

## A multi-perspective exploration of the environmental website disclosure in global manufacturing

Thimm, Heiko; Rasmussen, Karsten Boye

*Published in:*  
Business Strategy and the Environment

*DOI:*  
10.1002/bse.3214

*Publication date:*  
2023

*Document version:*  
Final published version

*Document license:*  
CC BY-NC

*Citation for pulished version (APA):*  
Thimm, H., & Rasmussen, K. B. (2023). A multi-perspective exploration of the environmental website disclosure in global manufacturing. *Business Strategy and the Environment*, 32(4), 1719-1738.  
<https://doi.org/10.1002/bse.3214>

Go to publication entry in University of Southern Denmark's Research Portal

### Terms of use

This work is brought to you by the University of Southern Denmark.  
Unless otherwise specified it has been shared according to the terms for self-archiving.  
If no other license is stated, these terms apply:

- You may download this work for personal use only.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying this open access version

If you believe that this document breaches copyright please contact us providing details and we will investigate your claim.  
Please direct all enquiries to [puresupport@bib.sdu.dk](mailto:puresupport@bib.sdu.dk)

# A multi-perspective exploration of the environmental website disclosure in global manufacturing

Heiko Thimm<sup>1</sup>  | Karsten Boye Rasmussen<sup>2</sup> 

<sup>1</sup>School of Engineering, Pforzheim University, Pforzheim, 75175, Germany

<sup>2</sup>Department of Business & Management, University of Southern Denmark, Odense M, DK-5230, Denmark

## Correspondence

Heiko Thimm, School of Engineering, Pforzheim University, Tiefenbronnerstr. 65, 75175 Pforzheim, Germany.  
Email: [heiko.thimm@hs-pforzheim.de](mailto:heiko.thimm@hs-pforzheim.de)

## Funding information

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

## Abstract

In this work, more than 340 of the largest manufacturing companies from China, Europe, Japan, and the United States are analysed to measure the extent of their environmental website disclosure from multiple perspectives, to explore determining factors of disclosure and to investigate whether disclosure correlates to scores of environmental performance ratings. The study data set included more than 80 website observation items, data about downloadable annual sustainability reports, financial performance data and the environmental scores in the CDP Rating and the Refinitiv ESG Scores. Descriptive statistical analyses and correlation analyses were performed for the entire sample and for the regional subsets of the sample. One of the major results is that all regions show low levels of website disclosure. However, some variation in the extent of disclosure was found. The lowest level of disclosure was found for Chinese websites. Higher levels were observed for the companies from Europe, Japan and the United States. The analysis of the reports revealed that only one-third of the sample companies from China but more than half of the companies from Europe, Japan and the United States supply recent reports. It was also found that integrated reports are less used in the United States, particularly when compared with companies from Europe and Japan. Insights also suggest that there is a weak to moderate correlation between one of the disclosure scores used and the Refinitiv ESG Scores. Further correlation analyses did not provide indications that company age and financial performance are to be considered determining factors of environmental website disclosure.

## KEYWORDS

corporate environmental management, environmental reporting, environmental scores, environmental sustainability, environmental website disclosure, ESG rating, explorative research study, global production industry, sustainability disclosure, sustainability reporting

## 1 | INTRODUCTION

A growing set of drivers are pushing companies to address the United Nations Sustainable Development Goals (SDGs) by launching corporate transformation programmes aimed at improving business

sustainability. Sustainability efforts are often at the centre of image building and reputation management activities intended to make the company recognized as an environmentally responsible business entity sometimes just referred to as a 'green company'. For these activities, corporate websites often serve as an effective and relatively

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial](https://creativecommons.org/licenses/by-nc/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.

© 2022 The Authors. Business Strategy and The Environment published by ERP Environment and John Wiley & Sons Ltd.

cheap medium to promote a 'green company' image through well-designed environmental website disclosure (Gill et al., 2008). Companies also increasingly use social media to communicate their sustainability efforts (Knight et al., 2022). However, firms may be tempted to present themselves 'greener' than they actually are (Delmas & Burbano, 2011; Li et al., 2022) or may even misuse disclosure to distract the public attention from environmental scandals (Siano et al., 2017).

The global movement towards sustainable business has brought forth company ratings that are intended to provide helpful insights into nonfinancial business performance for investors, sustainability researchers and other actors. So-called ESG Ratings such as the Refinitiv ESG Rating (Refinitiv, 2021a), also known as Thomson Reuters ESG Rating until its renaming in the second half of 2018, provide performance scores for three categories of nonfinancial performance: Environment (E), Social (S) and corporate Governance (G). Another popular environmental rating is the CDP Rating of the Carbon Disclosure Project (CDP, 2021a). The CDP Rating provides firm-level environmental performance scores that have been used in various disclosure studies, for example, (Mateo-Márquez et al., 2021).

A great source of information for detailed company-specific environmental information such as environmental programmes, projects and key figures regarding energy consumption, resource consumption, carbon footprints and waste are nonfinancial annual reports that are disclosed by a growing number of companies (Hahn & Kühnen, 2013; Stacchezzini et al., 2016). Environmental reporting can be required by law. For example, the European Union (EU) Directive on Non-Financial Reporting (European Union, 2014) requires large companies to include nonfinancial statements in their annual reports or in a separate filing from 2018 onwards. But, as a result of a recent disclosure study of sustainability reports in the Italian cosmetic industry, it is still argued for an increase of institutional pressure through new regulatory requirements (Tiscini et al., 2022). Recommendations regarding the non-financial information items to be addressed are, for example, given by the Global Reporting Initiative (GRI) (2015).

The explorative empirical study presented in this article contributes to the research field of voluntary corporate environmental website disclosure. Various scholar studies on why firms decide for or abstain from voluntarily provide environmental information can be found in the literature (Gray et al., 1996; Mateo-Márquez et al., 2021; Solomon & Lewis, 2002). Also, explorative studies with similarities to this work are contained in the prior research literature. However, as, for example, argued by Brammer and Pavelin (2008), in these studies, often small samples of companies limited to a particular country and/or a particular industry were explored with a focus on either the corporate website or online reports. Given the ongoing digital transformation in the business world and the fact that SDGs and the topic of sustainability only in recent years moved into the centre of public interest, it can be assumed that the results of these earlier studies do not reflect the current status of environmental disclosure. With the empirical study presented in this article, we attempt to fill these gaps by adding up-to-date science-based new knowledge to the research debate on voluntary environmental disclosure in both

corporate websites and sustainability reports. In particular, the following research questions are addressed: (1) What are the main characteristics of the current status of environmental disclosure of both websites and online annual reports? (2) What are today's determining factors of environmental disclosure, in particular, what is the influence of the country/region of origin of the firm, the environmental performance and the firm age on the extent of disclosure?

Our study operates with a sample size that is significantly larger than most of the samples used in other empirical disclosure studies. In particular, a random sample is used that consists of 346 large (more than 10,000 employees) manufacturing companies from China, Europe, Japan and the United States. The four constituent subsets of the sample are uniformly referred to in the article as regional subsets or just regions because of the vast territory of China and the United States. General data and financial performance data for the sample companies were obtained from the commercial company database Orbis of the Bureau van Dijk (2019). The study data collection was complemented by observational data about the companies' environmental website disclosure, data about environmental reporting and data about the companies' scores achieved in two different non-financial ratings. The website observation examined both the start page and relevant lower-level pages for about 40 disclosure items. Moreover, the entire website domains were searched for 30 search terms, and resulting hits were scraped for 13 further terms. The combined multi-perspective exploration approach that uses a large spectrum of diverse environmental website disclosure data to analyse a large transnational sample differentiates our work from many of the published prior research studies.

The data collection was used to build specific indices for environmental website disclosure. Based on these indices, data analyses were performed to investigate the above research questions. Furthermore, correlation analyses tested the following three research hypotheses:

**Hypothesis H1.** *There is a positive correlation between environmental website disclosure and environmental performance scores of ESG ratings.*

Hypothesis H1 draws on the fact that the environmental performance scores of rating agencies inherently address environmental disclosure. Hence, it can be assumed that companies with high scores disclose environmental information at the website to a higher extent than companies with low scores.

**Hypothesis H2.** *There is a negative correlation between environmental website disclosure and company age.*

Obviously, during recent decades, the extent of entrepreneurial activities has been growing, especially in the information services and information technology sectors. In comparison to these young companies, most firms in traditional 'old economy' business sectors have been around for long periods of time. Their human capital is often much older than the human capital of young companies. Old companies also often tend to have more traditional corporate cultures and

leadership principles. These particular characteristics may cause old companies to view environmental disclosure on websites and in online reports as a lower priority reputation management task than it is viewed by young companies. Indications for this assumption have been found, for example, in a study of the banking industry in Bangladesh (Sobhani et al., 2012). Hypothesis H2 draws on these considerations and puts forth the assumption that old companies disclose fewer environmental information than young companies.

**Hypothesis H3.** *There is a positive correlation between environmental website disclosure and financial performance.*

In principle, when a firm is little engaged in environmental efforts and green transformation programs, then naturally only little information of interest to the stakeholders can be reported. Little environmental engagement may be caused by weak financial performance. Some indication for the influence of financial strength on environmental disclosure can be found in a CFO study of Deloitte from 2012 (Deloitte, 2012), in which listed large private companies in Ireland and Irish subsidiaries of overseas multinational were surveyed. Ninety-three per cent of the respondents said that they believe that there is a direct link between sustainability programs and business performance, and 58% noted that it was extremely important or important for sustainability programs to be part of the CFO's role. In a more recent survey, Deloitte asked approximately 300 SME companies in Italy what were the main obstacles that the company encountered in pursuing sustainable innovation projects (Deloitte, 2021). The obstacles mentioned by the respondents as number one and number two were 'too high costs, or insufficient budgets' (35%) and 'lack of money and funding and/or tax incentives' (33%). Hypothesis H3 draws on these considerations and suggests that website disclosure correlates with financial performance. Some results that confirm Hypothesis H3 for the Danish environmental disclosure practice have been obtained in a study from 2012 (Andrikopoulos & Krikiani, 2013).

Following the literature review in Section 2, the study sample is described in Section 3. Section 4 contains the research approach concerning the website observation and data collection methods as well as the variables and indices built to measure disclosure. The descriptive results and results of the correlation analyses are described in Sections 5 and 6, respectively. A summary and an outlook on future research work in Section 7 conclude the article.

## 2 | LITERATURE OVERVIEW

While this work focuses on extent of website disclosure including download reports, other studies focused on the quality dimension of corporate environmental disclosure. For example, based on a sample of 447 companies from the United Kingdom listed in the FTSE All-Share Index, Brammer and Pavelin (2008) investigated influencing factors of the quality of voluntary environmental disclosure in general. They concluded that high-quality disclosure is '[...] primarily

associated with larger firms and those in sectors most closely related to environmental concerns' (p. 122). It is worth mentioning that the study was performed in the year 2000 using survey data on environmental disclosure of an independent research agency. The survey used content analysis to estimate the disclosure quality of annual reports and other relevant documents but apparently did not look at the companies' websites. This UK study and our two decades later investigation are in accord concerning the use of content analysis principles, in particular the use of a defined set of relevant phrases or terms that relate to environmental disclosure for analysing reports that can be downloaded from the website.

Similar to prior other research work (Cho & Roberts, 2010; Clarkson et al., 2008; Suttipun & Stanton, 2012), we use self-constructed indices to measure website disclosure. Other studies use environmental disclosure scores of rating agencies that are aggregated from a number of different information sources such as annual reports, sustainability reports, press releases and third-party research. For example, a research group from Scotland used the Bloomberg environmental disclosure score to investigate relations between corporate economic performance, environmental disclosure and greenhouse gas emissions (Hassan & Romilly, 2018).

Recently, research on voluntary environmental disclosure started to investigate the use of social media as channels to communicate corporate sustainability efforts (Knight et al., 2022). It can be expected that companies are paying a growing attention to these channels as effective medium for environmental disclosure. However, these channels are not within the present scope of our research.

A systematic literature review of research on environmental website disclosure is available in (Thimm & Rasmussen, 2020), including founding theoretical frameworks such as the legitimacy theory, methodological approaches and case studies. The following literature overview focuses in chronological order on earlier research with similar empirical case studies of environmental website disclosure.

Accessibility and functionality of the corporate website and its implications for sustainability reporting were investigated in an Australian study published by Adams and Frost (2006). The researchers monitored the websites of 24 global players of different industries from Australia, the United Kingdom and Germany. The information content of the websites was reviewed quarterly over the period 2000 to 2003 based on a checklist of '[...] desirable website features identified from the literature' (p. 278). In addition, six interviews with selected company website/environmental managers were performed to document the use of the website for environmental communication. From the article, it can be concluded that there is a large overlap between the website features of the Australian study and our study. While the samples and the methods of the two studies are fundamentally different, a common finding can be described. The results of both studies suggest that the majority of companies still only make little use of the web technologies for effective environmental disclosure.

In 2007, a global cross-industry study that focused on the website disclosure policies and practices of the 200 largest multinational companies was published by Jose and Lee (2007). The article reports that

29% of the study sample disclosed details of their Environmental Management System (EMS). Furthermore, website disclosure of approximately one-third of the companies also addressed office and site practices of the environmental management team. The study also revealed that of those companies that disclose environmental information at all, only 31% disclose compliance information regarding legal standards. The findings of our study suggest that the extent of environmental website disclosure has not fundamentally grown since observed by Jose and Lee in 2017.

In 2010, the environmental disclosure of US firms was investigated by Cho and Roberts (2010). The study revealed that 'worse environmentally performing firms' provide a larger extent of environmental disclosure than firms with better environmental performance. The distinction of the firms of the study sample is based on official pollution data from the Environmental Protection Agency's (EPA) Toxics Release Inventory. From this inventory, the Top 100 highest toxic scoring companies were considered environmentally worse performing. With Hypothesis H1, our study also investigates if environmental performance determines environmental disclosure. However, the performance scores of ESG Rating agencies are being used, which is fundamentally different from using official pollution data. That can be an explanation, why as opposed to the US study, we did not obtain in our work clear results concerning the relationship between environmental performance and extent of environmental disclosure.

Determining factors of environmental website disclosure were explored by Suttipun and Stanton (2012) in a study of Thai companies. The researchers obtained evidence for relationships between the amount of disclosures and type of industry, ownership status and audit firm. Our study focuses on other determining factors that are addressed in the above hypotheses. In particular, we investigate if environmental performance, company age and financial performance are determining factors of environmental disclosure.

A Canadian research group investigated oil firms (Berthelot et al., 2013). The study results suggest that the larger the firm and the greater its media exposure, the more likely the firm is to include environmental management disclosures on its website. Because of the fundamental differences between the Canadian study's sample and our cross-industry sample of large production companies, there do not exist direct similarities between the two research works. However, in a forthcoming greenwashing study, which is part of our future research agenda, we are contemplating including data on media exposure and pollution data of the sample companies. In this context, it is worth mentioning that in the earlier described study of Brammer and Pavelin (2008), no evidence was found that media expose of companies plays a role in the stimulation of voluntary environmental disclosure.

Lee (2017) investigated the annual reports, sustainability reports and integrated reports of the year 2013 of 55 companies of the Australian Mining and Metal Industry, and the study article refers 'internet web reporting' as a separate reporting type. However, details are missing about what is exactly meant by this category and

how the observation was performed. Using content analysis techniques, the reports were measured in terms of both the quality and quantity of environmental disclosure. The approach used words as measurement units (i.e. word counts) to measure disclosure quantity. The GRI G4 mining and metals reporting guideline from which 12 environmental aspects and 61 items were selected served as framework to measure disclosure quality. Statistical evidence was obtained that the size of firms in terms of market capitalization influences both the quantity and the quality of disclosure. In the Australian investigation, a high quality of environmental disclosure basically means high conformance to the GRI G4 mining and metals reporting guideline. Also, in our study, the download reports are categorized in terms of difference levels of conformance with GRI. But the categorization is simply based on the information given by the firms themselves. To employ content analysis techniques like in the Australian study in combination with a suitable selection of GRI aspects and items that fit to the sample set will be considered to be an option for our future research. Baral and Pokharel (2017) collected mission, vision and value statements of the S&P 500 companies from their official websites or annual reports submitted to the Securities and Exchange Commission. Through content analysis techniques, the statements were measured concerning the extent to which they reflect the concept of sustainability. The researchers' inductive assessment of the result is that corporations '[...] reflect sustainability when their stated goal was not only to generate profits but also to care about people and the planet'. In our work, the three statements were not explicitly observed and statistically analysed based on corresponding observation variables. Furthermore, our study explores the general extent of environmental disclosure in websites and download reports based on a set of pragmatically self-constructed indices. The indices to a low extent consider results of a limited content analysis, which is focused on keyword frequencies.

For a transnational comparison of environmental website disclosure, researchers from Brazil explored both website observation data and website sustainability reports (Portella & Borba, 2020). The study revealed that companies from the United States stood out in comparison to Brazilian companies concerning environmental disclosure. Based on this result, the researchers describe in the article that the country of origin of the company has to be regarded as a variable that explains the environmental disclosure on the corporate website. Evidence for this conclusion is also provided by our transnational study. In comparison to the other companies from the EU, Japan and the United States, we observed a considerably lower disclosure extent for the Chinese companies.

### 3 | STUDY SAMPLE

The production sector is the focus of this sustainability research because the production sector is considered to be a major pillar for many economies of the developed world, and it is also believed that in particular, production companies often impose a heavy environmental burden. We focus on large companies with more than

10,000 employees registered in member states of the EU plus Great Britain, China, Japan and the United States. A production company was defined as a company with the particular codes 13 to 16 and 22 to 31 among its primary NACE codes (EUROSTAT, n.d.). The selection of the population was performed in the global company database Orbis (<https://www.bvdinfo.com/en-gb/our-products/data/international/orbis>) of Bureau van Dijk, which is a Moody's Analytics Company (Bureau van Dijk, 2019). In particular, a random sample of 346 companies was obtained. The distribution of the sample by region and industry sector is shown in Table 1.

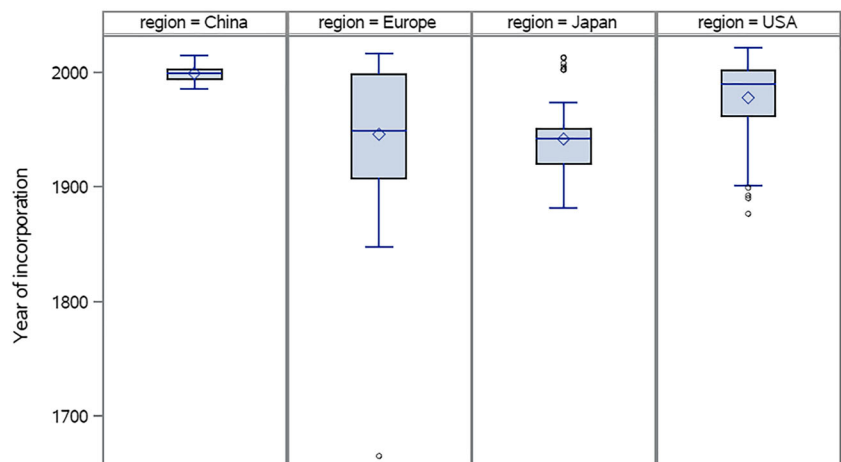
Additionally, data about the year of incorporation were extracted from Orbis to investigate Hypothesis H2. As shown by the box plot of Figure 1, almost all of the companies were incorporated before 2000. The youngest group of companies is the group of Chinese companies (mean year of incorporation: 1999), followed by the group of companies from the United States (1978). The companies from Europe

(1946) and Japan (1941) were founded approximately 25 years earlier than these companies.

To investigate Hypothesis H3, which considers the company's financial performance, the return on total assets (ROA) for 2019 and 2020 was also selected. ROA is a popular financial profitability performance indicator of the business world. According to Investopedia (2022), a popular website with finance information and educational content, ROA is defined '[...] as the ratio between net income and total average assets, or the amount of financial and operational income a company receives in a financial year as compared to the average of that company's total assets'. Investors are advised by Forbes that in general, '[...] An ROA of 5% or better is typically considered a good ratio while 20% or better is considered great' (Birken & Curry, 2021). In the same article, it is also noted that asset-heavy companies such as manufacturers often have lower values of ROA than asset-light companies.

**TABLE 1** Distribution of study sample by region and core business

Industry sector using NACE classification	China	EU	Japan	USA	All
	N	N	N	N	N
13 textiles	3		1		4
14 wearing apparel	2	2	1	3	8
15 leather and related products		1		3	4
16 wood and products of wood and cork				1	1
17 paper and paper products		2		1	3
22 rubber and plastic products	2	4	5	2	13
23 other non-metallic mineral products	3	3	4	1	11
24 basic metals	12	6	8	1	27
25 fabricated metal products		4	8	7	19
26 computer, electronic, optical products	16	14	25	34	89
27 electrical equipment	11	8	5	7	31
28 machinery and equipment	10	11	20	11	52
29 motor vehicles, trailers	12	18	22	10	62
30 other transport equipment	1	6	4	9	20
Missing	1	1			2
All	72	79	103	90	346



**FIGURE 1** Founding year of sample companies

As displayed by the box plots in Figure 2, the companies reached an ROA of approximately 5% in 2019 and 2020. The global ROA and the regional ROAs for 2019 and 2020 are 6% and 5% for all, 5% in both years for China, 5% and 3% for Europe, 4% in both years for Japan and 8% and 6% for the United States.

#### 4 | RESEARCH APPROACH

A graphical illustration of the main research steps is displayed in Figure 3. The solid arrows correspond to acquisition of data through data extraction from a dedicated repository, through observation of websites by human data collectors (arrows with circle) and through scraping of data from websites by a software tool (arrow with diamond). For the development of this scraping tool, we used the Python

programming language and various libraries specialized to perform website analyses. The arrows with dashed lines indicate that data are stored in and retrieved from a dedicated data collection. The mixed-method approach to acquire the data collection consists of five steps: (1) extraction of sample data and general and financial data of the companies from the Orbis database (Bureau van Dijk, 2019), (2) observation of websites, (3) observation of online reports, (4) acquisition of environmental performance data and (5) scraping of website data.

The website observation (Step 2) was carried out by trained observers using a standardized instructional data recording form. The observers looked for specific disclosure subjects, website features and artefacts. Google Advanced Search was used to obtain the number of occurrences of specific terms in the textual parts of the websites. The frequencies of the investigated items and the URLs of the containing webpages were recorded.

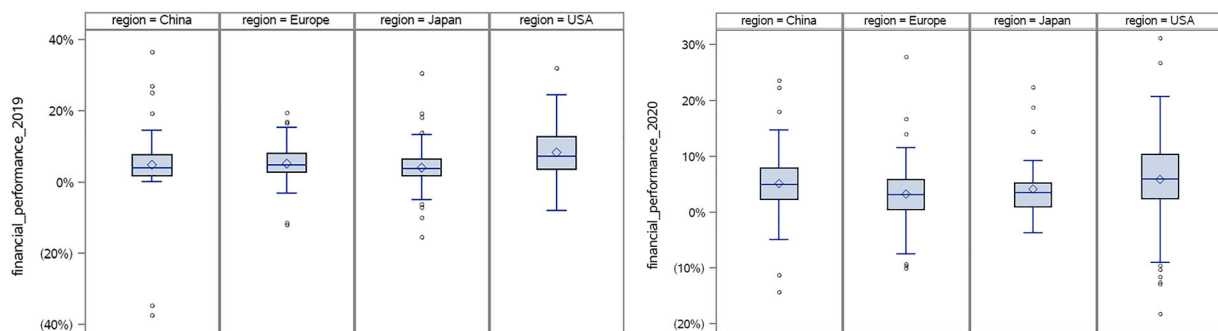


FIGURE 2 Return on assets (ROA) of the sample companies in 2019 and 2020

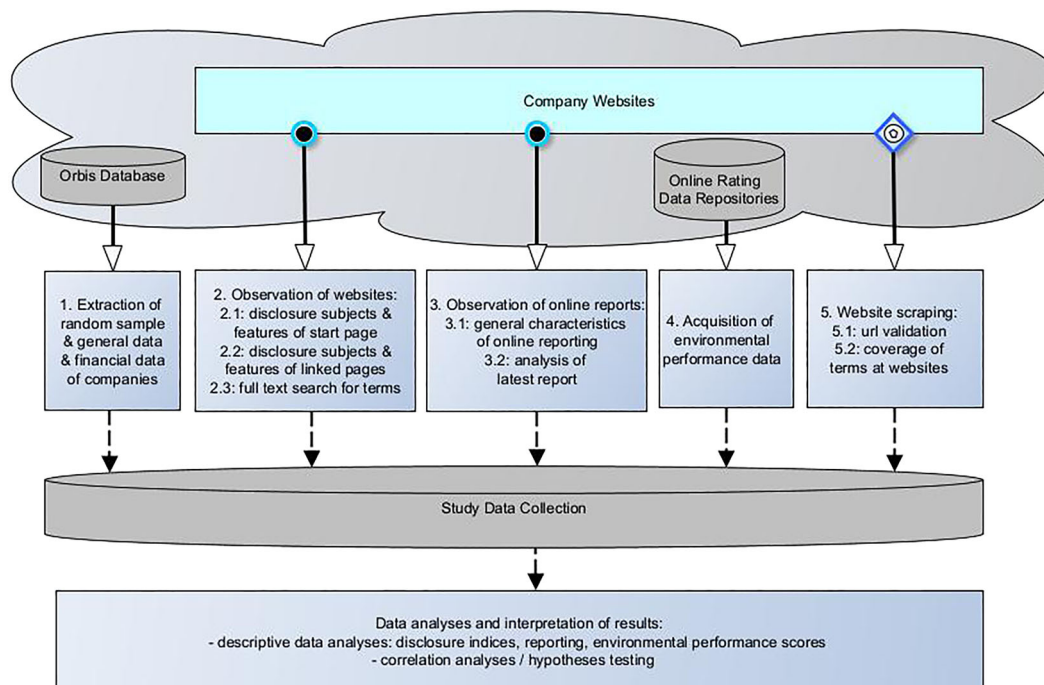


FIGURE 3 Overview of research steps

Step 3 was completed by another group of trained observers. They recorded data about downloadable online reports and the frequencies of particular search terms contained in the reports.

Step 4 focused on environmental and ESG performance data about the companies. Considering data accessibility, ease of use,

legal restrictions and costs, we chose to search the CDP (CDP, 2021a) and the Refinitiv ESG (Refinitiv, 2021a) data sets, which are two popular rating data sets. For a large majority of the companies, environmental performance scores could be acquired from the data sets.

**TABLE 2** Search terms of observation steps used in the indices EODI and CMDI

Search term	EODI	CMDI	Website	Report	Scraping
Environmental management activity	0.1		U		
Environmental information system	0.1		U		
Sustainability information system	0.1		U		
EHS	0.1		U		U
HSE	0.1		U		U
Environmental data	0.1		U		U
Environmental information	0.1		U		U
Environmental compliance	-	0.1	U		U
Environmental law enforcement	-	0.1	U		
Environmental regulation enforcement	-	0.1	U		
Environmental enforcement	-	0.1	U		
Environmental law assurance	-	0.1	U		
Environmental permission management		0.1	U		
Environmental risk management		0.1	U		
Environmental measure		0.1	U		U
Environmental control measure		0.1	U		
Environmental audit		0.1	U		U
Pollution tracking		0.1	U		
Discharge management		0.1	U		
Environmental complaint		0.1	U		
Environmental accusation		0.1	U		
Environmental charge		0.1	U		
Environmental incident		0.1	U		
Leakage		0.1	U		U
Breach		0.1	U		U
Spill		0.1	U		U
Regulation		0.1	U		
Registry		0.1	U		
Regulation database		0.1	U		
Environmental database		0.1	U		
Carbon disclosure project					U
CDP					U
Global reporting initiative					U
Compliance				U	
Compliance measure				U	
Compliance violation				U	
Environmental fine				U	
Information system				U	
Regulation database				U	
GRI				U	

Note: The three rightmost columns display the use (U) of the terms in the search of the entire website domain, in the content analysis of the reports and in the website scraping.



Step 5 was performed with a software program for 'website scraping'. The program validates a given set of URLs to filter out non-accessible webpages and non-English webpages. The search algorithm performed for each valid URL checks which terms of a given set of terms are contained in the referred webpage.

The search terms used in Steps 2, 3 and 5 are contained in Table 2. For obvious reasons, the terms are semantically connected to the theme of corporate environmental management and corporate environmental compliance management.

In the three rightmost columns, the symbol 'U' indicates the use of the term in the three particular term subsets. For example, the website domain of each sample company was in observation step 2 searched for the terms 'environmental management activity', 'environmental information system' and 'sustainability information system'. The website scraping in Step 5 was performed for the 13 search terms displayed in the rightmost column of Table 2.

The data analyses to address the research questions and hypotheses use two proxies that are based on self-constructed indices to measure environmental website disclosure. First, disclosure is measured through a formative index referred to as the Environmental Disclosure and Presentation Index (EDPI). The second proxy measures the disclosure based on the scraping results of Step 5. This second proxy is referred to by the Keyword Coverage Indicator (KCI). We are aware of the potential subjectivity of self-constructed indices as argued by Hassan and Romilly (2018), but a suitable specific website disclosure score is, to our knowledge, so far not available. The possible subjectivity and bias were addressed in the study through multiple measures such as a random distribution of companies to observers. Additional central details of the research approach are described in the following sections.

#### 4.1 | Website observation items

A comprehensive approach was devised to uncover the general environmental management disclosure focusing on extent of website disclosure rather than on disclosure quality, which has been the focus of other studies (Qian et al., 2018). Therefore, indicators that are typically used for environmental management accounting such as carbon emission (Qian et al., 2018), energy consumption, water consumption and recycling rate were not explicitly addressed as disclosure subjects for the observation steps.

The manual execution of observation step 2 inspects the start page (SP) as the observation item (OI) in partial step 2.1. Then, in the following partial step 2.2, all linked pages (LPs) identified by environmental links were traversed. The details of this pragmatic website exploration method are described in (<not disclosed according to submission rules>).

The observation inspects two different sets of website properties (WP), which are described in Table 3. For the later statistic investigations, each property is identified by a variable name contained in column one. The first set of website properties refers to environmental website features (F) such as environmental menu

items, environmental news sections or a notification function to inform the environmental department. These types of features are referred in the research of Adams and Frost (2006) as websites functions that can either restrict or promote accessibility for the users. Most of the functions considered in their survey are also contained in the set of features observed in this study. The second set refers to particular disclosure subjects (S), such as environmental training materials, names of environmental staff members or environmental certificates.

Most of the observed properties were coded in binary variables that recorded whether the website property was observed or was not observed. For several website properties, numeric variables were used to record how often the website property (e.g. environmental certificates) was observed. For all observed website properties, the web address of the containing page was also recorded. The third-most-left column of Table 3 signifies the type of website property (WP) that the variable refers to. The particular observation item (OI) is signified in the fourth column. A label 'SP' signifies that the website subject was found at the start page of the website. A label 'LP' signifies that the subject was found at a linked page below the start page. Only lower-level pages that could be reached from the start page by following environmental links were recorded and referred to as so-called linked pages (<not disclosed according to submission rules>). The rightmost three columns of Table 3 signify the use of the variables for the disclosure indices described below.

The full-text search at the complete website domain was performed in partial step 2.3 with Google's Advanced Search Tool. The obtained frequencies for the terms were recorded in further variables that are not contained in Table 3. Moreover, the URLs of the Top 5 hits of the search result list were recorded. However, in this step, only hits that referred to html pages were included, thus excluding search hits to pdf documents, images, continuous media content and advertisement links.

#### 4.2 | Observation of online reports

Recently, environmental reporting of the business world has gained significant momentum due to tighter environmental regulations around the world and due to the growing attention of investors in sustainable finance (Hahn & Kühnen, 2013). For example, according to a recent study by a consulting firm on corporate sustainability and ESG (Governance & Accountability Institute, 2021), '[...] 92% of the S&P 500 companies published a sustainability report in 2020, up from 90% in 2019'. The rise of environmental reporting has caused an increasing number of companies to release annual environmental management information and environmental performance data in downloadable web documents in recent years. Companies either offer the content in separate annual environmental reports or the environmental content is part of an annual so-called integrated report that describes both the financial and non-financial performance of the firm. Many different titles for separate annual reports with environmental content can be observed, such as 'sustainability report', 'CSR

**TABLE 3** Variables that refer to website properties (WP), focusing on website features (F) and disclosure subjects (S) are inspected in observation step 1

Variable	Description	WP	OI	EODI	CMDI	EPFI
F1_location	Left menu contains environmental item	F	SP	-	-	2.0
F2_location	Top menu contains environmental item	F	SP	-	-	2.0
F3_location	Right menu contains environmental item	F	SP	-	-	2.0
F4_location	Bottom menu contains environmental item	F	SP	-	-	2.0
F5_news	Environmental news section	F	SP	-	-	1.5
P1_news	Environmental news section	F	LP	-	-	1.0
F6_notification	Notification function	F	SP	-	-	1.5
F7_linked_notification	Linked notification function	F	SP	-	-	1.5
P2_notification	Notification function	F	LP	-	-	1.0
F8_sections	Environmental sections	F	SP	-	-	1.5
F9_environmental_links	Linked environmental pages	F	SP	-	-	1.5
F10_reports	Downloadable environmental reports	F	SP	-	-	1.5
P3_reports	Downloadable environmental reports	F	LP	-	-	1.0
F12_training	Environmental training material	S	SP	-	-	1.5
P4_training	Environmental training material	S	LP	-	-	1.0
F13_persons	Names of environmental personnel	S	SP	-	-	1.5
P5_persons	Names of environmental personnel	S	LP	-	-	1.0
F13c_contact	Contact info of environmental personnel	S	SP	-	-	1.0
P6_contact	Contact info of environmental personnel	S	LP	-	-	0.5
F13b_blogs	Blogs of environmental personnel	S	SP	-	-	1.0
P7_blogs	Blogs of environmental personnel	S	LP	-	-	0.5
S1_certificates	Environmental certificates	S	SP	1.5	-	-
L1_certificates	Environmental certificates	S	LP	1.0	-	-
S2_awards	Environmental awards	S	SP	1.5	-	-
L2_awards	Environmental awards	S	LP	1.0	-	-
S3_audits	Environmental audits	S	SP	-	1.5	-
L3_audits	Environmental audits	S	LP	-	1.0	-
S4_partners	External environmental partners	S	SP	1.5	-	-
L4_partners	External environmental partners	S	LP	1.0	-	-
S5_compliance	Phrase 'environmental compliance management'	S	SP	-	1.5	-
L5_compliance	Phrase 'environmental compliance management'	S	LP	-	1.0	-
S6_measures	Measures to enforce environmental compliance	S	SP	-	1.5	-
L6_measures	Measures to enforce environmental compliance	S	LP	-	1.0	-
S7_negative	Negative environmental information	S	SP	-	1.5	-
L7_negative	Negative environmental information	S	LP	-	1.0	-
S8_ict	Use of ICT for environmental mgmt.	S	SP	1.5	-	-
L8_ict	Use of ICT for environmental mgmt.	S	LP	1.0	-	-

Note: The explored observation items (OI) are the start page (SP) and linked pages (LP). The three rightmost columns display the use of the variables in the indices EODI, CMDI and EPFI. When a variable shows a numeric value (weight) in a particular column, the product of the variable value and the weight are added to the particular index.

report', 'ESG report' and 'climate change action report'. Of today's available standards and recommendations for corporate environmental reporting, the standard of the GRI (GRI, 2015; Petera & Wagner, 2015) has reached a relatively widespread use in the business world. One can find both companies that prepare fully GRI-

compliant annual environmental reports and companies that use the standard just as an orientation for their reports.

In observation step 3, the firms' websites were searched for online reports to explore the environmental reporting characteristics of the sample. It was the goal to find and download the most up-to-

date annual environmental English report for each company. Given the above-described variety of relevant reports, the following four report categories were considered in this work similar to the report categories addressed in a recent Italian study (Tiscini et al., 2022): (1) *integrated reports*, (2) *dedicated sustainability reports or environmental reports*, (3) *CSR reports* and (4) *other relevant reports*. Note that it was the objective to retrieve exactly one most recent report for each website that could be of either of the four categories applying a prioritization scheme as follows. It was first looked for an integrated report that can often be found in a website section titled 'Investor Relations' (or similar). If an integrated report was not found, it was attempted to find another annual non-financial report. The context of the webpage that provided the download option and the document's title and table of content were used as criteria to locate a dedicated environmental/sustainability report. If no such report was found, it was investigated if either a dedicated CSR report or some other annual report containing environmental performance data were published by the company.

The found reports were downloaded from the websites and then analysed in terms of the following general reporting properties: reporting year, type of report, title of report, number of pages and level of GRI conformance. The webpage content and the report content were explored to assess if at all and to what extent a report conformed to the GRI reporting standard. For each report, one of the following three conformance levels was assessed. (1) *Full GRI conformance* was assessed when the company itself explicitly stated that the report was created in full accordance with the GRI standard. (2) *Use of GRI as a means of orientation* for the report was assessed when a corresponding statement or a respective reference to the GRI standard was found. (3) *GRI conformance not clear* was assessed otherwise when no relevant information about the GRI conformance level was found. While such a human-lead assessment might suffer from subjectivity and/or the human factors, in the future, we might adopt the approach of Lee (2017). This referred approach builds on content analysis and a specialized selection of GRI aspects and items that fit to the industry sector of the sample.

The analysis of the downloaded reports also included full-text searches in order to perform a conceptual content analysis, which was, for example, also used as method in the research of Brammer and Pavelin (2008) in order to obtain data on voluntary environmental disclosure. In particular, the frequencies of the following terms found in the reports were recorded: 'compliance', 'compliance measure', 'compliance violation', 'environmental fine', 'information system', 'regulation database', 'GRI'.

### 4.3 | Environmental performance data of the study

The environmental performance data of business entities are being prepared by various players, such as ESG rating agencies. In principle, participating companies receive environmental performance scores and, in the case of ESG ratings, other non-financial performance scores based on specific scoring metrics applied to validated data sets. The scoring results are often made available in online databases that

offer search and analysis functions. Some rating agencies also publish annual lists of the top scorers. Using environmental performance data of rating agencies is a common approach of environmental disclosure research. In this work, the scores of the CDP rating and the Refinitiv ESG rating for 2020 are used. An interesting radically different approach to measure firm-level environmental performance is the use of official data about fines corporations received for environmental transgressions. For example, this approach has been used in the study of Brammer and Pavelin (2008).

The scoring results for 2020 of the CDP ranking have been published on the web as the so-called CDP 2020 ranking (CDP, 2021b). A general description of the questionnaire-based scoring approach and the method of the 2020 scoring round can be found in a recent article of the CDP organization (CDP, 2021a). The CDP approach is focused on three areas referred to as 'climate change', 'forests' and 'water security'. Sector-specific questionnaires are used to assess participating companies '[...] across four consecutive levels which represent the steps a company moves through as it progresses towards environmental stewardship' (CDP, 2021a, p. 6). The scoring levels are based on an ordinal scale, with 'D' being the lowest score and 'A' the highest score.

In the data set of the CDP 2020 ranking, 181 sample companies' scoring data were found. The so-called climate change scores were selected for this study and had to be transformed to enable statistical data analyses. Each scoring level of the original letter-based scale was assigned a corresponding number. The levels with their associated original scores and transformed scores are in ascending order: Disclosure (D-, D; 4, 5), Awareness (C-, C; 6, 7), Management (B-, B; 8, 9), Leadership (A-, A; 10, 11).

Refinitiv describes their ESG data as being '[...] designed to transparently and objectively measure a company's relative ESG performance, commitment and effectiveness, based on company-reported data. This covers 10 main themes including emissions, environmental product innovation, human rights, shareholders and so on [...]' (Refinitiv, 2021a). Trained content research analysts collect data from publicly available reported data for over 450 ESG measures. The ESG scores are in most cases recomputed once a year in line with the companies' own ESG disclosures. The scoring scheme uses the interval  $[0;100] \subset \mathbb{R}$  as the scoring range.

Refinitiv ESG data can be obtained by a number of different alternatives, including Eikon Refinitiv (Refinitiv, 2021b), which is a set of desktop applications to access and analyse the Refinitiv data universe. Through Eikon Refinitiv, the researchers found Refinitiv ESG scores for 259 companies in the study sample.

### 4.4 | Website disclosure proxies and indices

The EDPI serves as a first proxy for environmental website disclosure. Drawing on theoretical foundations for the construction of multiscale measures (Diamantopoulos & Winklhofer, 2001) and results of an application of the entire-array-polygon (EAP) method for building a government environmental disclosure index obtained by a group of

Chinese researchers (Kosajan et al., 2018), the EDPI is formed based on three different reflective indices. The reflective indices measure disclosure subjects and features observed about websites.

The above Table 2 (second and third columns) and Table 3 (right-most three columns) display information about the sets of variables used for the forming of the three reflective indices. On the basis of pragmatically chosen distinctive sets of variables, the three indices are intended to provide three complementary measures of the extent of website disclosure as follows: (1) The Environmental Management Overview Disclosure Index (EODI) measures the extent of overview information of the company's general environment management engagement, (2) the Compliance Management Disclosure Index (CMDI) measures the extent of information focused on the company's environmental compliance management efforts, and (3) the Environmental Presentation Features Index (EPFI) measures the extent of dialogical communication capabilities through website features such as contact options and specific information about environmental management.

Similar to other disclosure studies (Bonson & Escobar, 2002; Clarkson et al., 2008), the EODI, CMDI and EPFI use distinctive subsets of weighted variables. In Table 3, the variable weights are displayed in the three rightmost columns. Only when a numeric value is given is the respective variable associated with the index. For example, the variable 'F1\_location', which is assigned a weight of 2.0, belongs to the set of variables that determine the EPFI, and the variable is not used in the other index calculation formulas. The chosen variable weights of the indices are intended to compensate for otherwise occurring bias effects. Therefore, the variables that refer to features and disclosure subjects at the start page were assigned higher weights than their counterparts that referred to lower-level pages of the website. For example, the variables 'F5\_news' and 'P1\_news' are assigned a 1.5 weight and a 1.0 weight, respectively. The higher weight reflects an environmental news section at the start page most likely being more easily noticed by ordinary website visitors than a news section at a lower-level webpage.

The reflective indices EODI and CMDI also consider the frequencies of which distinctive subsets of search terms were found at the website. Whether a search term with the obtained frequency is considered by an index is indicated in Table 2 through the decimal number '0.1' in the column labelled 'EODI' and 'CMDI', respectively. The equally assigned decimal number serves the index as a degrading weight for the frequencies. The degradation approach reflects the fact that the great majority of the obtained search hits did not refer to webpages with extensive environmental management disclosure and thus only contribute very little to environmental disclosure of the website.

Each of the above-described indices measures an aspect-specific extent of environmental website disclosure on a numeric scale between 0 and a specific maximum value. Well-aligned scale designs for the reflective component indices have been an indispensable requirement of the formative index EDPI, which aggregates the EODI score, the CMDI score and the EPFI score to a corresponding summary score.

According to the scoring method described above that computes scores from a set of weighted variables, this study operates with a maximum EPFI score of 28. The calculation of the maximum EODI score and the maximum CMDI also has to add the frequencies of the search terms. To obtain educated guesses for the maximum scores of these indices, the following approximate estimates for the maximum frequencies of the search terms are used. For the search terms of the EODI, we assume that every term is at most found 20 times. For the thematically narrower terms of the CMDI, we assume the terms to be found at most 10 times. These rough estimates result in a maximum score for the EODI of  $10 + 0.1 \times 20 \times 7 = 11.4$  and for the CMDI a maximum score of  $10 + 0.1 \times 10 \times 23 = 12.3$ . Based on these numbers, a website can obtain a maximum EDPI score of  $11.4 + 12.3 + 28 = 51.7$ .

As described above, this study operates with a second proxy for environmental website disclosure referred to as the KCI. In principle, the KCI measures how many terms of a given set of terms were found at the website. The particular set of 13 terms used in this study can be obtained from the rightmost column of Table 2. Obviously, the 13 terms imply that a website can obtain a maximum KCI score of 13.

## 5 | DESCRIPTIVE STUDY RESULTS

The first step of the data analysis consists of descriptive statistics providing insights about the extent of website disclosure. Furthermore, statistical numbers describe the characteristics of reporting and the environmental performance in terms of two different ratings.

### 5.1 | Website disclosure

The environmental website disclosure of the sample is measured through two distinct disclosure proxies: (1) the formative index EDPI, which measures disclosure based on a weighted subset of observation variables, and (2) the indicator KCI, which measures disclosure based on terms found at the website. As described in Section 4.4, the scoring metrics of the EDPI and the KCI yield a numeric disclosure score for any given website.

The box plots in Figure 4 display the EDPI scores of the sample by region. In all four regions, the EDPI is far from the maximum value of 51.7. The low numbers suggest that website options for environmental disclosure are to a large extent left unused by a substantial majority of companies in all four regions. There are no outstanding differences between the regions. This is revealed by the relatively large shared area of the four interquartile ranges and the similar means of the regions as follows: Japan 12.07, USA 10.29, Europe 9.85 and China 7.09. The Japanese companies are slightly ahead of the companies from Europe and the United States. The Chinese companies are at a relatively marginal distance behind the companies of the other regions. Most low-scoring companies of the entire sample set are companies from China.

The box plots in Figure 5 show the KCI scores by region. In all regions, most of the companies achieve values that are far from the potential maximum value of 13. This result confirms the conclusion derived from the EDPI scores that the large majority of companies only to a limited extent exploit website options for environmental disclosure. The box plots reveal several regional differences. The group

of companies from Europe, Japan and the United States achieve similar KCI scores, which is evident by the corresponding similar mean values as follows: Europe 3.63, Japan 4.88 and USA 4.04. China follows well behind the other regions with a mean of 0.78. The companies with the best KCI scores among all sample companies are from Japan.

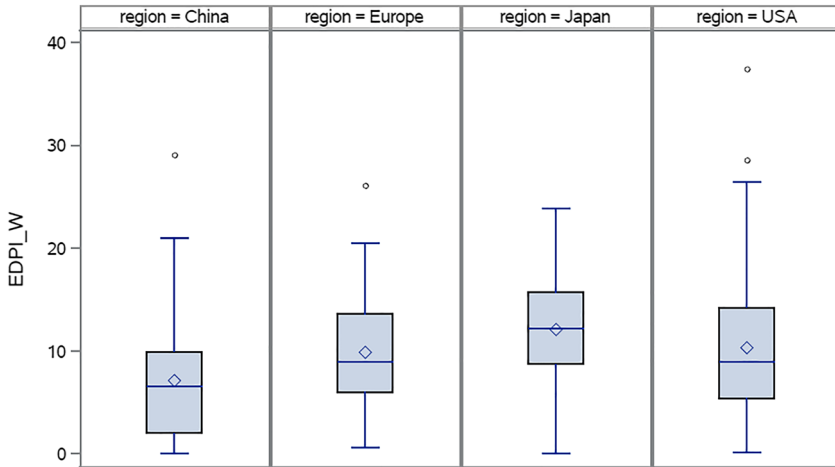


FIGURE 4 EDPI scores of the different regions (potential maximum score is 51.7)

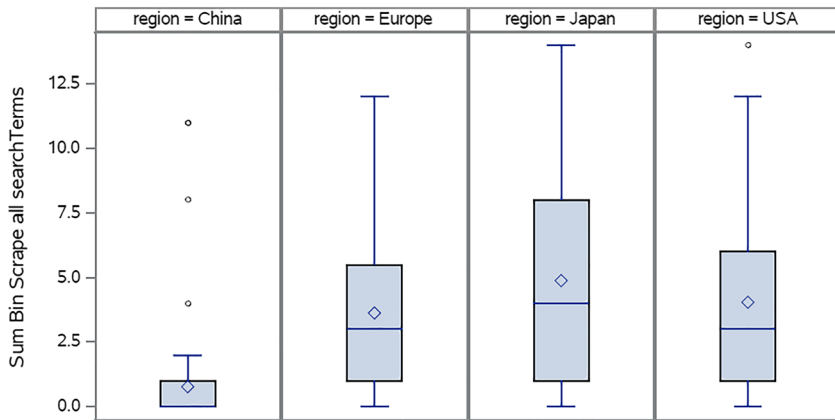


FIGURE 5 KCI scores of the different regions (potential maximum score is 13)

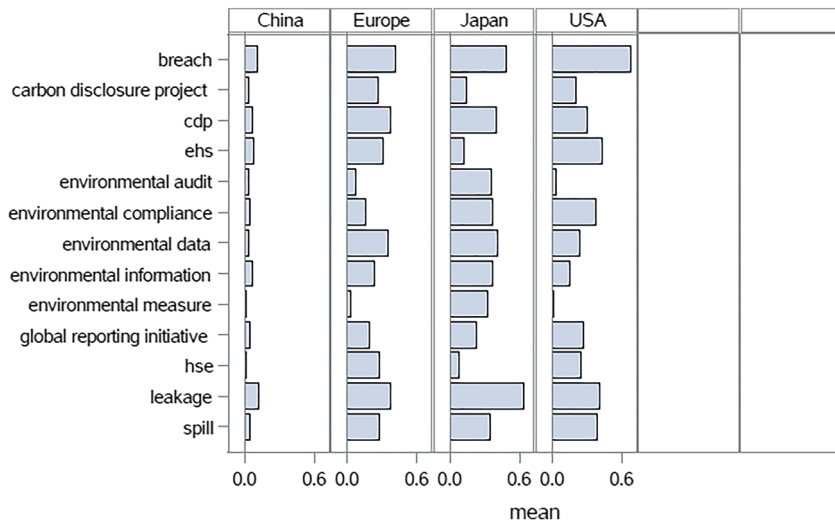


FIGURE 6 Relative frequencies of the search terms addressed by the indicator KCI

Figure 6 displays the relative frequency of websites containing the particular search terms addressed by the indicator KCI. For example, 'breach' was found on approximately 20% of the Chinese websites, approximately 40% of the websites of companies from Europe, approximately 50% of the Japanese websites, and approximately 70% of the websites of companies from the United States.

Most of the KCI terms were located on approximately one-third of the websites of companies from Europe, Japan and the United States. The terms occurred even more seldom on Chinese websites (<10%). The histogram reveals interesting findings concerning four particular search terms. The terms 'environmental audit' and 'environmental measure' were more often found on the websites of Japanese companies than on the websites of other regions. The fact that environmental legislation in Japan contains many laws that for non-compliance with statutory requirements provide direct criminal charges (imprisonment or a fine) (Kanagawa et al., 2021) may have led

to the high frequency numbers for the above two terms. The frequency numbers for the two acronyms 'hse' and 'ehs' are much lower for Japan than for Europe and the United States; here, China is omitted because of its generally low frequencies. The two acronyms might be less commonly used in the business world of Japan than in the business world of Europe and the United States.

## 5.2 | Environmental reporting

Recall from Section 4.2 that for each website, the data collectors observed one of the following exclusive alternatives: (1) an integrated report, (2) a dedicated sustainability report or environmental report, (3) a dedicated CSR report, (4) a relevant other report or (5) no report. The observed frequencies for these five alternatives per region are contained in Table 4. The numbers of positive finds for the different regions reveal some interesting insights. First, more than half of the

**TABLE 4** Frequencies of annual reports per relevant type of environmental report

Type of downloadable annual report containing corporate environmental performance data	China	EU	Japan	USA	All
	N	N	N	N	N
1. Integrated report	4	14	15	5	38
2. Dedicated sustainability/environmental report	16	51	44	59	170
3. Dedicated CSR report	2		14	1	17
4. Relevant other report	1	2	1	7	11
Total frequency	23	67	74	72	236
5. No report	50	13	29	18	110
All	73	80	103	90	346

**TABLE 5** Characteristics of reports concerning GRI conformance/orientation, report length, and frequency of the term 'compliance'

Characteristic of report	N	China	Europe	Japan	USA	All
		73	80	103	90	346
GRI conformance level						
1. GRI conformance	N	12	48	39	31	130
2. GRI orientation	N	6	9	15	11	41
1. GRI conformance or 2. GRI orientation	N	18	57	54	42	171
3. GRI not clear	N	13	11	21	35	80
4. Missing	N	42	12	28	13	95
Report—page count						
	Min	4.00	13.00	2.00	0.00	0.00
	Mean	169.9	155.1	81.16	60.51	105.7
	Max	963.0	528.0	341.0	224.00	963.0
	Std	187.8	134.8	71.16	42.43	114.5
	NMiss	42	12	27	13	94
Report—frequency 'compliance'						
	Min	0.00	0.00	0.00	0.00	0.00
	Mean	30.52	79.00	52.80	25.71	48.72
	Max	187.0	288.0	272.0	183	48.72
	Std	43.69	68.69	57.15	29.38	56.31
	NMiss	42	13	28	13	96

companies in Europe, Japan and the United States offer at least one relevant report. Fewer reports are offered by Chinese companies. Only approximately one-third of them supply a report. For more than half of them, no report could be located at all. Furthermore, the numbers suggest that integrated reports are less used in the United States and China, particularly when compared to the findings at websites of European countries and Japan.

Table 5 displays the statistical numbers for the report characteristics investigated in the analysis of the found reports. As contained in the table's top part, approximately half of the companies from Europe, Japan and the United States supply reports that either conform to the GRI standard or for which at least some orientation was drawn from the GRI for the report creation. However, such reports are published by only approximately one-fourth of Chinese companies, which is an expected result because the GRI is less common for the Chinese business world.

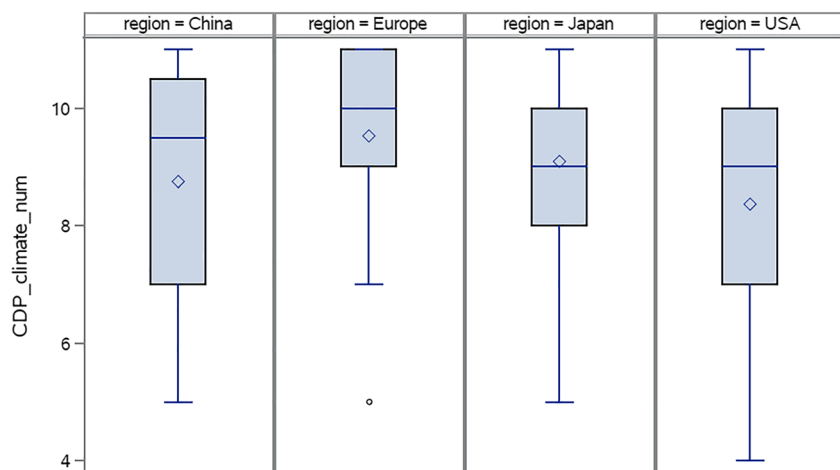
Concerning the report length (i.e. page count), Chinese companies and European companies of the sample published reports of approximately double the length of the reports published by companies from Japan and the United States. For further investigations of possible reasons for these differences, it can be helpful to consider cultural

differences such as investigated in a recent studies (Mateo-Márquez et al., 2021; Mohamed Adnan et al., 2018).

The numbers in the bottom part of Table 5 indicate how often the term 'compliance' was found in the reports. Only for the term 'compliance' did the investigation result in considerable frequencies, while almost none of the other investigated search terms (see Table 2) were found in the reports. This result may be viewed as an indication that the environmental compliance work area stands out from other topics of corporate environmental management. The special role of the compliance work area is also reflected in the research of Gemmill and Scott (2013), who argue that environmental regulations can be viewed as a fundamental means of securing sustainable development. As displayed in Table 5, 'compliance' was most often found in the reports of European companies (mean: 79) and Japanese companies (mean: 52.8). Considerably lower frequencies were observed for companies from China (mean: 30.52) and the United States (mean: 25.71). That 'compliance' was found more often in the reports of Chinese companies than in those of US companies may be explained by the fact that Chinese companies publish substantially longer reports (mean:169.9) than US companies (mean: 60.51).

CDP score 2020	Transformed score	China	EU	Japan	USA	All
		N	N	N	N	N
A	11	1	16	14	10	41
A-	10	1	16	17	10	44
B	9	1	15	14	10	40
B-	8		1	9	2	12
C	7		5	7	19	31
D	5	1	2	4	4	11
D-	4				2	2
All		4	55	65	57	181
Mean transformed scores		8.75	9.88	9.09	8.37	8.98

**TABLE 6** Distribution of the companies' climate change scores of the CDP rating for 2020



**FIGURE 7** CDP Climate Change scores for 2020 by region

### 5.3 | Environmental performance

The frequencies of the 2020 CDP climate change scores by region of the sample are displayed in Table 6. The statistical means of the regions computed from the transformed scores are contained in the last row. These numbers are together with other statistical indicators visualized in the box plots of Figure 7.

A comparison between the maximum numeric score of 11 and the mean scores reveals that the large majority of the companies in Europe, Japan and the United States in general achieved good scoring results in the 2020 CDP scoring round. Europe, with a mean score of 9.88, has the highest score, followed by Japan, with a mean score of 9.09. Compared to these, companies from the United States are slightly behind, reaching a mean score of 8.37.

In general, the analysis results in the box plots of Figure 8 visualize that the sample companies also achieved relatively good scores on the Refinitiv ESG rating in which all companies together reached a mean score of 63.89 (N = 259). However, the regions did not come as close to the maximum score as they did in the CDP rating. The top scoring regional subset is the set of European companies with a mean

of 76.63 (N = 67), followed by some distance by Japan with a mean of 64.09 (N = 77) and the United States with a mean of 61.56 (N = 89).

The Refinitiv ESG Score was found for 26 Chinese companies, while the CDP Climate Change score was found for four Chinese companies of the 73 Chinese companies. The meagre information inhibits conclusions regarding an environmental performance scoring tendency, and consequently, China is excluded from further analysis.

### 6 | CORRELATION ANALYSES

Obviously, different rating agencies use different rating methodologies and measures to compute rating scores for environmental performance. However, it can be expected that companies do not obtain fundamentally different scores from different agencies. That is, it can be assumed that the scores of different agencies correlate. The researchers performed a corresponding correlation analysis with the set of N = 165 sample companies for which both a CDP climate score

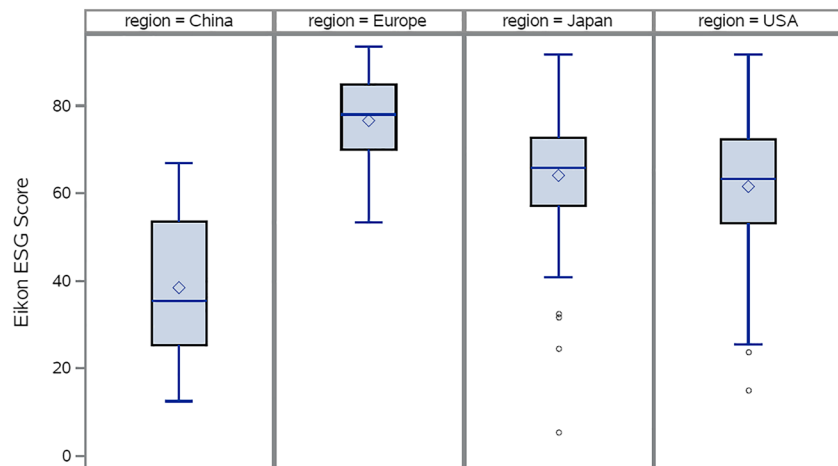


FIGURE 8 Refinitiv ESG scores by regions

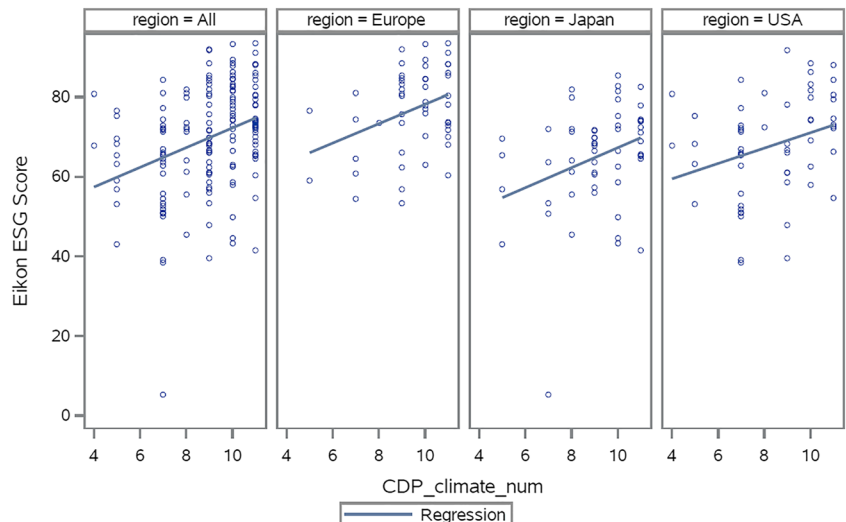


FIGURE 9 Scatter plot for CDP Climate Change scores and Refinitiv ESG scores



and a Refinitiv ESG score were available. The analysis was also performed for regional subsets. As displayed by the scatter plots in Figure 9, positive correlations were revealed. The corresponding Pearson correlation figures and verbal descriptions of the correlation strength using the guide of Evans (Evans, 1996) under consideration of a significance level of  $\alpha = 0.05$  are:

- for all regions ( $N = 165$ ) with  $r = 0.3355$ ,  $p < 0.0001$ : weak, significant correlation
- for Europe ( $N = 51$ ) with  $r = 0.3494$ ,  $p = 0.012$ : weak, significant correlation
- for Japan ( $N = 57$ ) with  $r = 0.3172$ ,  $p = 0.0165$ : weak, significant correlation
- for the United States ( $N = 57$ ) with  $r = 0.2982$ ,  $p = 0.0243$ : weak, significant correlation

The remainder of this section is focused on tests of Hypotheses H1–H3. The first hypothesis H1 assumes a positive correlation between

environmental website disclosure and environmental performance scores in ESG ratings. Simply speaking, it is hypothesized that environmental disclosure is larger at the websites of companies with a high environmental performance score than at the websites of companies with a low score. Using the EDPI scores and the KCI scores as measures for website disclosure, correlations with the CDP climate scores and the Thomson Reuters environmental scores were investigated through four Pearson correlation tests.

The Pearson correlation analyses found no correlation between the EDPI scores and the CDP scores and no correlation between the EDPI scores and the Refinitiv ESG scores. However, the analyses with the KCI scores and the same two environmental scores revealed a weak to moderate significant correlation. That is, some of the tests of Hypothesis H1 lead to some confirming results, which are described in the following two paragraphs. However, because the KCI is only a rough measure of website disclosure, the researchers are postponing a final assessment of Hypothesis H1 until more insights from further investigations are available.

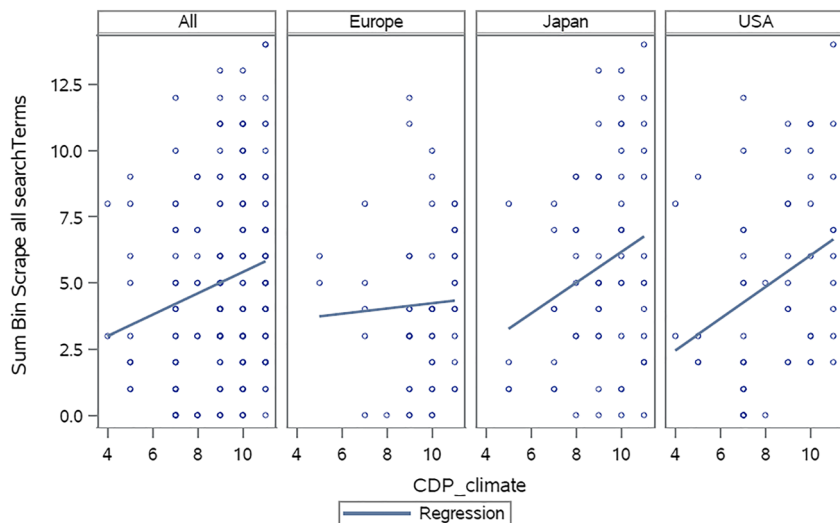


FIGURE 10 Scatter plots for CDP Climate Change scores and KCI scores

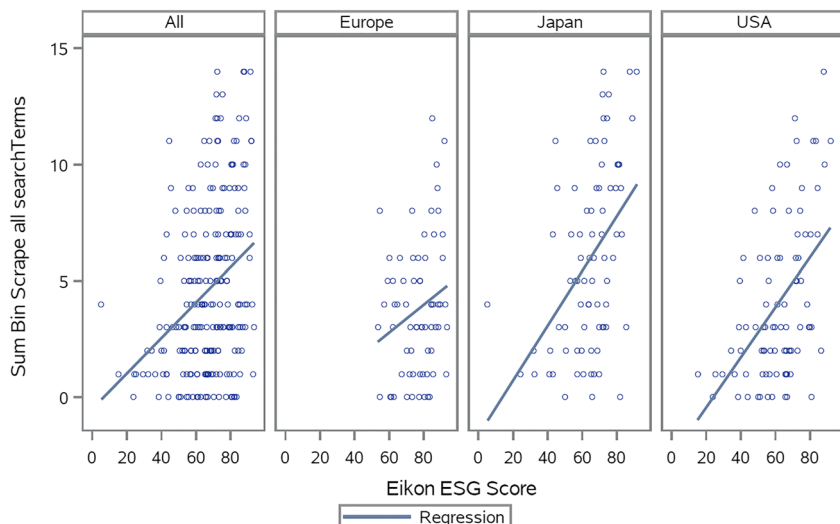


FIGURE 11 Scatter plots for Refinitiv ESG scores and KCI scores

In Figure 10, the most left scatter plot displays the data points for the combined set of  $N = 177$  companies having a CDP climate score. A significant but weak correlation was revealed for the combined set ( $r = 0.2018$ ,  $p = 0.0071$ ), for Japan ( $r = 0.2544$ ,  $p = 0.0408$ ) and the United States ( $r = 0.3206$ ,  $p = 0.0150$ ). No correlation was obtained for Europe.

The plots of Figure 11 display the data points of the analysis that used the Refinitiv ESG scores and the KCI scores of the companies. Additionally, in this analysis, a significant but weak correlation is revealed for the combined set of 232 companies ( $r = 0.3312$ ,  $p < .0001$ ). However, different results are obtained for the regions. Significant moderate correlations were revealed for Japan ( $r = 0.4536$ ,  $p < .0001$ ) and the United States ( $r = 0.4925$ ,  $p < .0001$ ). A significant but weak correlation was revealed for Europe ( $r = 0.2232$ ,  $p = 0.0694$ ).

Hypothesis H2 describes that company age may be viewed as a determining factor of website disclosure. In particular, the hypothesis assumes a negative correlation between environmental website disclosure and company age. The core theory of Hypothesis H3 is that financial performance may be viewed as another determining factor of website disclosure. In particular, the hypothesis assumes that there exists a positive correlation between environmental website disclosure and financial performance. The company's ROA figures for 2019 and 2020 were used as a measure of financial performance. Pearson correlation tests of both hypotheses were performed using the EDPI scores and the KCI scores as proxies for website disclosure. The tests did not result in any confirmation for the hypotheses.

## 7 | CONCLUSIONS

In this research, descriptive data analyses of disclosure measures revealed that today, companies do not make full use of website capabilities for environmental disclosure. Often, functional capabilities such as the possibility of directly coming into contact with the environmental management department are left unused. Additionally, websites often contain only a small amount of information about environmental management, and it is difficult to access this information. A limited uptake of website features for communication on sustainability issues was also found in a study of Adams and Frost published in the year 2006 (Adams & Frost, 2006). Considering our investigation results, it seems that this situation did not substantially change during the 15-year time period between the two studies.

Adam and Frost suggest that the limited uptake of website features is in part driven by inexperience with web technologies and limited resources. One can expect new firms with young human capital to be more experienced with web technologies than old traditional companies. The analysis of Hypothesis H2, which performed tests for a negative correlation between company age and website disclosure, however, did not lead to evidence for this assumption. The second suggested reason for the limited uptake, that is, limited resources, can be caused by a low financial performance. However, the analysis of Hypothesis H3, which tested the data for a positive correlation

between financial performance using the ROA figures and several of our study's disclosure measures, resulted no clear evidence that a weak financial performance is connected to a low environmental disclosure. This result is one of the main differences between our study and the results of other research works (e.g. Andrikopoulos & Krikliani, 2013; Deloitte, 2012, 2021). Furthermore, as opposed to the work of Cho and Roberts (2010), who found evidence for a negative correlation, our data analysis of Hypothesis H1 did not lead to clear evidence that environmental performance correlates to extent of environmental disclosure.

This work also contributes several novelties to the research field of voluntary corporate environmental disclosure, first of all, in the form of an up-to-date evidence-based description of the current status of disclosure in websites and reports in four world regions. In particular, it is assumed that our combined approach to observe website disclosure from various angles contributes to a realistic measure of extent of website disclosure. Furthermore, only very few prior research works offered insights into cross-regional disclosure differences that are highlighted in this work. For example, in terms of the extent of website disclosure, the Chinese companies of the sample performed considerably lower than the companies from Europe, Japan and the United States, which all reached about the same still low disclosure scores. Our investigation results for the transnational sample provide evidence that environmental reporting is a major topic of the global business world. The data analyses reveal that half of the companies in Europe, Japan and the United States offer on their website a downloadable annual report with environmental performance data, which is similar to findings of an empirical study of the Australian mining and metals sector (Lee, 2017). Unlike these results for the remaining fourth regional sample, that is, China, we only found for one-third of the Chinese companies a corresponding report. Also, our studied revealed that integrated reports are less used in the United States, particularly when compared with companies from Europe and Japan.

One of the further novelties of this work is, to our best knowledge, the correlation analysis for environmental performance scores of two different official ESG Ratings. In particular, using the Refinitiv scores and CDP scores, weak significant positive correlations between the two scores were found for the regional sample sets except for China, which was excluded from this analysis.

As a main practical implication this work suggests initiatives to drive the business world towards more and better use of today's web technologies for environmental website disclosure. In particular, the future websites should allow stakeholders to easily find all kinds of up-to-date environmental information and offer options to get into contact with people of the corporate environmental management team. Potential main actors for these initiatives are governmental institutions and business support organizations specialized on reporting and disclosure such as the GRI and the CDP. One may assume that the growing momentum of sustainable finance may stimulate firms to welcome such initiatives.

It is also assumed that the data collection obtained as well as the methods and the indices described in the article are of interest to other researchers. This interest may lead to a future enlargement of

the described data collection and further updates about the current status of voluntary environmental website disclosure in other world regions not addressed in this work.

This study is not without limitations and some of these limitations will be addressed in the future research. Subjectivity and the human factors can result into data collection errors during the observation of the websites. This bias of data can be avoided by a fully automated observation of the websites. For a final assessment of Hypothesis H1, more data analyses are required using revised versions of the disclosure indices applied in the study. Regarding Hypothesis H3, no evidence was found that financial performance is a determining factor of environmental website disclosure. The limitation of this result is that data experiments were performed using the ROA numbers as measure of financial performance. In order to obtain greater certainty for this assessment, the result could be validated with other financial numbers such as the turnover. Furthermore, a methodological limit of the study concerns the sample size. Even though a sample size that is bigger than the samples of many other works of the prior research was used, a generalization of the findings is not permitted.

An extensive agenda for the continuation of this research is being devised. The sample data will be used to explore disclosure differences between manufacturing companies that belong to environmentally sensitive sectors and the 'cleaner companies' of the sample. Our transnational and cross-industry sector sample offers the possibility to investigate this question for different regions where most likely different environmental legislation and enforcement systems exist.

Our future research will also target to add knowledge about the current status of greenwashing and blackwashing at corporate websites. It is planned to use an extensive sample of the largest companies for this investigation. The websites will be completely automatically scraped through a correspondingly extended version of the scraping tool used in this research. The explored environmental website disclosure is planned to be compared to media reports, environmental footprints, official pollution data and data about environmental performance published in ESG ratings. These comparisons are intended to uncover tendencies of greenwashing and blackwashing.

Latest content analysis techniques such as topic modelling and techniques that make use of machine learning are already being applied for environmental disclosure research (Gill et al., 2008; Tiscini et al., 2022). The use of these techniques is also on our research agenda. In particular, it is planned to use computer-based natural language understanding (i.e. NLP/NLU techniques) to further explore the content of the downloaded sample reports with respect to their topical orientation, their sentiment and language styles.

## ACKNOWLEDGMENTS

Not applicable. Open Access funding enabled and organized by Projekt DEAL.

## CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## AUTHOR CONTRIBUTIONS

Heiko Thimm: Conceptualization and design, methodology, supervision, resources, investigation, data curation, writing—original draft, writing – review and editing. Karsten Boye Rasmussen: Conceptualization and design, methodology, supervision, resources, investigation, formal analysis, data curation, validation, visualization, software, writing—review and editing.

## ORCID

Heiko Thimm  <https://orcid.org/0000-0002-6200-9655>

Karsten Boye Rasmussen  <https://orcid.org/0000-0002-0545-3098>

## REFERENCES

- Adams, C. A., & Frost, G. R. (2006). Accessibility and functionality of the corporate web site: Implications for sustainability reporting. *Business Strategy and the Environment*, 15(4), 275–287. <https://doi.org/10.1002/bse.531>
- Andrikopoulos, A., & Krikliani, N. (2013). Environmental disclosure and financial characteristics of the firm. The case of Denmark. *Corporate Social Responsibility and Environmental Management*, 20(1), 55–64. <https://doi.org/10.1002/csr.1281>
- Baral, N., & Pokharel, M. P. (2017). How sustainability is reflected in the S&P 500 companies' strategic documents. *Organization & Environment*, 30(2), 122–141. <https://doi.org/10.1177/1086026616645381>
- Berthelot, S., Coulmont, M., & Thibault, K. (2013). Sustainability content on oil and gas company websites. *BMR*, 2(1), 94–103. <https://doi.org/10.5430/bmr.v2n1p94>
- Birken, Emily Guy; Curry, Benjamin (2021): Understanding return on assets (ROA), Forbes Advisor. Forbes. Available online at <https://www.forbes.com/advisor/investing/roa-return-on-assets/>, updated on 10/28/2021, checked on 19 January 2022.
- Bonson, E., & Escobar, T. (2002). A survey on voluntary disclosure on the internet. Empirical evidence from 300 European Union companies. *The International Journal of Digital Accounting Research*, 2(1), 27–51. [https://doi.org/10.4192/1577-8517-v2\\_2](https://doi.org/10.4192/1577-8517-v2_2)
- Brammer, S., & Pavelin, S. (2008). Factors influencing the quality of corporate environmental disclosure. *Business Strategy and the Environment*, 17(2), 120–136. <https://doi.org/10.1002/bse.506>
- Bureau van Dijk. (2019): Untangling the world of private company information (white paper). Bureau van Dijk, A Moody's Analytics Company. Available online at <https://www.bvdinfo.com/en-gb/knowledge-base/white-papers/>, checked on 20 Ma, 2019.
- CDP. (2021a): Scoring introduction 2020. An introduction to 2020 scoring. Edited by Carbon Disclosure Project. Carbon Disclosure Project. Available online at [www.cdp.net](http://www.cdp.net), updated on 2021, checked on 19 March 2021.
- CDP. (2021b): The A list 2020- explore the full 2020 scores. Edited by Carbon Disclosure Project. Carbon Disclosure Project. Available online at <https://www.cdp.net/en/companies/companies-scores>, checked on 25 February 2021.
- Cho, C. H., & Roberts, R. W. (2010). Environmental reporting on the internet by America's toxic 100. Legitimacy and self-presentation. *International Journal of Accounting Information Systems*, 11(1), 1–16. <https://doi.org/10.1016/j.accinf.2009.12.003>
- Clarkson, P. M., Li, Y., Richardson, G. D., & Vasvari, F. P. (2008). Revisiting the relation between environmental performance and environmental disclosure. An empirical analysis. *Accounting, Organizations and Society*, 33(4–5), 303–327. <https://doi.org/10.1016/j.aos.2007.05.003>
- Delmas, M. A., & Burbano, V. C. (2011). The drivers of greenwashing. *California Management Review*, 54(1), 64–87. <https://doi.org/10.1525/cmr.2011.54.1.64>

- Deloitte. (2012): The Deloitte CFO survey sustainability and the CFO. Edited by Deloitte. Deloitte. Available online at [https://www.bitc.ie/wp-content/uploads/2015/09/CFOsurvey\\_Q2\\_20121.pdf](https://www.bitc.ie/wp-content/uploads/2015/09/CFOsurvey_Q2_20121.pdf), checked on 20 January 2022.
- Deloitte. (2021): Connect for future: Innovability. Towards a more ethical world, driven by sustainable innovation. Edited by Deloitte. Deloitte. Available online at [https://www2.deloitte.com/content/dam/Deloitte/it/Documents/about-deloitte/NGEU\\_ConnectForFutureInnovability\\_ENG\\_Deloitte.pdf](https://www2.deloitte.com/content/dam/Deloitte/it/Documents/about-deloitte/NGEU_ConnectForFutureInnovability_ENG_Deloitte.pdf), checked on 20 January 2022.
- Diamantopoulos, A., & Winklhofer, H. (2001). Index construction with formative indicators: An alternative to scale development. *Journal of Marketing Research*, 38(2), 269–277. Available online at [https://www.jstor.org/stable/1558630?seq=1#page\\_scan\\_tab\\_contents](https://www.jstor.org/stable/1558630?seq=1#page_scan_tab_contents). PMID: checked on May 20th, 2022.
- European Union. (2014): Directive 2014/95/EU. Available online at <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014L0095&from=EN>, checked on 20 January 2022.
- EUROSTAT. NACE rev. 2. Revision 2, English edition. Luxembourg.
- Evans, R. H. (1996). An analysis of criterion variable reliability in conjoint analysis. *Perceptual and Motor Skills*, 82(3), 988–990. <https://doi.org/10.2466/pms.1996.82.3.988>
- Gemmell, J., & Scott, M. (2013). Environmental regulation, sustainability and risk. *Sustainability*, 4(2), 120–144. <https://doi.org/10.1108/SAMPJ-Jan-2012-0003>
- Gill, D. L., Dickinson, S. J., & Scharl, A. (2008). Communicating sustainability: A web content analysis of north American, European and Asian firms. *JCOM*, 12(3), 243–262. <https://doi.org/10.1108/13632540810899425>
- Global Reporting Initiative. (2015). Guidelines part 1 reporting principles and standard disclosures. Available online at <https://www.globalreporting.org/Pages/resource-library.aspx>, checked on May 2019.
- Governance & Accountability Institute. (2021): 2021 sustainability reporting in focus. Examining 2020 sustainability reporting trends of the largest publicly-traded companies in the U.S. Available online at <https://www.ga-institute.com/index.php?id=9128>, checked on 19 January 2022.
- Gray, R., Owen, D., & Adams, C. (Eds.) (1996). *Accounting and accountability: Changes and challenges in corporate social and environmental reporting*. Prentice-Hall.
- Hahn, R., & Kühnen, M. (2013). Determinants of sustainability reporting. A review of results, trends, theory, and opportunities in an expanding field of research. *Journal of Cleaner Production*, 59, 5–21. <https://doi.org/10.1016/j.jclepro.2013.07.005>
- Hassan, O. A. G., & Romilly, P. (2018). Relations between corporate economic performance, environmental disclosure and greenhouse gas emissions: New insights. *Business Strategy and the Environment*, 27(7), 893–909. <https://doi.org/10.1002/bse.2040>
- Investopedia. (2022): Return on total assets (ROTA), updated on 19 January 2022, checked on 6 April 2022.
- Jose, A., & Lee, S.-M. (2007). Environmental reporting of global corporations. A content analysis based on website disclosures. *Journal of Business Ethics*, 72(4), 307–321. <https://doi.org/10.1007/s10551-006-9172-8>
- Kanagawa, H., Nakayama, Y., Sakai, N., Soma, Y., & Kane, S. (2021). Environmental law and practice in Japan: overview. A Q&A guide to environment law in Japan. Edited by Thomson Reuters. Kanagawa International Law Office. Available online at [https://uk.practicallaw.thomsonreuters.com/6-502-8920?transitionType=Default&contextData=\(sc.Default\)&firstPage=true#kh\\_relatedContentOffset](https://uk.practicallaw.thomsonreuters.com/6-502-8920?transitionType=Default&contextData=(sc.Default)&firstPage=true#kh_relatedContentOffset), checked on 1/20/2022.
- Knight, H., Haddoud, M. Y., & Megicks, P. (2022). Determinants of corporate sustainability message sharing on social media: A configuration approach. *Business Strategy and the Environment*, 31(2), 633–647. <https://doi.org/10.1002/bse.2941>
- Kosajan, V., Chang, M., Xiong, X., Feng, Y., & Wang, S. (2018). The design and application of a government environmental information disclosure index in China. *Journal of Cleaner Production*, 202, 1192–1201. <https://doi.org/10.1016/j.jclepro.2018.08.056>
- Lee, K.-H. (2017). Does size matter? Evaluating corporate environmental disclosure in the Australian mining and metal industry: A combined approach of quantity and quality measurement. *Business Strategy and the Environment*, 26(2), 209–223. <https://doi.org/10.1002/bse.1910>
- Li, W., Li, W., Seppänen, V., & Koivumäki, T. (2022). Effects of greenwashing on financial performance: Moderation through local environmental regulation and media coverage. *Business Strategy and the Environment*, 31(6), 1–22. <https://doi.org/10.1002/bse.3177>
- Mateo-Márquez, A. J., González-González, J. M., & Zamora-Ramírez, C. (2021). The influence of countries' climate change-related institutional profile on voluntary environmental disclosures. *Business Strategy and the Environment*, 30(2), 1357–1373. <https://doi.org/10.1002/bse.2690>
- Mohamed Adnan, S., Hay, D., & van Staden, C. J. (2018). The influence of culture and corporate governance on corporate social responsibility disclosure. A cross country analysis. *Journal of Cleaner Production*, 198, 820–832. <https://doi.org/10.1016/j.jclepro.2018.07.057>
- Petera, P., & Wagner, J. (2015). Global reporting initiative (GRI) and its reflections in the literature. *EFAJ*, 10(2), 13–32. <https://doi.org/10.18267/j.efaj.139>
- Portella, A. R., & Borba, J. A. (2020). Environmental disclosure in corporate websites. A study in Brazil and USA companies. *RAUSP*, 55(3), 309–324. <https://doi.org/10.1108/RAUSP-07-2018-0053>
- Qian, W., Hörisch, J., & Schaltegger, S. (2018). Environmental management accounting and its effects on carbon management and disclosure quality. *Journal of Cleaner Production*, 174, 1608–1619. <https://doi.org/10.1016/j.jclepro.2017.11.092>
- Refinitiv. (2021a): Environmental, social and governance scores from Refinitiv. Edited by Refinitiv. Refinitiv. Available online at [https://www.refinitiv.com/content/dam/marketing/en\\_us/documents/methodology/refinitiv-esg-scores-methodology.pdf](https://www.refinitiv.com/content/dam/marketing/en_us/documents/methodology/refinitiv-esg-scores-methodology.pdf), checked on 11 February 2022.
- Refinitiv. (2021b): ESG data in EIKON. Quick start guide. Available online at [https://www.refinitiv.com/content/dam/marketing/en\\_us/documents/quick-reference-guides/esg-data-in-eikon-march-2021.pdf](https://www.refinitiv.com/content/dam/marketing/en_us/documents/quick-reference-guides/esg-data-in-eikon-march-2021.pdf), checked on 19 January 2022.
- Siano, A., Vollero, A., Conte, F., & Amabile, S. (2017). “More than words”. Expanding the taxonomy of greenwashing after the Volkswagen scandal. *Journal of Business Research*, 71, 27–37. <https://doi.org/10.1016/j.jbusres.2016.11.002>
- Sobhani, F. A., Amran, A., & Zainuddin, Y. (2012). Sustainability disclosure in annual reports and websites. A study of the banking industry in Bangladesh. *Journal of Cleaner Production*, 23(1), 75–85. <https://doi.org/10.1016/j.jclepro.2011.09.023>
- Solomon, A., & Lewis, L. (2002). Incentives and disincentives for corporate environmental disclosure. *Business Strategy and the Environment*, 11(3), 154–169. <https://doi.org/10.1002/bse.328>
- Stacchezzini, R., Melloni, G., & Lai, A. (2016). Sustainability management and reporting. The role of integrated reporting for communicating corporate sustainability management. *Journal of Cleaner Production*, 136, 102–110. <https://doi.org/10.1016/j.jclepro.2016.01.109>
- Suttipun, M., & Stanton, P. (2012). A study of environmental disclosures by Thai listed companies on websites. *Procedia Economics and Finance*, 2, 9–15. [https://doi.org/10.1016/S2212-5671\(12\)00059-7](https://doi.org/10.1016/S2212-5671(12)00059-7)
- Thimm, H., & Rasmussen, K. B. (2020). Disclosure of environmental compliance management on corporate websites – A literature review and

future research foundation. *International Journal of Sustainable Entrepreneurship and Corporate Social Responsibility (IJSECSR)*, 5(1), 42–55. <https://doi.org/10.4018/IJSECSR.2020010103>

Tiscini, R., Martiniello, L., & Lombardi, R. (2022). Circular economy and environmental disclosure in sustainability reports: Empirical evidence in cosmetic companies. *Business Strategy and the Environment*, 31(3), 892–907. <https://doi.org/10.1002/bse.2924>

**How to cite this article:** Thimm, H., & Rasmussen, K. B. (2023). A multi-perspective exploration of the environmental website disclosure in global manufacturing. *Business Strategy and the Environment*, 32(4), 1719–1738. <https://doi.org/10.1002/bse.3214>