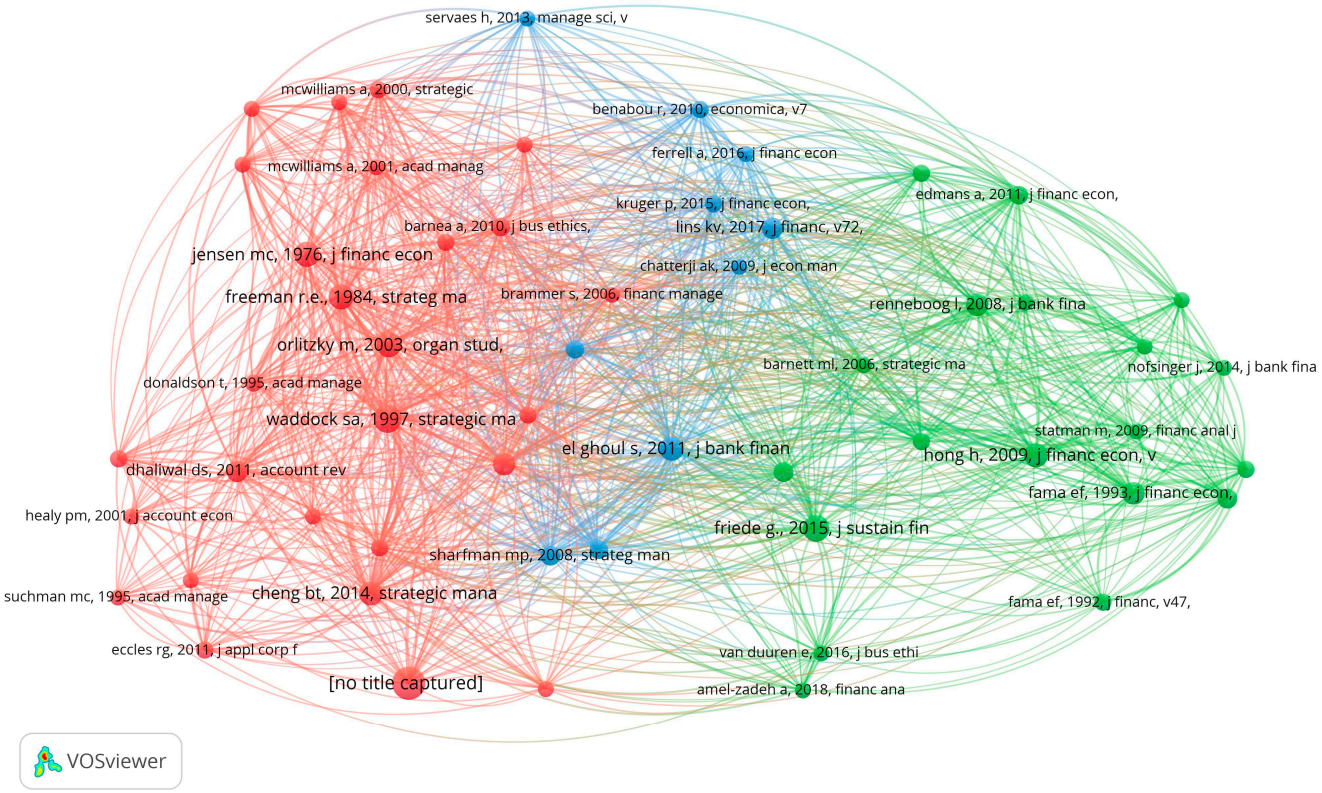

Figure 6. Co-citation analysis result for GF/ESG literature [31–33,35,47,73–117].

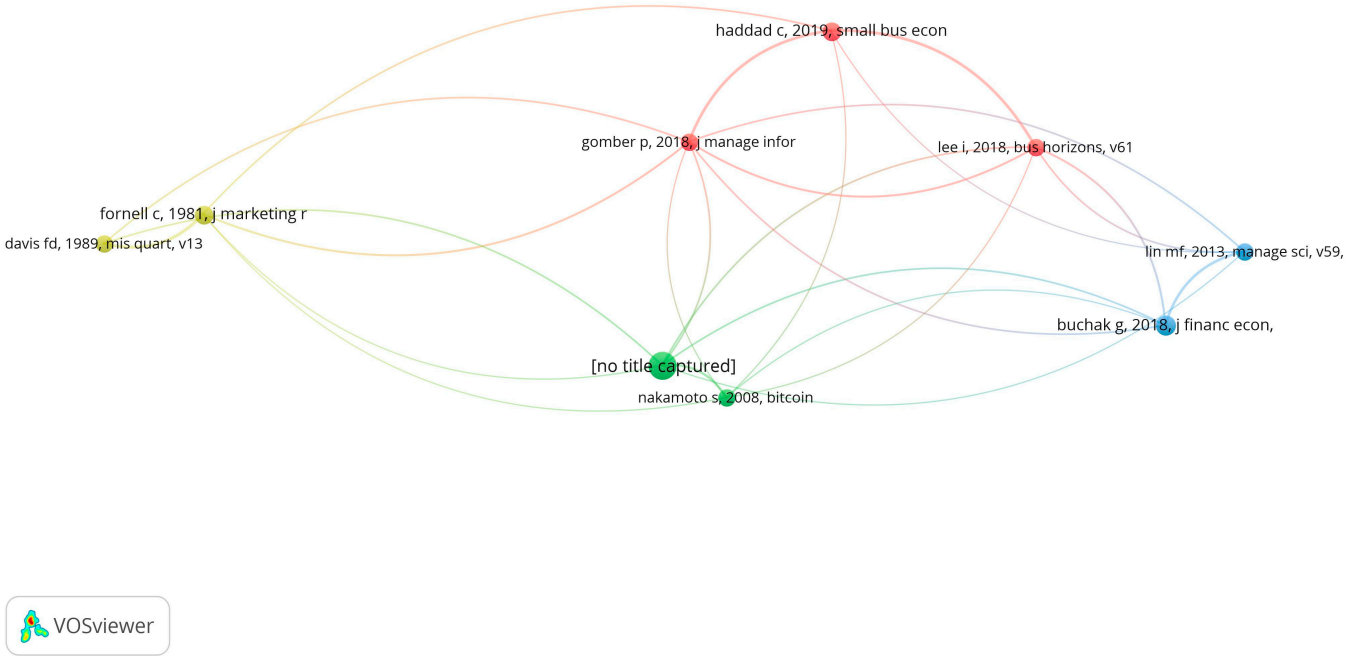

Figure 7. Co-citation analysis results for FinTech literature [40,118–124].

Table 7. Co-citation analysis results for GF/ESG literature in clusters.

Author(s) (Year)	Journal	DOI
	Cluster 1	
Dhaliwal et al. (2011) [73]	*The Accounting Review*	10.2308/accr.00000005
Dhaliwal et al. (2012) [74]	*The Accounting Review*	10.2308/accr-10218
Donaldson and Preston (1995) [75]	*Academy of Management Review*	10.5465/amr.1995.9503271992
Eccles et al. (2011) [76]	*Journal of Applied Corporate Finance*	10.1111/j.1745-6622.2011.00357.x
Eccles et al. (2014) [77]	*Management Science*	10.1287/mnsc.2014.1984
Fatemi et al. (2018) [31]	*Global Finance Journal*	10.1016/j.gfj.2017.03.001
Friedman (1970) [78]	*The New York Times Magazine*	
Galbreath (2013) [35]	*Journal of Business Ethics*	10.1007/s10551-012-1607-9
Griffin and Mahon (1997) [79]	*Business and Society*	10.1177/000765039703600102
Healy and Palepu (2001) [80]	*Journal of Accounting and Economics*	10.1016/s0165-4101(01)00018-0
Hillman and Keim (2001) [81]	*Strategic Management Journal*	10.1002/1097-0266(200101)22:2%3C125::AID-SMJ150%3E3.0.CO;2-H
Ioannou and Serafeim (2012) [82]	*Journal of International Business Studies*	10.1057/jibs.2012.26
Jensen and Meckling (1976) [83]	*Journal of Financial Economics*	10.1016/0304-405x(76)90026-x
Jo and Harjoto (2011) [84]	*Journal of Business Ethics*	10.1007/s10551-011-0869-y
Margolis and Walsh (2003) [85]	*Administrative Science Quarterly*	10.2307/3556659
Mcwilliams and Siegel (2000) [86]	*Strategic Management Journal*	10.1002/(SICI)1097-0266(200005)21:5<603::AID-SMJ101>3.0.CO;2-3
Mcwilliams and Siegel (2001) [87]	*Academy of Management Review*	10.5465/amr.2001.4011987
Orlitzky et al. (2003) [88]	*Organizational Studies*	10.1177/0170840603024003910
Porter and Kramer (2006) [89]	*Harvard Business Review*	
Suchman (1995) [90]	*Academy of Management Review*	10.2307/258788
Waddock and Graves (1997) [91]	*Strategic Management Journal*	10.1002/(SICI)1097-0266(199704)18:4<303::AID-SMJ869>3.0.CO;2-G
	Cluster 2	
Amel-Zadeh and Serafeim (2018) [32]	*Financial Analysts Journal*	10.2469/faj.v74.n3.2
Barnett and Salomon (2006) [92]	*Strategic Management Journal*	10.1002/smj.557
Bauer et al. (2005) [93]	*Journal of Banking and Finance*	10.1016/j.jbankfin.2004.06.035
Carhart (1997) [94]	*Journal of Finance*	10.2307/2329556
Derwall et al. (2005) [95]	*Financial Analysts Journal*	10.2469/faj.v61.n2.2716
Dimson and Karakas (2015) [96]	*The Review of Financial Studies*	10.1093/rfs/hhv044
Edmans (2011) [97]	*Journal of Financial Economics*	10.1016/j.jfineco.2011.03.021
Fama and French (1992) [98]	*Journal of Finance*	10.2307/2329112
Fama and French (1993) [99]	*Journal of Financial Economics*	10.1016/0304-405x(93)90023-5
Fama and French (2015) [100]	*Journal of Financial Economics*	10.1016/j.jfineco.2014.10.010
Friede et al. (2015) [101]	*Journal of Sustainable Finance and Investment*	10.1080/20430795.2015.1118917

Table 7. *Cont.*

Author(s) (Year)	Journal	DOI
Galema et al. (2008) [102]	*Journal of Banking and Finance*	10.1016/j.jbankfin.2008.06.002
Heinkel et al. (2001) [103]	*Journal of Financial and Quantitative Analysis*	10.2307/2676219
Hong and Kacperczyk (2009) [104]	*Journal of Financial Economics*	10.1016/j.jfineco.2008.09.001
Khan et al. (2016) [105]	*The Accounting Review*	10.2308/accr-51383
Nofsinger and Varma (2014) [33]	*Journal of Banking and Finance*	10.1016/j.jbankfin.2013.12.016
Renneboog et al. (2008) [106]	*Journal of Banking and Finance*	10.1016/j.jbankfin.2007.12.039
Statman and Glushkov (2009) [107]	*Financial Analysts Journal*	10.2469/faj.v65.n4.5
Van Duuren et al. (2016) [47]	*Journal of Business Ethics*	10.1007/s10551-015-2610-8
Cluster 3		
Benabou and Tirole (2010) [108]	*Economica*	10.1111/j.1468-0335.2009.00843.x
Chatterji et al. (2009) [109]	*Journal of Economics and Management Strategy*	10.1111/j.1530-9134.2009.00210.x
El Ghoul et al. (2011) [110]	*Journal of Banking and Finance*	10.1016/j.jbankfin.2011.02.007
Ferrell et al. (2016) [111]	*Journal of Financial Economics*	10.1016/j.jfineco.2015.12.003
Godfrey et al. (2009) [112]	*Strategic Management Journal*	10.1002/smj.750
Goss and Roberts (2011) [113]	*Journal of Banking and Finance*	10.1016/j.jbankfin.2010.12.002
Kruger (2015) [114]	*Journal of Financial Economics*	10.1016/j.jfineco.2014.09.008
Lins et al. (2017) [115]	*The Journal of Finance*	10.1111/jofi.12505
Servaes and Tamayo (2013) [116]	*Management Science*	10.1287/mnsc.1120.1630
Sharfman and Femando (2008) [117]	*Strategic Management Journal*	10.1002/smj.678

Table 8. Co-citation analysis results for FinTech literature in clusters.

Author(s) (Year)	Journal	DOI
Cluster 1		
Gomber et al. (2018) [118]	*Journal of Management Information Systems*	10.1080/07421222.2018.1440766
Haddad and Hornuf (2019) [119]	*Small Business Economics*	10.1007/s11187-018-9991-x
Lee and Shin (2018) [120]	*Business Horizons*	10.1016/j.bushor.2017.09.003
Cluster 2		
Nakamoto, S. (2008) [121]	*Bitcoin*	
Cluster 3		
Buchak et al. (2018) [40]	*Journal of Financial Economics*	10.1016/j.jfineco.2018.03.011
Lin et al. (2013) [122]	*Management Science*	10.1287/mnsc.1120.1560
Cluster 4		
Davis (1989) [123]	*MIS Quarterly*	10.2307/249008
Fornell and Larcker (1981) [124]	*Journal of Marketing Research*	10.2307/3151312

In the domain of green finance, research clusters elucidate a multifaceted understanding of corporate social responsibility (CSR), financial outcomes, and societal expectations. Cluster 1 accentuates the tangible financial advantages that companies gain from transparent CSR reporting, including reductions in equity capital costs and sharpened analyst projections [31,73,74,79,80]. This emphasis on transparency is deeply anchored in stakeholder theory, suggesting firms can leverage their CSR activities for competitive benefits [75,87,88].

Furthermore, as Cluster 2 reveals, the weaving of environmental, social, and governance (ESG) criteria into investment decisions poses varying financial implications, with outcomes contingent on the specific ESG screening techniques employed [92,95–105]. Meanwhile, Cluster 3 accentuates the mounting societal pressures on corporations to transparently showcase genuine CSR endeavors. Amidst genuine environmental and social concerns, it is essential that these CSR activities maintain authenticity, a sentiment echoed by the call for stringent CSR rating systems to uphold green finance's credibility [108–112,114,115].

The transformative role of FinTech in the financial sector is mirrored in the diverse research themes spread across the respective clusters. Cluster 1 delves into FinTech's transformative potential, highlighting its power to innovate and challenge traditional financial molds [118–120]. Cluster 2 introduces blockchain's pivotal role, underscoring the relevance of decentralized financial transactions [121]. Cluster 3 expands on the burgeoning world of shadow banking, emphasizing the growing prominence of online peer-to-peer lending platforms within FinTech's purview [40,122]. Cluster 4, meanwhile, shifts focus toward technological usability, dissecting the dynamics of user acceptance and the complexities of structural equation modeling [123,124].

The co-citation analysis shows that green finance's landscape is defined by the intricate interplay between CSR transparency, ESG-driven investments, and society's ethical demands on corporations. Concurrently, FinTech's rise exemplifies the confluence of technology, finance, and user behavior in contemporary finance. Stakeholders venturing into these domains must stay abreast of their evolving narratives.

3.8. Sources of GF/ESG and FinTech Literature

Tables 9 and 10 present the sources of the GF/ESG and FinTech literature, respectively. Interestingly, *Green Finance* ranked first in the GF/ESG area as an open-access journal. This is a very young journal, with its first volume appearing in 2019. This journal has not received any rankings from the Australian Business Deans Council (ABDC), Academic Journal Guide (ABS), or Scimago Journal and Country Rank (SJR). Ranked second is the *Journal of Sustainable Finance and Investment*. This journal is also relatively young, having been around for about 11 years since its first volume in 2011. It is ranked Q1 in SJR and 1 in ABS, although it does not have a ranking from ABDC. Nonetheless, it is believed that this journal will gradually climb in ranking and academic status due to the increasing number of publications and research outputs related to green finance and ESG. Only *Business Strategy and the Environment* (ranked third) and *Finance Research Letters* (ranked fifth) are top-tier journals among the top five.

Table 9. Top 10 sources of publications for GF/ESG.

Journals	Articles Published	ABDC	ABS	SJR	Year of the 1st Volume
Green Finance	75	N/A	N/A	N/A	2019
Journal of Sustainable Finance and Investment	74	N/A	1	Q1	2011
Business Strategy and the Environment	72	A	3	Q1	1992
Corporate Social Responsibility and Environmental Management	60	C	1	Q1	1993
Finance Research Letters	58	A	2	Q1	2004
Journal of Business Ethics	40	A	3	Q1	1982
Journal of Portfolio Management	40	A	3	Q1	1974
Journal of Business Research	28	A	3	Q1	1973
Journal of Risk and Financial Management	22	B	N/A	N/A	2008
Sustainability Accounting Management and Policy Journal	20	B	2	Q1	2010

N/A means the journal does not receive any rankings from the respective organizations.

Table 10. Top 10 sources of publication for FinTech.

Journals	Articles Published	ABDC	ABS	SJR	Year of the 1st Volume
Finance Research Letters	35	A	2	Q1	2004
Journal of Risk and Financial Management	27	B	N/A	N/A	2008
Review of Financial Studies	18	A *	4 *	Q1	1988
Pacific-Basin Finance Journal	16	A	2	Q1	1993
Research in International Business and Finance	16	B	2	Q1	2004
International Journal of Bank Marketing	14	A	1	Q2	1983
International Review of Financial Analysis	14	A	3	Q1	1992
European Journal of Finance	13	A	3	Q1	1995
Journal of Asian Finance Economics and Business	13	N/A	N/A	Q2 (2020)	2014
Electronic Commerce Research	12	A	2	Q1	2001

A * and 4 * is the highest ranking of the ABDC and ABS, respectively.

The sources for the FinTech literature differ slightly from those in the GF/ESG literature. Among the top five, only the *Journal of Risk and Financial Management* (ranked second) is not considered a top-tier journal, as it does not have a ranking from ABS or SJR, although it is ranked B in ABDC. *Finance Research Letters* (ranked first), *Review of Financial Studies* (ranked third), *Pacific-Basin Finance Journal* (ranked fourth), and *Research in International Business and Finance* (ranked fifth) are all renowned, traditional finance-related journals. This suggests that these established journals are open to FinTech research.

3.9. Attention on Green FinTech

Based on the previously reported results and the increasing importance of the application of FinTech in GF, the most significant research direction is the synergy between green finance and FinTech, termed Green FinTech. As discussed earlier, FinTech can be applied to green finance, particularly in building trust among individuals purchasing green bonds through the IoT and blockchain and in reducing due diligence costs via smart contracts, decentralization, and distributed networks. Thus, Green FinTech presents a promising research opportunity in finance.

We conducted an additional analysis of research papers on Green FinTech based on the literature search process discussed earlier to reinforce our suggestion. Surprisingly, we identified only five articles with the keyword 'Green FinTech' in WoS (Table 11). These articles emphasized the integration of FinTech and green finance together rather than investigating either topic separately. The first study was published in 2020, and this increase in publications suggests an annual growth rate of 200%. Out of these five articles, four discussed the application of FinTech in green finance. We further used the same keyword for a search on Google Scholar and found 234 results. Many of these publications were either open-access or discussion papers. Consequently, there is an urgent need to focus more on examining Green FinTech given its significance in both practical and academic realms.

In response to the rapid development in the practical realm of Green FinTech, research should also be conducted to address the academic aspects of this practical development. Although there is literature on Green FinTech, it is still in its infancy; the number of publications is limited; and the scope is narrow. Future research on Green FinTech can focus on various aspects, such as e-wallet or e-payment support. E-commerce transactions involve different stakeholders, like consumer-to-consumer (C2C), business-to-consumer (B2C), and business-to-business (B2B). Researchers can concentrate on the willingness, intention, and behavior of utilizing Green FinTech in these types of transactions. Other

areas may include robo-advisors, which guide and advise people to invest in green assets through these advisory services across industries, such as life and non-life insurance and financial services.

Table 11. Publications on Green FinTech under WoS search.

Author(s)/Year	Journal	Title
Wan, Qian, and Yu (2022) [125]	*Journal of Sensors*	Analysis of Green Financial Policy Utility: A Policy Incentive Financial Mechanism Based on State Space Model Theory Algorithm
Wang (2022) [126]	*Managerial and Decision Economics*	Research on the Impact Mechanism of Green Finance on the Green Innovation Performance of China's Manufacturing Industry
Puschmann, Hoffmann, and Khmarskyi (2020) [127]	*Sustainability*	How Green FinTech Can Alleviate the Impact of Climate Change: The Case of Switzerland
Macchiavello and Siri (2022) [128]	*European Company and Financial Law Review*	Sustainable Finance and Fintech: Can Technology Contribute to Achieving Environmental Goals? A Preliminary Assessment of 'Green Fintech' and 'Sustainable Digital Finance'
Lee and Khan (2022) [129]	*Journal of World Energy Law and Business*	Blockchain and Energy Commodity Markets: Legal Issues and Impact on Sustainability

4. Conclusions

We used a bibliometric approach to analyze the academic landscape of the literature on GF/ESG and FinTech. The number of publications has surged since 2015, particularly after 2017. Scholars have been keen on studying the impacts of green finance and the applications of FinTech. The co-word analysis further highlights several crucial research clusters in the GF/ESG and FinTech literature. Under GF/ESG, investments, sustainability, reporting, disclosure, and impact are the primary research topics. In the FinTech literature, applications, digital assets, artificial intelligence, data analytics, innovations, and financial institutions and markets stand out. Notably, most UN members have delved deeper into green finance and FinTech research. Still, there is growing interest in these areas among scholars from developing countries, such as China and India. Apart from UN initiatives, the COVID-19 outbreak has also made people more aware of the significance of green finance and technological applications, as reflected in the co-word analysis for both GF/ESG and FinTech.

From our bibliometric exploration, it is clear that the FinTech literature possesses unexplored theoretical potential, especially concerning its application and regulatory aspects. While banking applications, peer-to-peer lending, and financial inclusion have been studied, the next promising area seems to be the integration of innovative technologies to enhance company operations, like e-payment systems and entrepreneurial finance. The surprisingly limited focus on cryptocurrency, despite its mainstream popularity, points to an unexplored research area. Questions about the implications of accepting cryptocurrency and how blockchain could transform smart contracts and enhance e-payment security warrant deeper academic exploration. Moreover, the regulatory landscape of FinTech remains underrepresented in academic discussions. Considering China's prominent role in FinTech research and its unique institutional framework, a study of its regulatory context compared with other developing nations could enrich theoretical discussions. Our findings underscore the importance of actionable insights for industry experts and policymakers. In the realm of FinTech applications, there is a continuous need for the evolution and adoption of innovative methods, such as combining the potential of the IoT with advancements like 5G to enhance company operations. Regarding regulation, nations must stay alert, learn, and adapt by studying regulatory practices from leaders like China. Furthermore, the revelation of the leading nations in GF/ESG and FinTech research indicates a geopolitical transition.

The pivotal roles of developing countries, especially China and India, in green finance research, underscore their importance in tackling global climate challenges. The increasing greenhouse gas emissions highlight the urgency. China's dominant role in FinTech, fueled by companies like Tencent and Ant Group, and its widespread consumer adoption solidifies its leadership in guiding global FinTech trends. Additionally, the emergence of nations like Indonesia in FinTech research underscores the transformative impact of financial inclusion policies. Practitioners, especially in Asia, can utilize these insights to forge partnerships, foster innovation, and guide strategies in both green finance and FinTech spheres.

Basing our study on bibliometric analysis, we offer a systematic way to understand the research landscapes of both green finance and FinTech, enabling the identification of research gaps for future studies. Green finance and FinTech are pivotal for societal development, as seen in our daily use and recent advancements in FinTech in several developed countries aiming for sustainability. Concurrently, academic research should reflect or provide insights and theories on our practices. Thus, the research directions outlined in this study, especially regarding Green FinTech research, merit exploration and should appeal to mainstream financial research journals.

Although our bibliometric method provides structured insight into the green finance and FinTech research panorama, it has its constraints. This study is bound by the databases and keywords used, potentially missing relevant publications or emerging trends. Additionally, our emphasis on publication and citation counts might overlook influential yet less-cited contributions. Future studies could engage in more in-depth qualitative reviews, pinpointing specific thematic gaps. Regularly updating the bibliometric analysis would also be advantageous, given the rapid evolution of both fields, to maintain a current understanding and promote cross-disciplinary collaborations.

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