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Sustainable Investment Strategies in the Timber Construction Sector: ESG Timber Score for Assessing CO_2 Storage Capacity

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Abstract: The construction and real estate industry has been held responsible for nearly 40% of global CO_2 emissions, a key focus for gathering efforts to combat climate change. Timber, a sustainable and carbon-storing building material, unravels significant potential to decarbonize the sector by replacing carbon-intensive materials such as steel and concrete. However, the full potential of timber remains underutilized, owing to a lack of knowledge, transparency, and investment opportunities in the forestry and timber industries. This paper addressed this gap by developing a comprehensive framework for investors to evaluate listed companies in the timber construction sector, based on their sustainability and financial performance. Specifically, the study sought to answer: How can investors effectively channel capital into the carbon storage capacity of timber, and what approaches are both sustainable and economically viable for timber investments? To achieve this, this paper examined how investors could invest in the CO_2 storage capacity of timber, with a particular focus on the creation of Environmental, Social, and Governance (ESG) Timber Score to evaluate the sustainability of listed companies in the sector. By integrating sustainability and financial performance metrics, this study provided a robust framework that enabled investors to assess both the economic and environmental aspects of their investments. The findings revealed investment opportunities in both traditional markets (North America and Europe) and emerging markets (Asia and Africa). The current study emphasizes that investment decisions, if probable, should be tailored to individual preferences to achieve different levels of sustainability and financial goals.

Keywords: ESG investment; CO_2 storage; ESG Timber Score; Sustainable timber investment; Timber construction; Sustainable finance

1. Introduction

An ongoing increase in global CO_2 emissions and the resultant climate change have positioned sustainability as a critical issue in numerous sectors. The construction and real estate industry is one of the most significant contributors to carbon emissions, as it accounts for nearly 40% of global emissions (Richter et al., 2022; UNEP, 2022). As part of the efforts to decarbonize this sector, the use of sustainable materials, particularly timber, has gained increasing attention. Since not all emissions can be avoided, CO_2 storage technologies are particularly relevant in this context to bind unavoidable emissions (Bundesamt für Umwelt [BAFU], 2023). While companies such as Climeworks are advancing direct CO_2 removal in a technical sense (Climeworks, 2024) and garnering international attention, other natural methods are currently receiving less attention. These include the use of timber in the construction industry (Bundesrat, 2023) although its climate benefits are well-known. When sustainably sourced, timber as a natural carbon storage offers a promising alternative to conventional and carbon-intensive building materials, such as steel and concrete.

Timber in construction accounts for only a small fraction of total project volumes globally. In Germany, for instance, timber buildings account for only 2.5% of all construction projects, with a slightly higher share of 4.5% for multi-storey buildings (Bauen mit Holz, 2023; Charrey et al., 2023). While countries such as Austria and Switzerland exhibit higher adoption rates, timber construction remains marginal on a global scale. To provide a

broader context, studies indicated that the share of timber in new construction across major global markets, including North America and Asia, also remain relatively low compared to traditional materials, despite its environmental advantages (Charrey et al., 2023; FAO, 2020). This global underutilization underscores the need for strategies to promote timber construction on a larger scale. Expanding the use of timber in construction could significantly contribute to decarbonizing the construction sector, with timber acting as both a substitute for more carbon-intensive materials and a means of long-term CO_2 storage (D'Amico et al., 2021; Hansen et al., 2024; Myllyviita et al., 2022). The challenges hindering greater adoption are multifaceted, including a lack of market transparency, insufficient funding in the forestry and timber industries, and inadequate knowledge of timber's climate benefits among investors and financial institutions (Charrey et al., 2023; Hart & Pomponi, 2020).

This paper aims to increase transparency regarding the targeted channeling of capital flows by addressing the research questions: How can investors invest in the carbon storage capacity of timber on the stock market, and what approaches are both sustainable and economically advisable? To answer these questions, the study identified and analyzed internationally listed companies for their contribution to timber construction and long-term CO_2 storage. Given the lack of official Environmental, Social, and Governance (ESG) scores for nearly 60% of the companies analyzed, as well as the controversy surrounding existing ratings, we developed a proprietary sustainability score (i.e., ESG Timber Score) to assess a company's sustainability based on relevant qualitative and quantitative characteristics. The goal is to create a transparent and comprehensible rating system that objectively evaluates the sustainability performance of companies related to timber construction and CO_2 storage. Simultaneously, we assessed a company's financial performance using a performance score based on historical stock price development, in order to create a comprehensive framework that integrates both sustainability and economic metrics. This allows investors to evaluate both the financial and environmental merits of timber investments.

Based on this objective, we formulated the following hypotheses:

H1: A comprehensive and proprietary ESG Timber Score can reliably assess the sustainability performance of listed timber construction companies, thus addressing current data gaps and controversies in existing ESG ratings.

H2: Integrating the ESG Timber Score with financial performance metrics will reveal distinct investment opportunities in both traditional and emerging markets for the CO_2 storage capacity of timber.

H3: The identified investment opportunities will highlight companies with a genuine connection to long-term CO_2 storage through timber construction, differentiating them from those primarily involved in short-life wood products.

The results showed that investments in the carbon storage capacity of timber were complex and required a differentiated approach. To date, the topic is mainly examined from a theoretical perspective (Rammerstorfer & Eisl, 2011; Walsh et al., 2014). This study identified a large number of listed companies with links to timber construction that vary significantly in their characteristics. While existing investment products such as the Pictet Timber Fund mainly include North American and European companies, this paper also identified attractive investment targets in Asia and Africa.

2. Sustainable Investments and Timber

The vast majority of companies hold official forest/timber certifications, similar to accreditations for management and procurement practices, which raise doubts about their relevance (Wolff & Schweinle, 2022) for an overview of the effectiveness of forest certification). However, there exists research that suggested that timber certification was negatively related to deforestation (Damette & Delacote, 2011).

Addressing the barriers of timber usage in construction presents numerous opportunities, not only for decarbonization but also for economic growth, environmental conservation, and social sustainability. Sustainable forestry can preserve ecosystems and promote biodiversity (Sample, 2005; WWF, 2023) while also creating new jobs and markets in rural areas (FAO, 2020; Trømborg et al., 2000). Furthermore, improving social standards and fostering local communities through fair labor conditions in the timber supply chain align with broader sustainability goals (International Labour Organization [ILO], 2019). Given these dynamics, it is crucial to raise awareness of the role of timber in long-term CO_2 storage and to channel investment into companies that promote sustainable timber construction, a view shared by forestry experts with financial expertise (Begemann et al., 2023). The first essential step towards this is creating transparency in the timber investment market. Many companies in the forestry and timber industries, although appearing sustainable because of their association with timber, may also be involved in short-life products such as paper or packaging, which do not contribute to long-term carbon sequestration (Charrey et al., 2023). This paper aims to fill this gap by providing a framework for investors interested in carbon storage potential of timber, so as to ensure that their investments are aligned with both sustainability and economic objectives.

Sustainable investments can take various forms and can be categorized into four approaches based on existing literature, as illustrated in Figure 1. These approaches, i.e., Exclusion, ESG Integration, Active Ownership, and Impact Investing, represent a spectrum from risk avoidance to proactive value creation (Affolter et al., 2022). In

the context of timber, these strategies can guide investors towards opportunities that align with both financial returns and environmental goals, particularly CO_2 storage. Beyond specific funds, opportunities exist across the timber value chain, from sustainable forest management and certification schemes to innovative timber product manufacturing and timber construction projects. Public and private equity investments, as well as green bonds focused on sustainable forestry and timber, represent further avenues for capital deployment (Ferrando et al., 2021; Zhou et al., 2024).

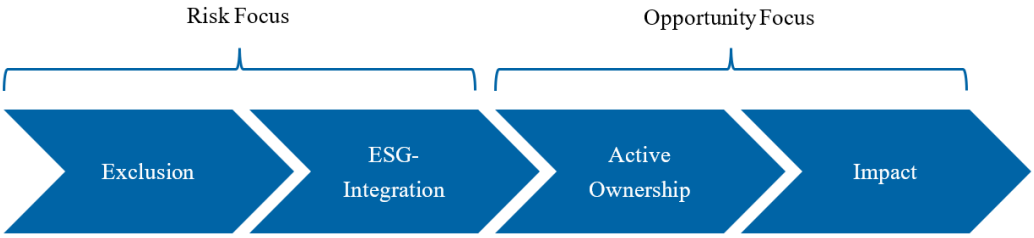

Figure 1. Strategic model for sustainable investments (Affolter et al., 2022)

In this strategic model, exclusion refers to the elimination of certain investments, such as those in the arms industry or fossil fuels. This reduces risk and ensures that investments are not made in environmentally damaging or unethical businesses. ESG integration involves incorporating ESG ratings, such as Morgan Stanley Capital International (MSCI) scores, into investment decisions. Companies with high ESG ratings tend to exhibit better financial performance and lower risk; they serve as more attractive investment targets (Friede et al., 2015). Active ownership involves funding corporate transformation or helping companies implement new business models and offer more sustainable products. This strategy also includes shareholder engagement, which involves exercising voting rights to promote positive change (Dimson et al., 2015). Impact refers to the financing of sustainability solutions, namely, innovative products, processes, or techniques (Affolter et al., 2022). Impact investments aim to achieve measurable positive social and environmental impacts, in addition to a financial return (Bugg-Levine & Emerson, 2011).

While most sustainability endeavors currently focus on exclusion and ESG integration (thus risk avoidance), active ownership and impact investing, with their focus on opportunities, offer the greatest chance of a lasting impact (Affolter et al., 2022). These strategies allow investors to contribute actively to solving global challenges, such as the climate crisis, while reaping financial benefits (Global Impact Investing Network [GIIN], 2020).

Investments in timber have the potential to offer both ecological and economic advantages. Until the early 2000s, the focus of timber investments was on forests in general (e.g., through timber real estate investment trusts (REITs)); however, attention has recently shifted towards timber construction. Despite this change, there is a lack of direct investment opportunities that specifically target the carbon storage capacity of timber. The market is currently geared more towards investors who want to diversify their portfolios through timber investments or being more sustainable. The challenges being faced include the gathering of information and knowledge gaps regarding ESG criteria and systematic risk (Charrey et al., 2023; Chudy & Cubbage, 2020).

2.1 Existing Timber Investment Products

Building upon the strategic model for sustainable investments, it is crucial to understand the landscape of existing timber investment products. These products often serve as benchmarks or represent current market approaches, which our study aims to enhance or differentiate.

One of the best-known and largest existing timber investment opportunities is the Pictet Timber Fund. Launched in 2008, the fund had a volume of USD 917 million as of 31 May 2024, holds 61 positions, and has a net asset value per share (NAV/share) of USD 282.88. With an alpha of -6.05 and a beta of 0.99, the fund is an underperformer with a risk profile that is not significantly different from that of the existing market. The fund primarily invests in forests and forest products (20%), as well as wood products (16%), packaging (13%), hygiene products (9%), and paper (8%). According to its factsheet, investments are also made in fossil fuels and nuclear energy (0.08%) and in other "controversial activities" (0.07%) through certain individual positions (Pictet, 2024). In terms of geographical distribution, the focus is on North America (53%), followed by Sweden (10%) and Finland (8%).

Another established investment option is the Global Timber & Forestry Exchange-traded Fund (ETF) from iShares, which was launched in 2007. It currently has 35 holdings, total assets of USD 192 million, and invests in companies active in the global timber and forestry industry. As of 28 June 2024, the ETF had a net asset value (NAV) per unit of USD 27.26 and a three-year beta of 0.99. The ETF invests in (raw) materials (80%) and real estate (15%), and in terms of regions, mainly in the U.S. (30%), Swedish (13%), and Finnish (10%) companies. As regards the company, it excludes businesses "deemed to be in breach of the United Nations Global Compact

principles or involved in very serious ESG controversies" (iShares, 2024).

As mentioned above, current investment opportunities in timber generally neglect the long-term CO_2 storage potential of wood (Charrey et al., 2023). In response to this, Swiss company Timber Finance, in collaboration with the Zürcher Kantonalbank (ZKB), launched a special tracker certificate in 2023 with an issue volume of CHF 25 million and an issue price of CHF 100. According to its investment profile, the certificate allows investors to invest in a basket of shares of leading European and North American companies in the forestry and timber industry that specialise in timber products and buildings that store CO_2 (Timber Finance, 2023). Key indicators such as alpha or beta are not publicly available.

Having examined the ZKB Tracker Certificate, we observed that the basket primarily focused on long-term CO_2 storage, yet still included short-life positions such as pulp, paper, and packaging (6%). The question is why a product that emphasizes the importance of long-term storage to such an extent does not exclude such positions. This may be connected to making the investments more financially attractive or better diversified. Again, this highlights the potential of a transparent investment framework in terms of the carbon storage potential of timber.

3. Methodology

To address the research questions and develop a framework for sustainable timber investments, this study employed a multi-stage methodology. This approach included data collection and filtering to identify relevant companies, the development of a proprietary sustainability score, and the assessment of financial performance. The specific methods are detailed below to guarantee replicability of the research approach.

3.1 Fields of Action for Timber Investments

Based on the strategic model presented above, timber investments can be classified into four categories as shown in Figure 2.

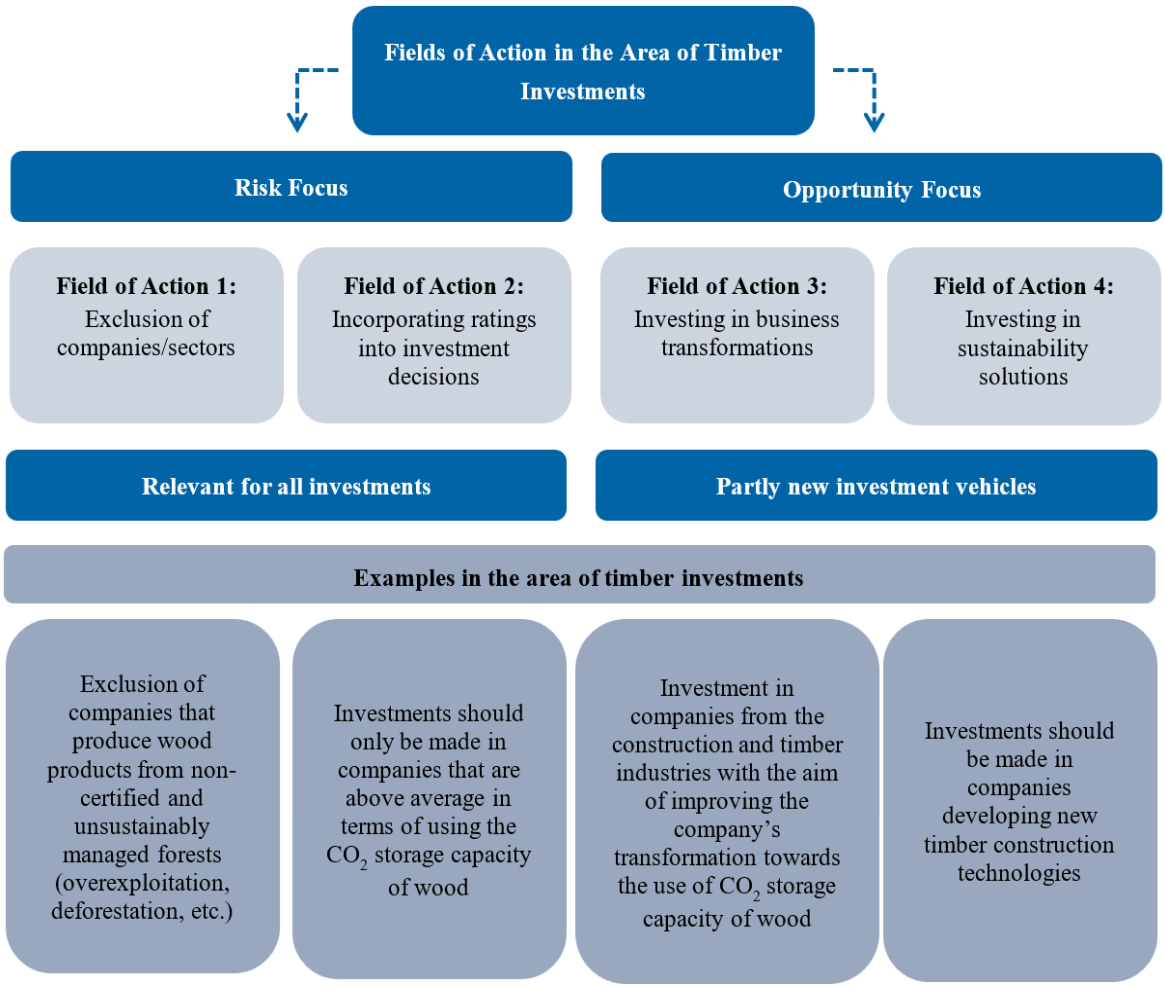

Figure 2. Fields of action in the area of timber investment (Charrey et al., 2023)

These Fields of Action delineated specific investment strategies:

- Field of Action 1 (Exclusion): This involves removing companies whose timber products are not certified by independent third-party organizations, such as Sustainable Forestry Initiative (SFI), Forest Stewardship Council (FSC), and Programme for the Endorsement of Forest Certification (PEFC), or those engaged in unsustainable forestry practices (e.g., overexploitation and deforestation).
- Field of Action 2 (Incorporating Ratings): Investments are made in companies that demonstrate above-average performance in utilizing the CO_2 storage capacity of timber, potentially informed by sustainability ratings.
- Field of Action 3 (Investing in Business Transformations): This targets companies within the construction and timber industries committed to transforming their operations towards greater utilization of CO_2-storing timber. These companies often require private equity investments due to the need of extensive information gathering.
- Field of Action 4 (Investing in Sustainability Solutions): This focuses on companies aiming to be pioneers in the field or expecting to develop innovative technologies for CO_2 storage (e.g., specially treated and absorbent timber).

The implementation of Fields of Action 1 and 2 can be directly applied to stock market investments by setting clear criteria. For Fields of Action 3 and 4, while private equity investments are currently most suitable in view of the demand for extensive private information gathering (Charrey et al., 2023), our framework aims to identify publicly listed companies that align with these innovative and transformative goals.

3.2 Data Collection and Analysis

To provide a transparent overview of investment opportunities in the CO_2 storage capacity of wood and to identify relevant companies, the following procedures and criteria were applied: (i) operating in the timber (or timber-related) sector; (ii) being listed on the stock exchange or having tradable shares; and (iii) ensuring availability of data in the London Stock Exchange Group (LSEG) tool, formerly Refinitiv.

Initially, the LSEG database was employed to create an overview of all relevant companies. To filter the companies, all "public companies" operating in the "Forest and Wood Products" sector according to the Refinitiv Business Classification (TRBC) were selected. The resulting overview generated 278 companies. In the next step, to supplement and verify the collected companies, various online sources were visited to source further timber stocks that are represented in other TRBC categories, as their primary business focus is in a different area. For example, companies active in the "Construction and Engineering" or "Paper Products" sectors, according to TRBC, may also make a significant contribution to CO_2 storage and timber construction.

After various online searches, further companies were included in the overview from websites "MarketScreener" (overview of shares of resource timber), "Wallstreet Online" (popular shares in the timber industry), "Finanzen.net" (timber industry/wood processing sector), "CAPinside" (the largest forestry and timber shares), and "Börse.de" (shares in the timber industry). A comparison was also made with the positions of the Pictet Timber Fund, the iShares Global Timber & Forestry ETF, and the ZKB Tracker Certificate. At a certain point, data saturation was observed and this remained unchanged after further online research. Finally, Chat-GPT was consulted to check the existing list of companies and make necessary additions. The author halted the process of data collection when new results could not be yielded.

3.2.1 Data cleansing and potential of CO_2 storage

The resulting overview of nearly 400 companies was then refined and updated to exclude companies that had become insolvent or delisted. This step involved manually verifying that all companies in the LSEG tool were up to date. The final and adjusted list contained 316 active and listed companies in the timber sector.

The 316 companies identified were subject to further scrutiny. The question was whether these companies had a genuine connection with timber construction (long-term CO_2 storage potential) or whether they only produced short-life products, such as paper or wood processing technologies, like chainsaws. The LSEG was consulted on this issue. Based on the various information available in the tool (company overview, share of turnover in specific sectors, etc.), a brief description was created for each company and the primary focus of the business activity was determined. If anything was unclear, the company website was visited for clarification. A "genuine connection" to timber construction was operationally defined as companies whose core business activities directly involve the production of structural timber elements (e.g., cross-laminated timber (CLT) and glued laminated timber (glulam)), the construction of buildings primarily using timber, or the manufacturing/trading of timber components specifically designed for long-term CO_2 storage in built environments. Companies primarily involved in short-life wood products (e.g., paper, packaging and wood pellets for energy), or the manufacturing of tools/machinery for wood processing (e.g., chainsaws), were excluded as they do not significantly contribute to long-term CO_2 sequestration through construction. Examples of companies with a genuine connection include those that build multi-story timber buildings or produce mass timber products for structural applications.

This approach identified 72 companies that have a genuine connection with timber construction; for example, they build with timber or manufacture/trade in timber components, such as CLT. These companies constituted approximately one-quarter of the companies analyzed.

3.2.2 Detailed analysis

The 72 companies underwent a more detailed analysis to obtain a picture of each company as complete as possible. Various sources were used:

- Company website: The first step was to consult each company's website. Attention was paid to the information the companies published and how they presented themselves. Any anomalies were noted. Only one company's website (Yunnan Jinggu Forestry Ltd.) was inaccessible and could not be verified.
- Annual report: In each case, the 2023 annual report was consulted. For most companies, the report was directly available on the website, while for a few, it had to be obtained from other sources (LSEG tool or stock exchange websites). Ultimately, all 72 reports were accessed. The focus was mainly on products, services, strategic initiatives, and sustainability efforts.
- ESG reports (optional): Where available, various sustainability reports were analyzed. These took the form of "sustainability reports" or "governance reports".

Based on this information, a comprehensive description was prepared and recorded in an Excel file for each of the 72 companies. Essentially, this involved generating individual keywords, namely capturing the company's activities and main characteristics in specific keywords. These included products such as CLT, certifications such as FSC, and innovations in terms of CO_2 storage (e.g., high-tech woods such as Accoya).

To improve comparability, individual keywords were combined into several higher-level keywords (Table 1), to which the individual keywords were assigned. Care was taken to distinguish between "positive" and "negative" expressions both in terms of CO_2 storage and sustainable business practices. Some individual keywords were classified as "neutral" (e.g., sawmill, forest experience, and biomedicine). As these do not contribute to CO_2 storage or sustainability, or directly harm the environment, these keywords were placed in this third category no longer relevant for analysis.

Table 1. Higher-level keywords

Positive	Negative
Reforestation	Automotive, aviation
Greening, seedlings	Asphalt industry
Advice on wood/forest	Concrete industry
Biodiversity	Chemicals
Disclosure	Disposable/consumable products
Renewable energies	Charcoal
Timber construction	Wood pellets
Timber components	Plastics industry
Innovation (CO_2)	Metal industry
Circular economy	Paper
Life cycle assessment	Steel industry
Certifications: Construction	Tobacco industry
Certifications: Wood/Forest	Packaging
Certifications: Management/Supply Chain	Pulp
	Cement industry

Note: Keywords were operatively defined and applied through systematic content analysis of company reports to ensure consistency in scoring and the sustainability and potential of CO_2 storage.

The operational definition and application of these keywords involved a systematic content analysis of company websites, annual reports, and ESG reports. For each of the 72 companies, trained researchers identified instances of the defined keywords or their synonyms in the text. A keyword was counted as "present" if it explicitly appeared or if the described company's activities unequivocally corresponded to the definition of the keyword (e.g., "reforestation efforts" contributed to the "Reforestation" keyword). Positive keywords indicated contributions to CO_2 storage or sustainable practices, while negative keywords indicated activities detrimental to these goals. Consistency in scoring was maintained by establishing clear guidelines for keyword identification and having multiple researchers independently review a subset of company reports to cross-validate the keyword assignments, in order to resolve any discrepancies through discussion.

Positive keywords include reforestation efforts, protection of biodiversity, or presence of various certifications (e.g., FSC). Negative keywords include activities in industries with high CO_2 emissions (e.g., concrete manufacturing), the use of wood for energy, or the production of short-life products (e.g., hygiene products). Table 1 provides an overview of the identified positive and negative keywords.

The final step before developing the proprietary sustainability score was to provide more additional information,

primarily sourced from the LSEG database, about the companies. These additional aspects included company/fundamental data (e.g., market capitalization, beta, or dividend yield) as well as ESG data (e.g., ESG score). It should be noted that ESG scores (LSEG) are only available for 29 of the 72 companies; the remaining 43 companies are not represented in this data. We therefore investigated whether these were included in other rankings, such as those of MSCI or Institutional Shareholder Services (ISS), but this was not the case.

3.3 Development of Sustainability Score

Given the lack of an official ESG score for nearly 60% of our sample, as well as the controversy surrounding existing ratings, we developed a proprietary sustainability score, ESG Timber Score.

This score aims to consider both qualitative and quantitative company characteristics related to sustainability to make the most accurate statement possible. It seeks to establish a transparent and comprehensible rating system that objectively evaluates the sustainability performance of companies involved in timber construction, while also taking into account ecological aspects related to CO_2 storage.

The newly developed scoring system for ESG Timber Score comprises three main components:

- Keyword score (60%): This is considered the most crucial component of the present work as it addresses actual business activities in an unembellished manner. It clearly and objectively highlights negative aspects without disguising them.
- LSEG ESG score (20%): Due to the prevailing controversy of ESG score, a smaller weighting was given to this score. This allows us to consider the general orientation of companies or the assessments of reputable rating agencies without giving too much weight to this assessment.
- ESG reporting score (20%): This is also given a lower share as reporting rules are not harmonized internationally. Nevertheless, regular disclosure of sustainability efforts by companies, whether mandatory or voluntary, seems highly relevant.

3.3.1 Keyword score

To develop the keyword score, the overarching keywords related to CO_2 storage were first grouped into four categories (Table 2):

Table 2. Evaluation of keywords

Very Positive	Positive	Negative	Very Negative
Reforestation	Advice on wood/forest	Wood pellets	Automotive, aviation
Greening, seedlings	Biodiversity	Paper	Asphalt industry
Timber construction	Disclosure	Packaging	Concrete industry
Innovation	Renewable energies	Pulp	Chemicals
Circular economy	Certifications: construction		Disposable/consumable products
Life cycle assessment	Certifications: wood/forest		Charcoal
	Certifications: management/supply chain		Plastics industry
			Metal industry
			Steel industry
			Tobacco industry
			Cement industry

Note: Keywords were categorized as “Very Positive”, “Positive”, “Negative”, or “Very Negative” based on their direct impact on CO_2 storage and sustainable business practices, as defined in the systematic content analysis.

To obtain a company’s keyword score, the occurrence of different keywords was counted and scored for each business according to the classification in Table 2. The total score was then calculated by adding positive and negative scores. To provide a consistent basis for comparison and account for the contribution of the keyword score (60%) to ESG Timber Score, the keyword scores were then normalized to a scale of 0 to 60. A feature scaling using the min-max method, in which the values are scaled to fall within a specified range (usually 0–1, in this case 0–60) was applied. The steps involved were the identification of the minimum and maximum values (-4 and 16), the application of the normalization formula $Xnorm = (X - Xmin)(Xmax - Xmin)*(b - a) + a$. This allowed enhanced comparability between companies. The best company with an original score of 16 received 60 points; the worst company with an original score of -4 received 0 points.

3.3.2 LSEG ESG score and ESG reporting score

The classification of the ESG scores available from LSEG was delineated as follows:

- Very good (A- to A+): 20 points
- Good (B- to B+): 10 points
- Average (C- to C+): 5 points

• Poor (D- to D+) or non-existent: 0 points

The general availability of publicly available sustainability reports was included in the assessment. To this end, company websites were consulted to determine whether (and if so, how regularly) ESG reports were available. Both separate ESG and integrated reports were considered.

• Annual ESG reporting (separate or integrated annual reports): 20 points
• Irregular ESG reporting (only in some years): 10 points
• No ESG reporting: 0 points

3.3.3 Validation of the ESG Timber Score

The final ESG Timber Score was determined for each company by summing the points awarded from the keyword score, the LSEG ESG score, and the ESG reporting score. A maximum of 100 points was possible.

To ensure that the ESG Timber Score is a reliable tool for assessing the sustainability performance of companies in the context of timber construction, we validated it in three ways:

- Pilot study: A pilot study was conducted to test the newly developed score on a small sample of companies and to ensure the results were consistent and plausible. In this study, 10 randomly selected companies were evaluated using ESG Timber Scores, and the results were reviewed. No discrepancies were found.
- Internal consistency: The internal consistency of the scores was checked by calculating Cronbach's alpha, for which a value above 0.7 indicates a high degree of reliability. The calculation was done directly in *R* using the alpha () command. Examining the individual components, the ESG reporting score exhibited a high raw correlation (0.77) and a high standardized correlation (0.83) with the total score. The corrected total item correlation (0.72) showed that the component correlated well with the total score even when it was excluded. The LSEG ESG score had a moderate raw correlation (0.62) and a high standardized correlation (0.77) with the total score. The corrected total item correlation (0.62) showed a good correlation with the total score when excluded. The keyword score had a high raw correlation (0.80) and a slightly lower standardized correlation (0.65) with the total score. However, the corrected total item correlation (0.33) indicated that this component correlated less strongly with the total score when it was excluded. In general, a cross-scale (comprising all three components) raw alpha of 0.53 and a standardized alpha of 0.61 were obtained, indicating moderate internal consistency. As the individual components are not necessarily correlated with each other (official ESG rating vs. actual sustainability of corporate activities), moderate internal consistency is considered acceptable.
- Comparison with existing scores: The results were compared with existing ESG scores to assess agreement or deviations. Again, no noticeable discrepancies were found.

These results suggested that the ESG Timber Score was sufficient to yield reliable results.

3.4 Development of the Economic Score (Performance Score) and the Aggregate Score

To analyze the longer-term performance (return) of companies, the historical price information for each stock had to be evaluated. To this end, both the daily and annual returns of the companies were analyzed between 1 January 2018 and 31 December 2023. The absolute values and the percentage change of the values on a daily and annual basis were extracted from the LSEG tool, before these returns were aggregated into a single average over the last five years. In the next step, the average annual returns were normalized using feature scaling and the min-max method. To this end, the minimum and maximum values (-57.46% and 99.04%) were identified and the normalization formula $Xnorm = (X - Xmin)(Xmax - Xmin)*(b - a) + a$ was applied. The lowest performing company (-57.46%) received 0 points, whereas the best performing company (99.04%) received the maximum number of 100 points.

The creation of an aggregate score that comprised both the sustainability score ("ESG Timber Score") and the performance score was the final step. No weighting of these two dimensions was specified.

4. Results

4.1 Distribution of the ESG Timber Scores

The distribution of the final ESG Timber Scores for the 72 analyzed companies, derived from the keyword score, LSEG ESG score, and ESG reporting score, is illustrated in Figure 3. Scores ranged from 6 to 91, with an average [median] of 43.3 [40] and a standard deviation of 22, indicating a wide spread in sustainability performance across the sample.

4.2 Distribution of the Economic Scores

The distribution of the economic scores, representing the normalized average annual returns from 2018 to 2023, is shown in Figure 4. Scores ranged from 0 (lowest performing company at -57.46%) to 100 (best performing

company at 99.04%), with an average [median] of 45.3 [44.2] and a standard deviation of 16.3. This distribution highlights the variability in financial performance within the timber construction sector.

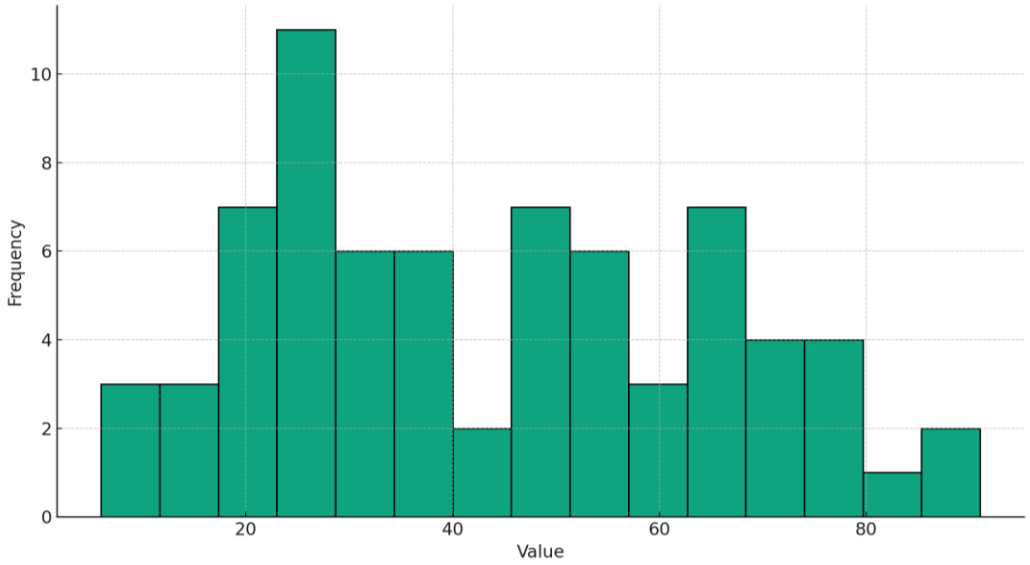

Figure 3. Distribution of the Environmental, Social, and Governance (ESG) Timber Scores

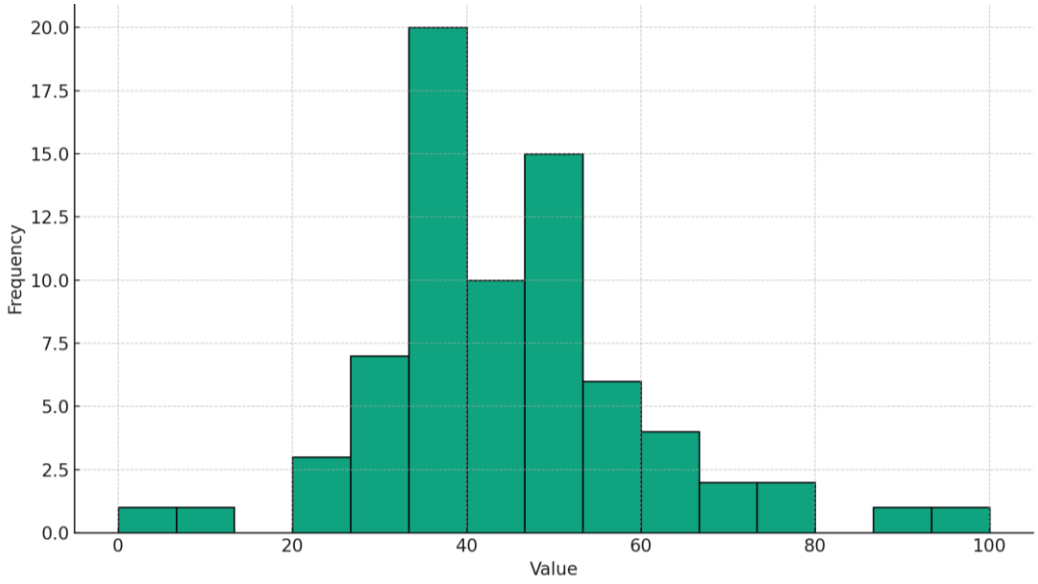

Figure 4. Distribution of the economic scores

4.3 Geographical Classification of the Companies

The analysis included companies from five continents: Africa, Asia, Europe, the Americas (North/South), and Australia.

Figure 5 illustrates that the majority of listed companies related to timber construction are based in Asia (35%), Europe (31%), and North America (26%). Africa and South America have two and three listed timber construction companies, respectively, while only one Australian company is identified.

Further analysis showed that companies in Europe were more diversified across countries than those in Asia and the Americas. While in the Americas, they are concentrated in Canada (11), the U.S. (8), Chile (2) and Brazil (1). In Europe, they are represented by Finland and France (3 each), Germany, Poland, Sweden and the United Kingdom (2 each) and Bulgaria, Greece, Lithuania, Norway, Portugal, Russia, Tunisia and Cyprus (1 each). In Asia, the main countries represented are Japan (6), India and China (5 each), and Indonesia (3), followed by Malaysia and Thailand (2 each) and South Korea and Vietnam (1 each).

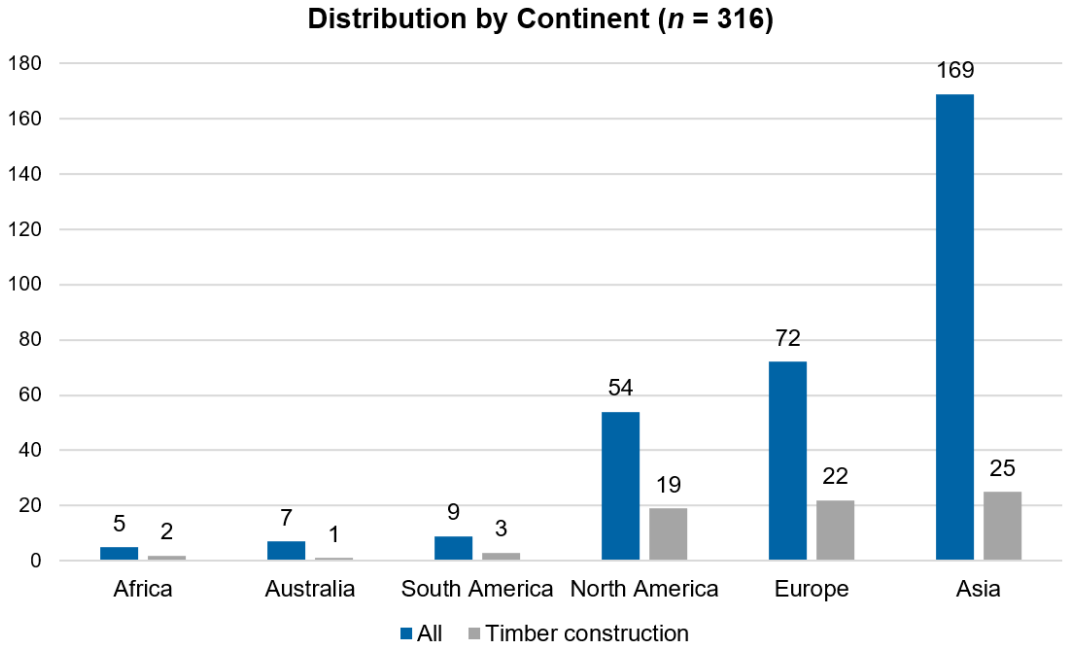

Figure 5. Listed companies in the timber industry by continent

4.4 Industry/Activity

The listed companies related to timber construction were mainly active in the "Wood Products" and "Forest and Wood Products" sectors (48 in total), with four companies in the "Paper Products" sector (Figure 6).

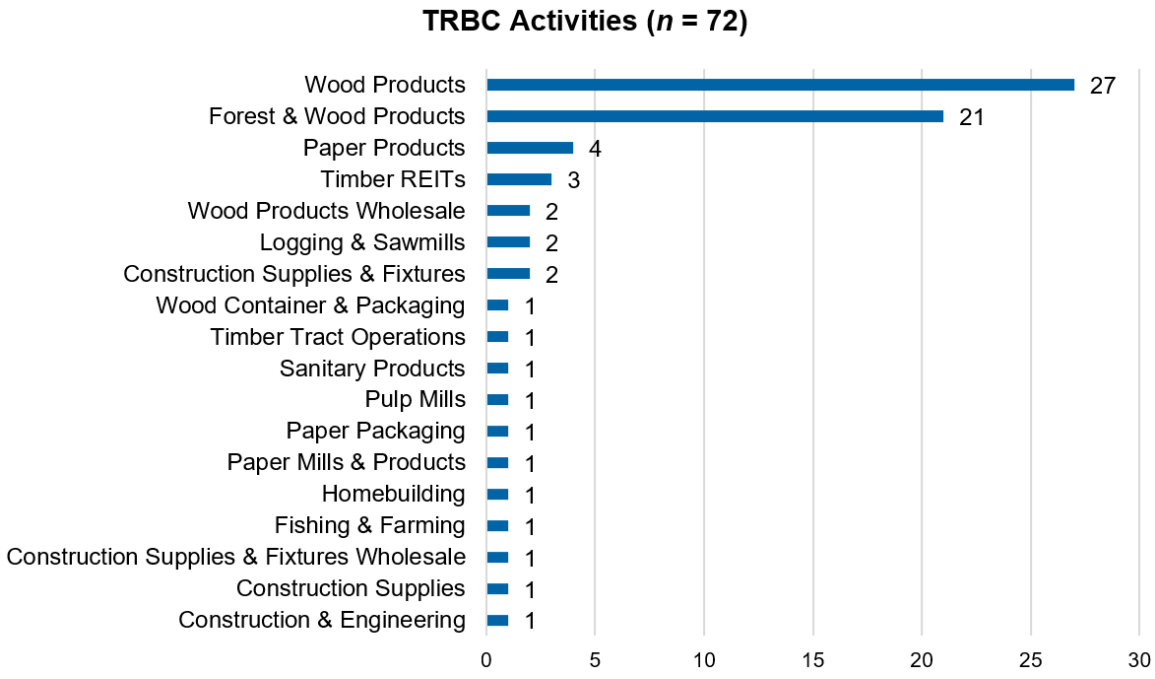

Figure 6. Activities of the companies surveyed

4.5 Keywords

An analysis of the companies in terms of the positive keywords is shown in Figure 7.

Almost all the companies surveyed (89%) had wood/forestry certifications, such as FSC, SFI, or PEFC, while most (83%) also had management and supply chain practices certified to International Organization for Standardization (ISO) or similar standards. While a circular economy is being considered in many places (72%),

a holistic life cycle approach is being implemented by only a small number of companies (21%). Just under 10% of all companies work directly with timber, including Holmen AB and Veidekke ASA.

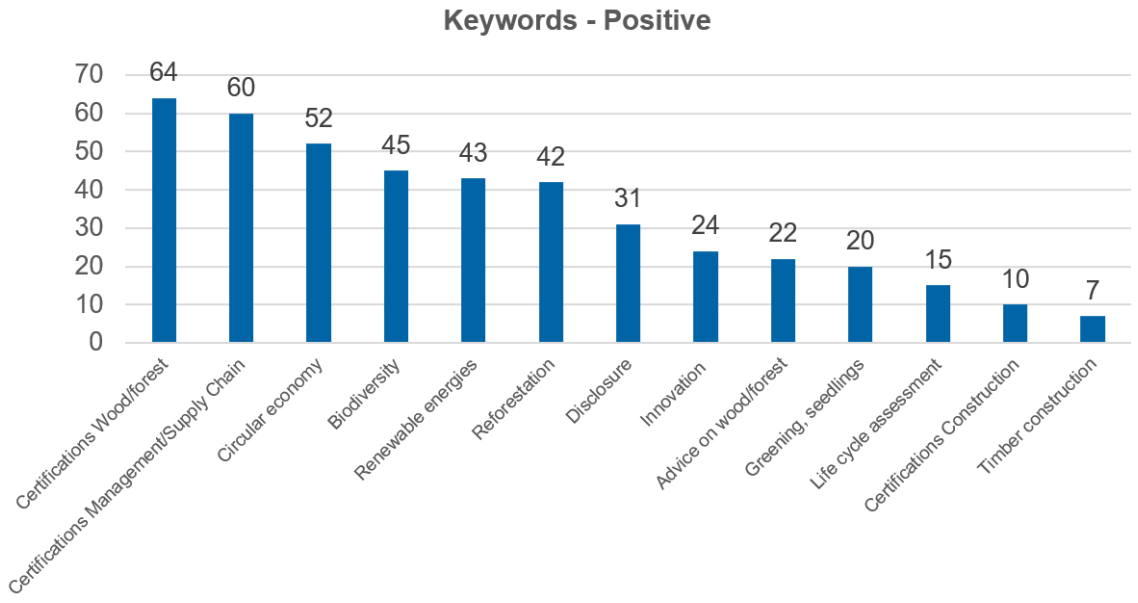

Figure 7. Number of the positive keywords (own representation)

Figure 8 shows the analysis of negative keywords.

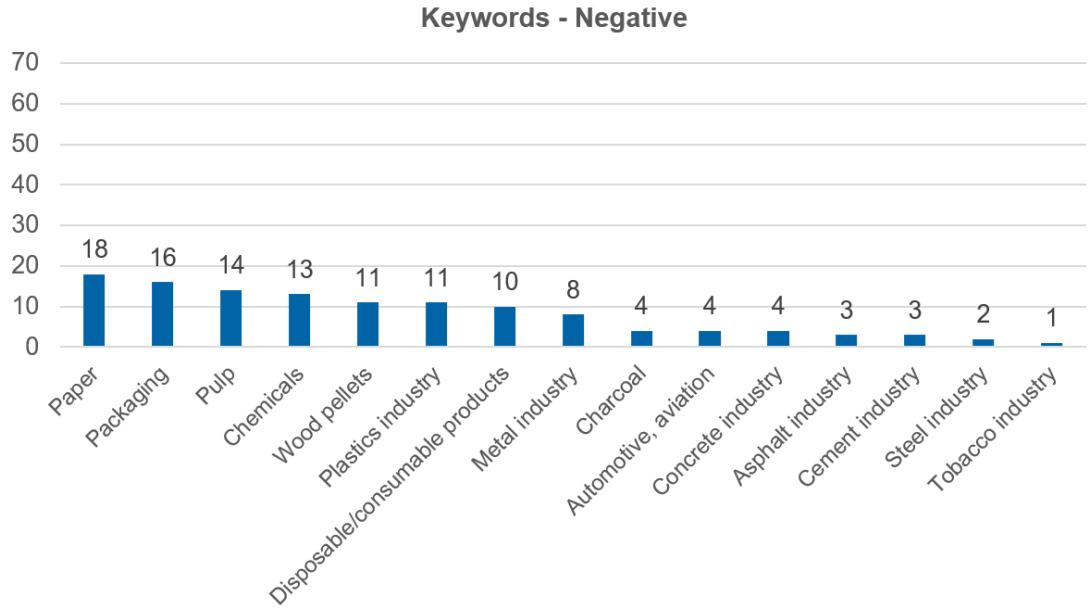

Figure 8. Number of the negative keyword

Paper production heads the list, with a quarter of all companies involved. 22% produced short-life packaging, while 15% promoted the use of wood for energy in the form of pellets. However, it is apparent that only a few companies are active in industries with high CO_2 emissions: 11% in the metals industry, 6% each in the automotive and concrete industries, 4% each in the asphalt and cement industries, and 3% in the steel industry. These are primarily construction companies like Builders FirstSource Inc., Sumitomo Forestry Ltd., and Veidekke ASA.

4.6 Key Economic Figures

4.6.1 Market capitalization

A look at this topic revealed that the number of companies decreased with increasing market capitalization

(Figure 9). For example, 28% fell into the "nano-cap" category with a market capitalization of less than USD 50 million (e.g., Rougier SA or York Timber Holdings Ltd.) or the "micro-cap" category with a market capitalization between USD 50 and 300 million (e.g., Acadian Timber Corp. or Grigeo AB). The small cap category (market capitalization between USD 300 million and USD 2 billion) comprised 15 companies (21%), including Canfor Corp. and Steico SE. Eleven (15%) were "mid-caps" with a market capitalization between USD 2 to 10 billion, for example, Holmen AB and UFP Industries Inc. The largest companies (large-caps) with a market capitalization were Builders FirstSource Inc., Conifex Timber Inc., Stora Enso Oyj, Svenska Cellulosa AB, UPM-Kymmene Oyj, and Weyerhaeuser Co.

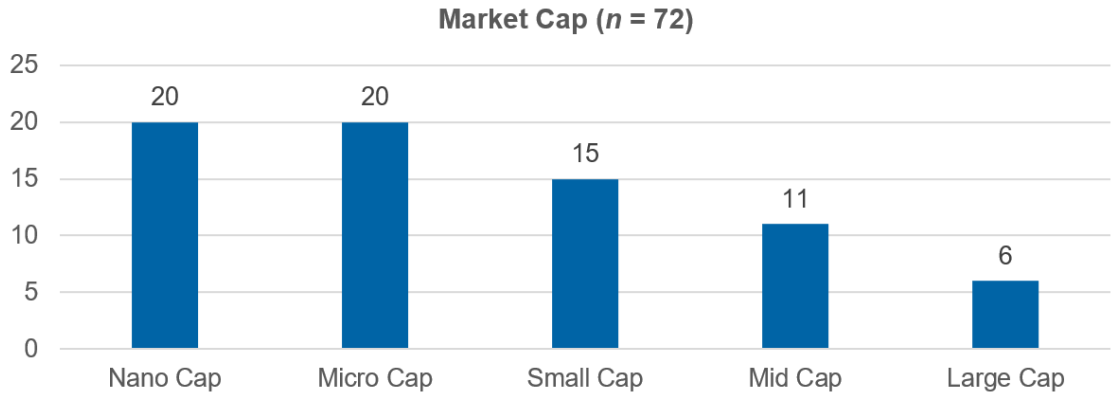

Figure 9. Market capitalization of the companies surveyed (own representation)

4.6.2 Beta (5Y monthly)

Another key figure is beta, which describes the systematic risk. For each company, the five-year beta, calculated using the monthly returns, was used. This is particularly helpful when analyzing the long-term risk of a stock compared to the market. A beta of 1 means that the stock tends to fluctuate in line with the market; a beta greater than 1 means that the stock is more volatile than the market, and a beta less than 1 means that the stock is less volatile than the market. If the beta is negative, the stock often moves in the opposite direction to the market.

It turns out that most companies behave similarly to the market, as illustrated in Figure 10. Almost two-thirds of the companies are in the range of 0.5 to 1.5. 15% are significantly more volatile than the market with a beta above 1.5, and 8% are even more than twice as volatile with a beta above 2. Two companies, Fabryka Konstrukcji Drewnianych SA and Interwood Xylemboria ATENE, have a slightly negative beta.

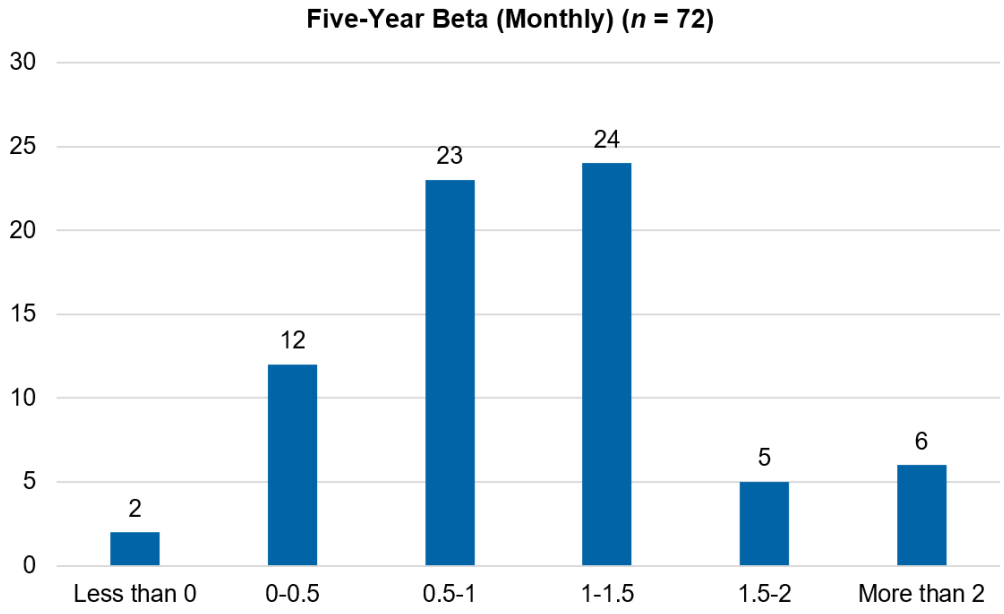

Figure 10. Five-year beta (5Y monthly) of the companies surveyed

Table 3 summarizes the companies that differ significantly from the market in terms of beta.

Table 3. Companies with significant beta deviations

Less than 0	0 to 0.5	1.5 to 2	More than 2
Interwood Xylemboria ATENE (-0.01) Fabryka Konstrukcji Drewnianych SA (-0.12)	Indonesia Fibreboard Industry Tbk (0.49) Svenska Cellulosa AB SCA (0.44) Holmen AB (0.4) Fazerles AD (0.38) Nippon Paper Industries Ltd.3 (0.38) Western India Plywoods Ltd. (0.34) Koskisen Oyj (0.33) Big River Industries Ltd. (0.32) Rougier SA (0.17) Cyprus Forest Industries Public Ltd. (0.11) National Plywood Industries Ltd. (0.11) Yunnan Jinggu Forestry Ltd. (0.11)	Louisiana-Pacific Corp. (1.92) Western Forest Products Inc. (1.88) Moulinvest SA (1.82) MDF VRG Quang Tri Wood JSC (1.61) Boise Cascade Co. (1.53)	Wijaya Cahaya Timber Tbk PT (2.55) Ta Ann Holdings Bhd (2.22) West Fraser Timber Ltd. (2.2) Builders FirstSource Inc. (2.08) Canfor Corp. (2.06) Interfor Corp. (2.02)

4.6.3 Dividend

The dividend yield, which is the ratio of the dividend paid to the share price, is also of interest to investors. The following classification was used: no dividend payment (0%), very low (0–1%), low (1–2%), medium (2–4%), high (4–6%), and very high (over 6%). The results are shown in Figure 11.

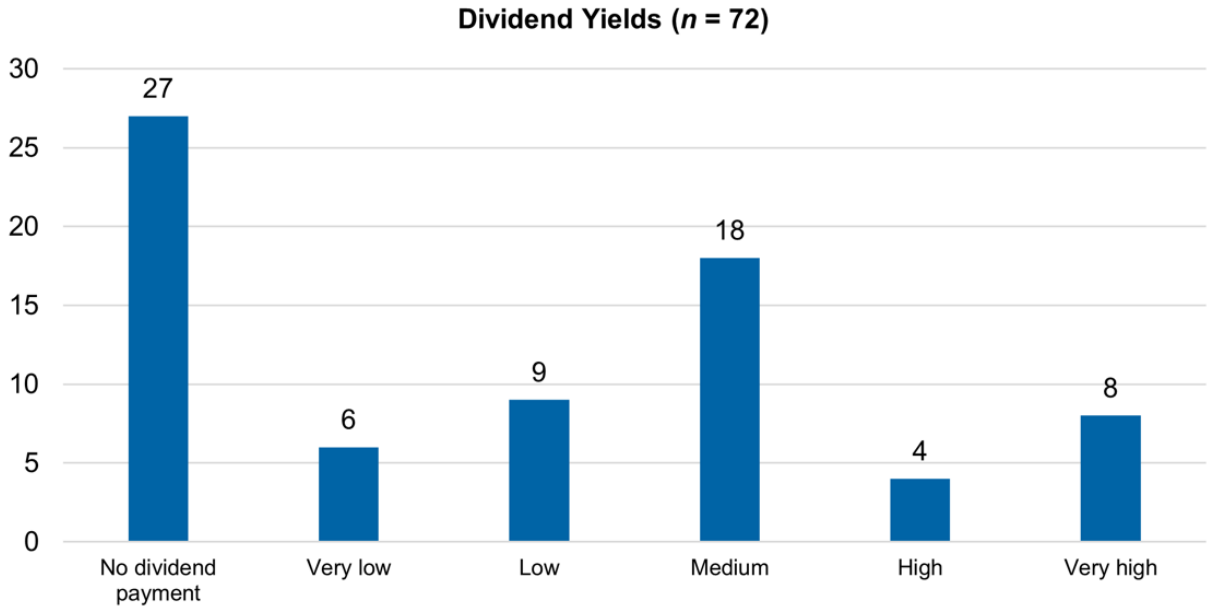

Figure 11. Dividend yields across the companies

While more than a third of companies paid no dividends (including Interfor Corp., Rougier SA, and Accsys Technologies PLC), one quarter paid medium dividends and 17% of the companies paid a high or very high yield. Koszalinskie Przedsiebiorstwo Przemyslu Drzewnego SA led the ranking with 8%, followed by Veidekke ASA and Koskisen Oyj, each with 7%. The lowest dividend yield was found at Century Plyboards India Ltd. (0.1%), followed by Greenpanel Industries Ltd. and Vanachai Group PLC (both 0.6%).

5. Discussion

How can investors invest in the carbon storage capacity of timber in the stock market, and which approaches are both sustainable and economically advisable? Our focus on the creation of an ESG Timber Score to evaluate the sustainability of listed companies in the timber construction sector as well as the related analyses, showed that it was extraordinarily complex and time-consuming to identify suitable companies. Most investors are either unable or unwilling to scrutinize companies with the required details. Instead, they will either invest in existing products, such as the Pictet Timber Fund or iShares, or when buying individual stocks, focus on well-known,

stable, and high-yielding positions, such as Weyerhaeuser Co. or Svenska Cellulosa AB. However, this is not necessarily the best way to invest in the CO_2 storage capacity of timber, which requires a much more sophisticated approach.

Our findings directly addressed Hypothesis H1 by demonstrating that a comprehensive and proprietary "ESG Timber Score" can indeed reliably assess the sustainability performance of listed timber construction companies. This score, which integrates keyword analysis, existing ESG ratings, and reporting transparency, successfully navigates the limitations of current data availability and controversies surrounding conventional ESG metrics, particularly for the specific context of CO_2 storage potential of timber. The development and validation of this score provide a robust tool though official ESG data is often lacking or deemed insufficient, thus enhancing market transparency as initially aimed.

Existing products all focused on North American and European companies. However, the results of this study revealed a high concentration of attractive investment targets in Asia, for example, Greenpanel Industries Ltd. (India) and Sumitomo Forestry Co., Ltd. (Japan). One African company, Woodbois Ltd. (Gabon), was also identified as a top performer, raising the question of why the focus was so broad on North America and Europe, while Asia, for example, was almost completely excluded from this category. One possible explanation is that better market conditions and regulatory support, such as subsidies, are more readily available in these regions. Our analysis revealed challenges in terms of data availability: while most European and North American companies provided comprehensive data in English, many Asian websites and reports were only available in the local language. Accordingly, translation tools are often required, which does not necessarily boost investors'confidence in these companies

These geographical insights directly supported Hypothesis H2; integrating our "ESG Timber Score" with financial performance metrics revealed distinct investment opportunities beyond traditional markets. The identification of attractive targets in Asia and Africa challenged the existing Eurocentric and North American bias of timber investment products (e.g., Pictet Timber Fund, iShares, Global Timber and Forestry ETF), suggesting that a broader geographical diversification is both possible and advisable for investors seeking to optimize both sustainability and financial returns. This finding is particularly significant, given the rapid growth of construction sectors in these emerging economies and their potential for sustainable timber adoption.

Similarly, the fact that almost all companies have certifications in the areas of wood/forestry and management/supply chain raises doubts about their actual validity or significance. It is questionable whether all companies truly operate sustainably in these areas or whether it is simply too easy to obtain the relevant labels. Furthermore, it is worth noting that the significant presence of smaller companies ("nano caps" and "micro caps") suggests a fragmented industry with numerous small players. This fragmentation could pose challenges in terms of economies of scale and market stability. The small number of sizable companies ("large caps") could indicate a lack of consolidation, which in turn could increase volatility and risk for investors. The extreme values in market capitalization, ranging from the Polish company Fabryka Konstrukcji Drewnianych SA with USD 0.4 million to the U.S.-based Weyerhaeuser Co. with USD 22 billion, illustrate the wide range of company sizes and their varying market conditions. This underlines the need for differentiated analysis and evaluation of investment opportunities in the sector.

Our analysis, particularly through the keyword categorization (Tables 1 and 2) and the subsequent filtering process, confirmed Hypothesis H3. By focusing on companies with a "genuine connection" to timber construction for long-term CO_2 storage, we effectively differentiated them from those primarily engaged in short-life wood products. This differentiation is crucial for investors aiming for actual environmental impact through carbon sequestration rather than merely investing in the broader wood products industry. The observed prevalence of certifications, while seemingly positive, requires critical assessment, as our findings suggested that not all certifications necessarily translated into verifiable long-term CO_2 storage efforts. This highlights the value of our granular keyword analysis in discerning true sustainability contributions.

In terms of economic figures, the identified companies have a relatively small market capitalization overall. In terms of beta factors, most companies behave similarly to the market, but there are companies with a beta greater than 1.5 at one end and some with a slightly negative beta at the other.

5.1 Practical Implications of the Aggregate Score

The developed aggregate score, which combines the "ESG Timber Score" with financial performance metrics, offers a novel tool for investors. It moves beyond a siloed view of sustainability or financial returns by providing a holistic framework for portfolio decisions.

Investors can utilize this score to uncover companies in the emerging markets or smaller cap segments that possess strong sustainability credentials related to CO_2 storage but might be overlooked by conventional ESG funds focused on larger and more established players. Depending on an investor's preference for sustainability versus financial risk/return, the aggregate score allows a nuanced selection. For instance, an investor prioritizing environmental impact might accept a slightly higher beta for a company with a very high ESG Timber Score, while

a risk-averse investor might prefer a lower beta company with a still-strong, but perhaps not leading ESG score. By providing a transparent methodology for evaluating timber companies, the score may encourage companies to improve their sustainability reporting and actual practices. The identified geographical and industry diversification opportunities, guided by the aggregate score, enable investors to construct more resilient portfolios that are less concentrated in traditional markets and offer exposure to companies at the forefront of sustainable construction globally.

In summary, this paper showed that investments in the CO_2 storage performance of timber required a differentiated consideration of the sustainable and financial aspects. The present study contributed significantly to promoting sustainable investments in timber construction and created transparency in the market for timber investments. Limitations of this paper include its focus on listed companies as many private and smaller companies in the timber construction sector could also make significant contributions to CO_2 storage. Future research should seek to include these companies and assess their potential.

6. Conclusions

This study set out to address the critical need for transparent and actionable investment strategies in the timber construction sector, particularly its CO_2 storage capacity. We developed and validated a new "ESG Timber Score" by integrating qualitative keyword analysis, existing ESG data, and reporting transparency, thereby providing a robust framework to assess the sustainability performance of listed companies.

Our findings demonstrated significant investment opportunities across various geographical regions, not limited to the traditional North American and European markets, but notably extending to Asia and Africa. This broadened the scope for sustainable timber investments and suggested a potential for greater diversification in investors' portfolios. Furthermore, the filtering process, which focused on companies with a connection to long-term CO_2 storage through timber construction, proved effective in differentiating impactful investments from those in short-life wood products, hence reinforcing the value of our granular analytical approach.

The aggregate score, combining both sustainability (ESG Timber Score) and economic performance, offers a pragmatic tool for investors. It enables a nuanced decision-making process, allowing the alignment of financial objectives with environmental impact. By providing a first evaluation system, this research contributes to fostering greater investors' confidence and capital flow into the timber construction sector, which is vital for global decarbonization efforts.

The practical significance of this study lies in its provision of a clear and replicable methodology for investors to identify and evaluate sustainable timber investment opportunities. It serves as a guide for constructing portfolios that not only aim for financial returns but also actively contribute to mitigating climate change through enhanced CO_2 storage. The theoretical relevance stems from advancing the understanding of ESG integration in specific industrial contexts and highlighting the limitations and necessary adaptations of broad ESG ratings for specialized sectors like timber construction.

While this research focused on listed companies, future work should expand to include private and smaller companies in the timber construction sector, as they also hold significant potential for CO_2 storage. Further research could explore the dynamic interplay between regulatory frameworks, technological advancement in timber construction, and their influence on the performance of a company's sustainability and attractiveness to investors. By continually refining such tools, the transition towards a more sustainable and carbon-neutral built environment could be accelerated.

Author Contributions

Conceptualization, T.K., A.H., and T.R.; methodology, T.K., A.H., and T.R.; software, T.K.; validation, T.K., A.H., and T.R.; formal analysis, T.K.; investigation, T.K.; resources, T.K.; data curation, T.K.; writing—original draft preparation, T.K.; writing—review and editing, A.H and T.R.; visualization, T.K.; supervision, A.H and T.R.; project administration, T.K.; funding acquisition, A.H and T.R. All authors have read and agreed to the published version of the manuscript.

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Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

All authors declare no conflicts of interest in this paper.

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