



Review

Quantifying firm-level greenwashing: A systematic literature review

Ágnes Lublóy^{a,*}, Judit Lilla Keresztúri^b, Edina Berlinger^{b,c}

^a Department of Accounting and Finance, Stockholm School of Economics in Riga, Strēlnieku iela 4a, Rīga, LV-1010, Latvia

^b Institute of Finance, Corvinus University of Budapest, Fővám tér 8, Budapest, 1093, Hungary

^c Department of Finance, University of Luxembourg, 2, Avenue de l'Université, Esch-sur-Alzette, 4365, Luxembourg

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ABSTRACT

In this systematic methodological literature review, we provide an overview, a typology, and a critical analysis of firm-level greenwashing measures derived from secondary data and utilized in empirical studies. 111 eligible studies were incorporated in this review. The high number of recently published studies in the field signals that in addition to conceptualizing greenwashing, lately there has been significant advancement in its operationalization. In slightly more than half of the cases, researchers adopt a broader perspective, with the greenwashing measure covering environmental, social, and corporate governance dimensions as well. Greenwashing measures tend to focus on two aspects of the multifaceted phenomenon: selective disclosure and decoupling. At present, measures of decoupling are more widely used than the measures of selective disclosure. Decoupling measures capture symbolic and substantive corporate actions using diverse data. Typically, the ESG disclosure score, selected ESG data points, or the content of corporate releases are used for evaluating corporate communication, while ESG ratings and selected environmental actions or performance measures are used for assessing corporate actions. Most greenwashing measures are hypothetical; researchers develop a measure which suggests possible greenwashing incidents. Although greenwashing measures based on actual incidents are scant, it might be a promising new research direction, especially when supported by artificial intelligence. The insights from this systematic literature review might serve as an input for selecting or developing the most appropriate greenwashing measurement approach in future empirical research on greenwashing.

1. Introduction

Greenwashing has emerged as a new misleading practice. Greenwashing can be defined as the act or practice of making a product, policy, or activity appear to be more environmentally friendly or less environmentally damaging than it really is (Merriam-Webster 2023). Some infamous greenwashing examples include the case of Volkswagen promoting its diesel cars as eco-friendly while intentionally programming the cars to detect the emission test and altering the outcomes to meet the standards (Hotten, 2015), and Westinghouse claiming to provide sustainable power through nuclear energy while having disguising defects in its reactor and a plant leaking radioactive pollutants into the surrounding area's water (Wald, 2011). Some recent examples of greenwashing include British Petroleum misleading society with advertisements focusing on low-carbon energy products without specifying the proportion of those products in their portfolio (Carrington, 2021), and IKEA, advocating sustainable operation and launching its Forest Positive Agenda while being blamed for illegal logging in the

Carpathian mountains, home to endangered lynx and brown bears (IKEA, 2020; Reuters, 2020).

Several high-level policy papers collectively demonstrate that regulatory bodies and international organizations recognize greenwashing as a significant and growing issue (e.g., EC, 2020; ESMA, 2024; FCA, 2021; GSIA, 2023; OECD, 2022a; UN, 2022). These policy papers call for enhanced regulatory frameworks, improved consumer protection, and more rigorous sustainability standards to address the proliferation of misleading claims. The rising incidence of greenwashing, particularly in the ESG space, is a primary driver of these policy discussions.

When defining greenwashing, several authors emphasize selective disclosure, which is composed of two behaviours simultaneously: retaining the negative information and exposing the positive information regarding the firm's environmental performance (e.g., Lyon & Maxwell, 2011; Marquis et al., 2016; Huang & Huang, 2020). For example, Lyon and Maxwell (2011) define greenwashing as selectively disclosing the positive aspects of a company's environmental or social performance while withholding negative information in order to create

* Corresponding author.

E-mail addresses: agnes.lubloy@sseriga.edu (Á. Lublóy), lilla.kereszturi@uni-corvinus.hu (J.L. Keresztúri), edina.berlinger@uni-corvinus.hu (E. Berlinger).

an overly positive corporate image. Some other authors focus on the manipulative aspect of disclosure; intentional dissemination of information designed to deceive stakeholders (Huang & Huang, 2020; Yu et al., 2020). Manipulative disclosure misrepresents the company's true impact on the environment or society by highlighting the positive aspects of corporate actions while downplaying or omitting the negative ones, distorting facts, using misleading language or imagery.

In organization theory, the disconnection between espoused values and actual corporate practices is referred to as decoupling (Kim & Lyon, 2015). Decoupling results from organizations' responses to institutional pressures; in case of greenwashing, it translates into a gap between symbolic corporate communication and substantive corporate action. Several greenwashing definitions, and hence measurement approaches, reflect this decoupling mechanism. For example, the widely accepted definition of Delmas and Burbano (2011) portrays greenwashing as poor environmental performance and positive communication about environmental performance. Similarly, Walker and Wan (2012) define greenwashing as a strategy of engaging in symbolic communications of environmental issues without substantially addressing them in actions. All in all, these definitions reflect that companies simply claim to be environmentally responsible or socially conscious but fail to align their operations with the stated values.

Green communication (symbolic action) is cheaper than investing in green technologies and protocols (substantive actions). At the same time, pretending to be green might attract consumers and investors, and it helps complying with regulations. Hence, companies with poor environmental and social practices are more likely to engage in CSR or ESG reporting with the aim of changing stakeholder perceptions about their actual performance (Clarkson et al., 2011; Gatti et al., 2019; Doan & Sassen, 2020; Mahoney et al., 2013). Poor environmental performers have higher motivations to increase their level of disclosure than strong performers, and as a result, they typically disclose a greater level of environmental information (Doan & Sassen, 2020). Essentially, CSR and ESG reports are used as a legitimation strategy to create an impression that the firm is environmentally and socially responsible. Building and maintaining legitimacy is important because the firm's success depends upon its relations with various stakeholder groups, including regulators, customers, investors, or the wider population. When companies perceive a threat to their social legitimacy, they might turn to social and environmental reporting (Patten, 2002). Companies performing poorly socially and environmentally typically face a heavy social and political pressure which might lead them to selective or manipulative disclosure, or other symbolic actions.

Translating the various greenwashing concepts into measurable and actionable procedures or variables is challenging for several reasons. First, greenwashing is a complex, multifaceted, and dynamic phenomenon that spans across various disciplines and dimensions (Bernini et al., 2024). Second, the amount of greenwashing generated is usually determined by the discretion of the company (Yang, 2022). Third, greenwashing has a deceptive nature which makes direct observations difficult (Yang, 2022). Firms might engage in reporting environmentally and socially responsible practices in their CSR and ESG reports with two major motives: signalling and greenwashing (Mahoney et al., 2013; Uyar et al., 2020; Friske et al., 2023). Hence, researchers at the very end should disentangle whether by revealing more information companies send signals about their superior commitment and corporate performance (signalling) or they mislead stakeholders by generating a positive but deceitful impression (greenwashing).

When operationalizing greenwashing, researchers designed several greenwashing measures, focusing on selected aspects of the multifaceted phenomenon. In this systematic literature review, we aim at providing an overview of the firm-level greenwashing measurements in the empirical literature. We exclusively focus on quantitative greenwashing measurement approaches that are scalable across a broad sample of firms. We develop a typology of the firm-level greenwashing measures; we group the measures in three major categories: measures of selective

disclosure, measures of decoupling, and specific measures. We describe each measure in detail, show the data scholars use, and elaborate on the drawbacks of each method. We also show that although there is no widely accepted framework to measure greenwashing, a few greenwashing operationalizations are becoming more popular than others.

The main findings from this systematic review can be summarized as follows. In the last couple of years, over 100 studies have developed or adopted a firm-level measure for greenwashing, and in addition to conceptualizing greenwashing, there has been significant advancement in its operationalization. In approximately half of the cases, researchers adopt a broader perspective, incorporating environmental, social, and corporate governance dimensions into the greenwashing measure. The greenwashing measures tend to focus on two aspects of the multifaceted phenomenon: selective disclosure and decoupling. As of now, measures of decoupling have become dominant in the literature; these measures capture the gap between stated values and actual corporate practices. The far most widely used greenwashing measure has been developed by Yu et al. (2020) which suffers from several major deficiencies (e.g., it does not account for industry differences adequately). The majority of greenwashing measures are hypothetical—researchers develop a measure which suggests possible greenwashing incidents. Only nine studies assess actual instances of greenwashing incidents, potentially marking the emergence of a new branch of research. Artificial intelligence might play an increasingly important role in greenwashing detection, thanks to the rapid development of large language models.

This systematic literature review adds to the body of research on greenwashing by offering several contributions. First, we provide an overview and a detailed typology of the greenwashing measures used in the empirical literature. Although there are several systematic reviews on the definitions, concepts, and drivers of greenwashing (Delmas & Burbano, 2011; de Freitas Netto et al., 2020; Gatti et al., 2019; Yang et al., 2020; Bernini et al., 2024), to the best of our knowledge, this systematic review is the first to categorize quantitative greenwashing measurement approaches that are scalable across a broader sample of firms. Second, we add to the discourse on greenwashing by showing how widely various greenwashing measures are used, and which greenwashing quantification approaches are becoming the dominant ones. Third, we formulate a critique for each method. We show that the most widely used method of Yu et al. (2020) suffers from several misspecifications which are copied by other researchers. We also discuss how this measure could be improved. Fourth, we demonstrate that most greenwashing measures are hypothetical; they identify firms which are more likely to be involved in greenwashing. In our view, the recently developed incident-based greenwashing measures using the RepRisk database, information on environmental violations or controversies, have a huge future potential to be employed in empirical research on greenwashing. All in all, the insights from this systematic literature review, might serve as an input for selecting the most appropriate greenwashing measurement approach in future research on greenwashing.

This systematic review exceeds the methodological review by Bernini et al. (2024), which is the most comparable to our work, in several key aspects. First, their analysis identified 14 articles where greenwashing measures were calculated; in this paper, we assess 111 such articles. We identify a much larger pool of relevant papers because our search period is more recent in this rapidly evolving area, and we employ a significantly different search strategy. Bernini et al. (2024) only considered articles published in Scopus-listed journals and narrowed their scope to Management, Business, and Accounting, excluding emerging interdisciplinary research fields. Additionally, while they searched only titles, abstracts, and keywords, we conduct a more comprehensive search of full texts, including working papers in pre-publication phases. Second, in contrast to our work, their study lacked explanations, formulas, classifications, or critical assessments of the applied methodologies. Third, Bernini et al. (2024) omitted most incident-based measures and methods involving artificial intelligence

and machine learning techniques—the latest developments in this field.

Bernini et al.'s (2024) main conclusion was that, at the time, there were few calculated greenwashing measures, different approaches showed no convergence, and most measures were hypothetical (not incident-based). They documented that knowledge of greenwashing measures was scarce and fragmented, and called for further research in this area. Our paper can be considered a continuation of Bernini et al. (2024), as it addresses these gaps by providing a more comprehensive and up-to-date analysis of greenwashing measurement methodologies.

2. Materials and methods

2.1. Search strategy and literature selection

This systematic review focuses on studies that develop a quantitative greenwashing measure, with time and geography of no specific interest. The database used was Google Scholar, and the search was conducted in the period of 11 January to February 13, 2024. All articles found on Google Scholar were included in the review. Google Scholar indexes the full text or metadata of scholarly literature across an array of publishing formats and disciplines. Compared to Scopus and Web of Science, Google Scholar has a wider coverage due to its inclusive and unsupervised approach; scholarly documents are automatically indexed without approving the source by expert editors (Martín-Martín et al., 2018a, 2018b). Empirical evidence shows that Google Scholar finds the most scientific works and citations in social sciences (Martín-Martín et al., 2018b). The number of studies published on greenwashing measurement has significantly increased in recent years.¹ Google Scholar allows the inclusion of high-quality working papers and as-yet unpublished manuscripts. Google Scholar's broader coverage and the inclusion of works-in-progress in this new and rapidly evolving research field justifies its usage over Scopus and Web of Science.

Given that in Google Scholar the search term greenwashing resulted in close to 60 thousand scientific works, we developed a search strategy that allowed us to identify literature on quantitative greenwashing measurements. We used very specific search terms; expressions that included greenwashing and some other words related to measurement. An important feature of Google Scholar is that by using quotation marks around a phrase it delivers exact matches of the phrase found in any part of the study, a feature unavailable in Scopus or Web of Science. The initial search terms were updated and extended four times; after screening 258, 437, 536 and 766 scientific works in total. Thus, the final search strategy was determined after carefully reviewing and linguistically analysing a broad set of articles on greenwashing. Studies were retrieved if any part of the scientific work (main text, endnotes, appendix, etc.) included the search terms specified in Table 1. The bibliographies of the retrieved studies, as well as relevant literature reviews, were rigorously checked to identify further studies.

Studies were downloaded and screened for eligibility based on several criteria.

- 1 A Google Scholar search result was excluded by default if *i*) the study was written in a language other than English; *ii*) it was a citation; *iii*) the study was removed from the database.
2. The studies published in one of the following outlets were included: *i*) scientific journals, including forthcoming articles; *ii*) working paper series; *iii*) papers uploaded to Social Science Research Network (SSRN), a repository for social science disciplines being particularly strong in the fields of economics, finance, and accounting; *iv*) PhD

¹ In Scopus, the number of articles with the term greenwashing included in the abstract has grown exponentially in recent years. In the past five years, the number of articles published and included in Scopus evolved as follows: 54 (2019); 85 (2020); 128 (2021); 215 (2022); 347 (2023).

Table 1
Search terms and number of studies retrieved.

Category	Exact search term	# of studies retrieved
assess	"assess greenwashing"	107
	"assessment of greenwashing"	31
disclosure	"greenwashing" + "disclosure ratio" + "Trucost"	29
	"greenwashing" + "selective disclosure magnitude"	15
decoupling	"greenwashing" + "environmental decoupling"	34
degree	"degree of greenwashing"	99
identify	"identified as (a) green-washing" (firm/company)	3
	"identified as (a) greenwashing" (firm/company)	47
	"identified as (a) green-washer"	2
	"identified as (a) greenwasher"	2
indicator, metric	"greenwashing indicator"	41
	"indicator of greenwashing"	13
	"greenwashing metric"	1
	"metric of greenwashing"	0
level	"level of greenwashing"	140
measure	"measure of greenwashing"	35
	"measures of greenwashing"	17
	"we measure greenwashing"	5
	"measuring greenwashing"	37
	"greenwashing measure"	30
peer relative	"peer relative" + "greenwashing"	25
quantify	"quantify greenwashing"	11
	"quantification of greenwashing"	1
score	"greenwashing score"	49
severity, size	"severity of greenwashing"	14
	"magnitude of greenwashing"	8
	"size of greenwashing"	3
	"intensity of greenwashing"	3
value	(mean/average) "value of greenwashing"	17
variable	"greenwashing variable"	32
	"variable of greenwashing"	3
Total number of studies retrieved, including duplicates		854

dissertations. However, BA, BSc, MSc theses, university group projects and call for papers were excluded from this review.

3. The study employed a firm-level greenwashing measure. The greenwashing measure might be developed by the authors or could be adopted from another research. Product-level greenwashing measures were excluded from this review.
4. The study used information from secondary data sources, including databases managed by various information providers (subscription or free-of-charge), corporate reports and corporate websites. Studies involving primary data collection (surveys, observations, experiments, interviews) exploring perceptions of different actors were not eligible for inclusion. When collecting information directly from employees and customers, researchers may simply capture normative responses and perceived attitudes rather than what actually occurs in practice. In addition, surveys are not easily scalable across firms and years, and are prone to a number of biases, including sampling bias, non-response bias, acquiescence bias, and social desirability bias.

2.2. Data extraction

A database was created to investigate the characteristics of the eligible studies. It included the following information: *i*) author(s) and

year of publication; *ii*) key characteristics of the sample (size, type of firms, and their location); *iii*) data sources used; *iv*) keywords describing the greenwashing measure developed or used (e.g., selective disclosure, decoupling, natural language processing); *v*) measure of corporate communication or symbolic corporate action; *vi*) measure of corporate performance or substantive corporate action; *vii*) formal definition of the greenwashing measure. Standard database functions were used for the analysis. The charted characteristics served as an input to develop the typology of the greenwashing measures.

2.3. Search flow

As Fig. 1 shows, several studies were removed from the initial 854; 245 on grounds of duplication and 507 because at least one of the four eligibility criteria was not met. Nine additional studies were included, following identification through bibliographies and citations. At the end, 111 eligible studies were included in this review, as listed in Supplementary Material, Table S1.

3. Results

3.1. Descriptive statistics

In this section, we characterize the 111 studies included in this review along a number of dimensions. Key characteristics of reviewed studies and their greenwashing measures are shown in Supplementary Material, Table S1. As shown in Fig. 2, the huge majority of studies ($n = 85$) were published in an academic journal, while 16 pre-prints were uploaded to a research repository, either SSRN ($n = 15$) or arXiv ($n = 1$). Typically, many of the articles available on SSRN and arXiv are shared years before they are published in journals.

The most popular outlets for publishing studies in which a quantitative greenwashing measure was developed or used include Energy Economics, Journal of Business Ethics, Finance Research Letters, and Sustainability, as shown in Table 2. Corporate Social Responsibility and Environmental Management accommodated four papers on greenwashing, two journals published three studies, while seven journals

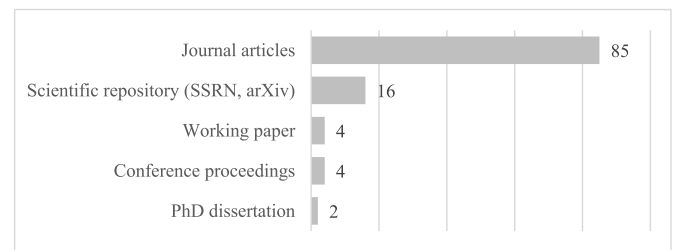


Fig. 2. Publication outlet.

Table 2
Journals with at least two studies on greenwashing.

Journal	No. of papers
Energy Economics	9
Journal of Business Ethics	6
Finance Research Letters	6
Sustainability	6
Corporate Social Responsibility and Environmental Management	4
Business Ethics, the Environment & Responsibility	3
Business Strategy and the Environment	3
Environment, Development and Sustainability	2
International Review of Financial Analysis	2
Journal of Cleaner Production	2
Journal of Management Studies	2
Organization Science	2
Pacific-Basin Finance Journal	2
Research in International Business and Finance	2

published two studies. In 34 journals one study was published. The scope of the major outlets thus encompasses a wide variety, covering the fields of energy, ethics, finance, and sustainability. Supplementary Material, Table S2 provides an overview of the journal quality, including article influence score and percentile, SJR indicator, and SJR best quartile.

Almost half of the reviewed studies ($n = 52$) assessed and quantified greenwashing among Chinese firms, while 20 studies focused on the US (Fig. 3). There were nine additional single-country studies. 30 studies had a global coverage. In large global samples, the headquarters of the firms were located in a maximum of 58 countries and a minimum of 12 countries.

Scholars conceptualized a greenwashing measure as an exclusively environmental issue in 56 studies. Scholars took a broader perspective in 55 studies, with greenwashing measures covering social and corporate governance dimensions as well. In this latter case, the term greenwashing encompasses any type of misleading claim within the domains of ethical actions and corporate social responsibility.

3.2. Typology of the greenwashing measures

Fig. 4 shows the typology of the greenwashing measures developed in this review. In 23 studies, researchers equated greenwashing with selective disclosure, and quantified its magnitude. In this category, 11

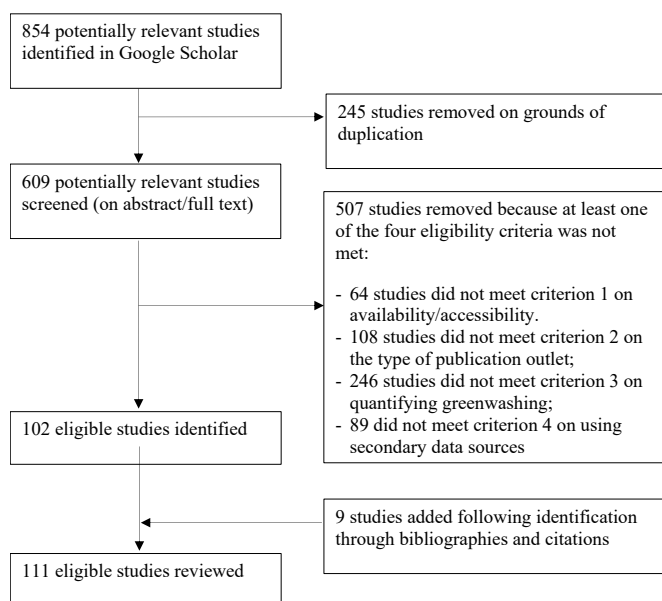


Fig. 1. Flow diagram of the search strategy. Note: The full texts of the 609 potentially relevant studies were assessed by Ágnes Lublóy and Judit Lilla Keresztúri. Colleagues agreed on all studies reviewed together.

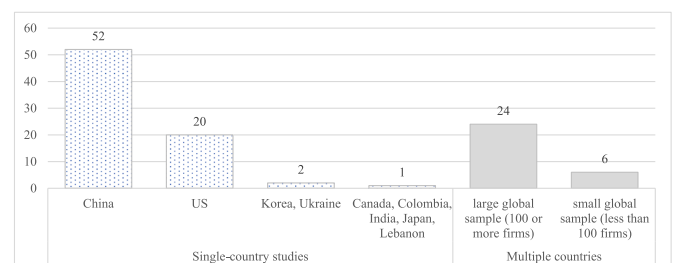


Fig. 3. Country coverage.

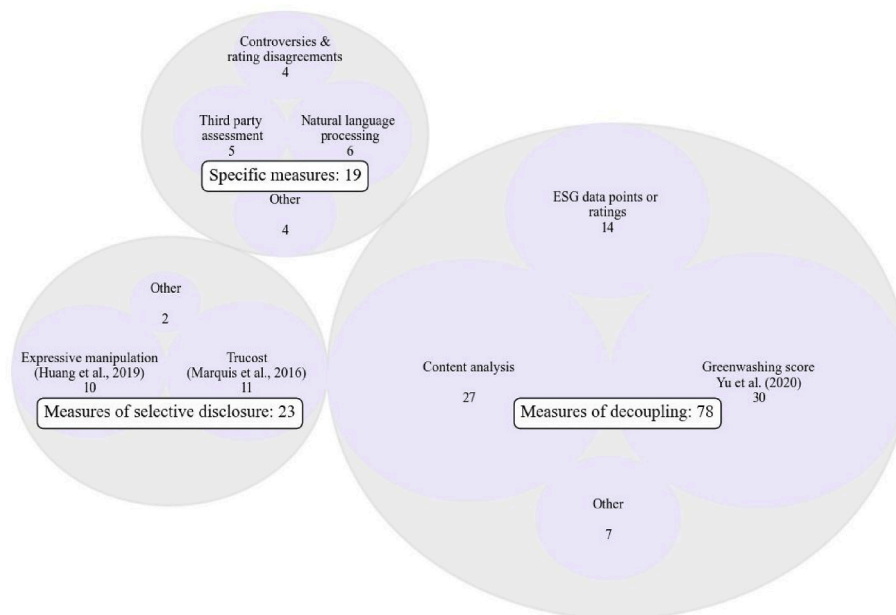


Fig. 4. Typology of the greenwashing measures.

Note: In some studies, more than one greenwashing measure is used. In the 111 studies reviewed, the authors developed 120 greenwashing measures in total.

studies employed the selective disclosure magnitude developed by Marquis et al. (2016), using data from Trucost. In ten studies on China, the authors relied on the selective disclosure and expressive manipulation measures developed by Huang et al. (2019). Two studies employed some other selective disclosure measures.

In 78 studies, researchers focused on the decoupling aspects of greenwashing—when corporate walk does not meet corporate talk. By decoupling, organizations may maintain favourable image and reputation without bearing the burden associated with the sustainability initiatives. Companies might claim to be environmentally responsible or socially conscious but fail to align their operations with these stated values. Decoupling is the term used to describe the disconnection between corporate communication (symbolic action) and actual corporate behaviour (substantive action). The most popular measure in this category is the greenwashing score of Yu et al. (2020) which was used in 30 studies. In 14 studies, the authors drew upon the principle of decoupling and developed a greenwashing measure based on selected ESG data points or ESG ratings. In 27 studies, researchers analysed the content of corporate releases, identifying key themes and the overall emphasis on environmental sustainability. In seven studies, the authors utilized highly specific data to quantify symbolic and substantive corporate actions.

In 19 studies, researchers developed greenwashing measures which are related to selective disclosure or decoupling as well. However, these measures, labelled as specific measures, significantly differ from the previous ones in how they operationalize greenwashing. Authors utilized either highly specific data (e.g., assessment by a third party, rating disagreements) or very distinct methods (e.g., artificial intelligence, multiple-factor modeling). In five studies, the authors relied on a list compiled by a third party, for example, RepRisk. In four studies, researchers defined a greenwashing measure based on an ESG-related construct. In six studies, researchers employed artificial intelligence, specifically natural language processing, to detect greenwashing. Four studies used greenwashing measures not fitting in any of the above categories.

3.3. Measures of selective disclosure (n = 23)

3.3.1. Selective disclosure magnitude based on Trucost (n = 11)

In the empirical literature, a widely used greenwashing measure in the environmental domain is the selective disclosure magnitude developed by Marquis et al. (2016). The authors conceptualize selective disclosure as a symbolic strategy wherein companies reveal positive environmental actions while concealing negative ones, aiming to create a misleadingly positive impression of their overall environmental performance. The selective disclosure magnitude shows the extent to which firms might create a misleading public impression of accountability and transparency by disclosing somewhat benign environmental performance metrics rather than those properly describing the environmental harm they cause.

The authors calculate the selective disclosure magnitude as the difference between the absolute and weighted disclosure ratios retrieved from the Trucost database maintained by S&P Global. The absolute disclosure ratio indicates the number of indicators the firm publicly disclosed that year, regardless of their relative importance, divided by the number of indicators relevant to a particular company. Trucost collects information from annual reports, sustainability or CSR reports, and official corporate communications, and considers only quantitative disclosures assessing the firm’s worldwide operations. The environmental indicators attributed to each company are chosen from Trucost’s extensive database of over 700 metrics, encompassing natural resource consumption and emissions of various pollutants to air, land, and water.

The weighted disclosure ratio shows how much of the most important information was disclosed. Based on the pollution release and transfer registries, for every dollar of economic output, Trucost estimates for each environmental indicator the emissions released and natural resources consumed in each industrial sector. These physical emissions and consumed natural resource estimates are subsequently multiplied (weighted) by cost factors reflecting the environmental damage. This weighted sum is the denominator of the weighted disclosure ratio. The numerator of this ratio is the sum of the products of the quantity and the environmental cost factor of each disclosed indicator. The weighted disclosure ratio is finally calculated as the proportion of the firm’s environmental damage cost for which the company disclosed quantitative worldwide figures. Formally:

$$GW_i = \text{absolute disclosure ratio}_i - \text{weighted disclosure ratio}_i = ADR_i - WDR_i \tag{1}$$

The absolute disclosure ratio is calculated as follows:

$$ADR_i = \frac{K_i}{R_i} \tag{2}$$

where K_i is the number disclosed indicators by the firm in their corporate reports (related to emissions or use of natural resources) and R_i is the number of relevant indicators for the firm that align with the industries in which the firm is active.

The weighted disclosure ratio is calculated as follows:

$$WDR_i = \sum_{k=1}^{K_i} \frac{C_{k,i}}{C_i} \tag{3}$$

where $C_{k,i}$ is the estimated environmental cost of firm i related to the k th disclosed indicator, and C_i is the total estimated environmental cost of the firm (disclosed or not).

The selective disclosure magnitude variable of Marquis et al. (2016) captures the degree by which symbolic environmental transparency, as gauged by the absolute disclosure ratio, surpasses substantive environmental transparency, as assessed by the weighted disclosure ratio. By construction, the selective disclosure magnitude variable reaches its maximum value of 1 when a company publishes several less harmful indicators while hiding the ones showing the environmental harm from their operations.

In the empirical literature, the selective disclosure magnitude became a popular variable for quantifying the extent of greenwashing. Supplementary Material, Table S3 provides an overview of the studies employing this greenwashing measure. All studies listed in the table rely on the Trucost database when retrieving the absolute and weighted disclosure ratios.

Although the disclosure ratios provided by Trucost are based on carefully developed models and expert knowledge, they have several drawbacks. First, this greenwashing measure can be calculated only for companies included in the Trucost database. Second, to calculate the absolute disclosure ratio, the environmental indicators relevant to a particular company within a specific industry should be determined. This assessment is non-transparent and involves economic modelling and expert judgement. Third, the absolute disclosure ratio solely evaluates the presence of a quantitative worldwide disclosure figure, without assessing the reliability of the indicator, for example, whether the firm understates its emissions. In addition, the firm might generate false impression and deceive stakeholders using textual descriptions only, a factor not accounted for by Trucost. Fourth, Trucost uses sophisticated and proprietary models to estimate the extent of environmental costs; the details of the model are not disclosed to the public. Fifth, as argued by Marquis et al. (2016), the selective disclosure magnitude captures the extent to which firms disproportionately disclose their less-damaging environmental impacts. This disproportionate disclosure might sometimes be unintentional, a result of limited management attention rather than a deliberate aim to create a misleading public impression. Sixth, the most serious concern with this measure is that it focuses only on the communication side while neglecting the environmental outcome. It follows from the logic of Equations (2) and (3) that if a firm polluted 50% less in each indicator while the communication remained the same, the greenwashing measure would also remain the same.

3.3.2. Selective disclosure and expressive manipulation ($n = 10$)

Huang et al. (2019) developed a greenwashing measure that captures two aspects of greenwashing within the environmental domain: selective disclosure and expressive manipulation. The greenwashing measure of Huang et al. (2019) was employed in seven later studies. In the

following, we rely on Huang and Huang (2020) when describing this greenwashing measurement; the study of Huang et al. (2019) is available only in Chinese.

First, the authors identified 20 topics that firms should disclose in their environmental reports when following relevant laws, announcements, standards, and guidelines. The authors grouped these items into four major themes.

- i) governance and structure including four indicators (environmental policy and strategy; environmental protection goals and realization; environmental regulations and enforcement; environmental management agency and operation)
- ii) process and control including five indicators (environmental certification system and implementation; environmental honours and recognition; environmental protection investment and comprehensive improvement plan; environmental education training and public welfare activities; environmental technology R&D and process innovation)
- iii) input and output including seven indicators (energy consumption; water consumption; greenhouse gas emissions; exhaust emissions; wastewater generation; solid waste generation and treatment; other emissions)
- iv) law and regulation compliance including four indicators (compliance with environmental laws and regulations; risk assessment from environmental policies; industry characteristics on environmental impact; disclosing whether major environmental pollution accident has occurred)

Second, after carefully screening corporate environmental reports, CSR and/or sustainable development reports, the authors performed content analysis and scored each item on a binary scale (1-yes, 0-no) by answering the following questions: *i*) Has the firm disclosed the item that should have been disclosed? *ii*) If yes, was the disclosure symbolic? *iii*) If yes, was the disclosure substantive? The disclosure was considered symbolic if it was a simple description or general summary and included difficult-to-verify and easy-to-imitate type of statements. The disclosure was considered substantive if it was more verifiable and difficult-to-imitate, and included factual statements, case descriptions, or quantitative information.

Third, the authors defined selective disclosure (SD_i) as 1 minus the ratio of the number of items disclosed to the number of items that should be disclosed, multiplied by 100, see Equation (4). Therefore, selective disclosure is a measure of how often the information mentioned in the reports is irrelevant. Expressive manipulation (EM_i) was defined as the number of symbolically disclosed items to the number of disclosed items, multiplied by 100, see Equation (5). Therefore, expressive manipulation is a measure of how often the information mentioned in the reports is superficial. As a final step, the authors quantified greenwashing as the geometric mean of the variables of selective disclosure and expressive manipulation.

$$SD_i = \left(1 - \frac{\text{number of disclosed items}}{\text{number of items that should be disclosed}} \right) \cdot 100 \tag{4}$$

$$EM_i = \left(\frac{\text{number of symbolically disclosed items}}{\text{number of disclosed items}} \right) \cdot 100 \tag{5}$$

$$GW_i = \sqrt{SD_i \cdot EM_i} \tag{6}$$

Supplementary Material, Table S4 provides an overview of the studies employing the greenwashing measure developed by Huang and Huang (2020).

In two studies, the authors developed a measure similar to that of Huang and Huang (2020). Zhang (2023c) measured selective disclosure based on the amount of hard and soft environmental information the company discloses in any of its reports. The authors manually collect

detailed information about 26 hard items grouped in four categories (governance structure and management systems, credibility, environmental performance indicators, and environmental spending), and nine soft items grouped in three categories (vision and strategy claims, environmental profile, environmental initiatives). The authors scored each item on a 0–1 scale: 1 point if the related information was disclosed, 0 otherwise. Zhang (2023c) develops three selective disclosure measures capturing particular aspects of greenwashing: *i*) the ratio of hard items disclosed to the maximum number of disclosable hard information, *ii*) the proportion of soft items disclosed to the total number of items disclosed; *iii*) geometric mean of these two measures. In a similar vein, Jia and Li (2023) calculate greenwashing severity as the difference between the relative values of soft and hard disclosure scores. The relative soft disclosure score equals the number of soft items disclosed to 16 (the sum of the soft disclosure scores), while the relative hard disclosure score equals the number of hard items disclosed to 79 (the sum of the hard disclosure scores). Note that the authors do not reveal any details about the hard and soft items scored.

The above greenwashing measures, used exclusively for the Chinese market thus far, have several drawbacks. First, full texts of corporate reports (annual reports, corporate social responsibility reports, environmental reports) are needed. Although in China all these reports can be downloaded from a single database (e.g., the website of China Securities Regulatory Commission), in other countries, researchers should retrieve the required reports one-by-one from the official corporate websites. Second, the greenwashing measure is based on content analysis, which is an extremely time-consuming process, hence difficult to scale up. Each corporate report should be carefully screened, and items should be scored. Third, the items are scored by researchers potentially introducing subjective biases. Scoring by two independent researchers may lower the subjectivity bias and enhance the reliability of the scoring—a common practice in the field. Fourth, when quantifying selective disclosure, the measure considers each disclosure item equally relevant to each company in each industry. Nevertheless, the number of disclosure indicators relevant to a particular industry should be determined for each industry individually, as done by Trucost. Fifth, when Huang et al. (2019) quantified expressive manipulation, the authors took the ratio of the number of symbolically disclosed items to the number of disclosed items. Nevertheless, a firm might provide simple description for various disclosure items due to their irrelevance. For this measure, it would be important to understand the intentions behind the symbolic communication and whether it aligns with honest and open communication, or it involves deceptive manipulation. Comparing the symbolic disclosure activity among peers might be a more appropriate measure. Sixth, in these studies, the authors do not make the data publicly available, owing to privacy concerns or lack of permission; therefore, research findings are not replicable or comparable.

3.3.3. Other selective disclosure measures (n = 2)

In addition to the selective disclosure measures outlined above, we have identified two studies capturing specific aspects of selective disclosure. In general, these measures reflect how much hard information the firms disclose.

Penalty data (n = 1). Xia et al. (2023) used a powerful selective disclosure measure to assess greenwashing. The authors matched corporate disclosure reports with administrative environmental penalties. Companies were considered to greenwash if they did not disclose the environmental penalty they received. These companies released environmental performance information selectively to mislead the public. The drawback of this measure is its limited applicability; in countries with high disclosure requirements and free media, typically all environmental penalties are disclosed.

Disclosure of (non-)materiality-based ESG information (n = 1). Choi et al. (2023), proxied greenwashing by capturing the mismatch between any type of ESG information the firm discloses and those ESG information which are based on materiality. The authors used the Bloomberg

ESG disclosure score as the former metric, and the ESG disclosure based on materiality (ESGMD) as the latter. Both scores were standardized using the z-score normalization method. The ESG disclosure based on materiality (ESGMD) was calculated as a percentage of the Bloomberg ESG disclosure score, capturing the proportion of material sustainability indicators in each industry, as identified by SASB. The mapping process was facilitated by a tool provided by Bloomberg; it helped to match the indicators of SASB with that of Bloomberg. The higher the ESGMD, the more financially material the ESG disclosures of the company is. Choi et al. (2023) argue that ESGMD is not a performance metric. Instead, it is a proxy for manipulating disclosure; it assesses the relevance of ESG activities in terms of financial materiality. This indicator shows a lot of similarities with that of Marquis et al. (2016): it compares the amount of all information the firm discloses with those being relevant and material in each industry. The advantage of this method is its industry-specificity; material sustainability indicators are defined for each industry. The complexity and hence drawback of this method lies in the matching process; material sustainability indicators defined by SASB shall be matched with the indicators provided by Bloomberg.

3.4. Measures of decoupling (n = 78)

Decoupling is rooted in organizational theory, particularly when studying the organizations' responses to institutional pressures (Kim & Lyon, 2015). Institutional theory suggests that organizations are influenced by external expectations, norms, and values (Zucker, 1987). In case of corporate social responsibility, there may be pressure from stakeholders, including customers, investors, and regulators, to adopt sustainable practices (Crilly et al., 2012).

By decoupling, organizations may seek to maintain a positive image and reputation without incurring the costs or challenges associated with the sustainability efforts (Clarkson et al., 2008; Gatti et al., 2019; Mahoney et al., 2013; Uyar et al., 2020). Decoupling might take several forms; organizations might engage in various practices that create the appearance of responsibility without fully implementing sustainable practices throughout their operations. For example, organizations may engage in symbolic gestures, such as adopting green marketing or making public commitments to sustainability, without making substantial changes in their actual operations (Kärnä et al., 2001; Lashitew, 2021). Hence, companies simply claim to be environmentally responsible or socially conscious but fail to align their operational behaviours with these stated values. The disconnection between corporate communication (symbolic action) and corporate behaviour (substantive action) is referred to as decoupling. In case of decoupling, there is a gap between espoused values and commitments to sustainability and actual corporate practices.

Table 3 presents the typology of the greenwashing measures grounded in decoupling theory. In this typology, studies are classified based on the measures researchers use to assess symbolic and substantive corporate actions. Content-analysis based constructs, rating-based proxies, and other measures are used for assessing both symbolic and substantive corporate actions.

3.4.1. The greenwashing score of Yu et al. (2020) (n = 30)

The greenwashing score developed by Yu et al. (2020), referred to as the peer-relative greenwashing score by the authors, is currently the most widely used method in the empirical literature. According to Yu et al. (2020), a firm is involved in greenwashing if it reveals a large amount of ESG data with the aim of creating a highly transparent public image while having a poor ESG performance. In this case, decoupling is manifested in the disconnection between communication (revealing large amount of ESG data and hence signalling corporate social responsibility) and corporate action (poor sustainability performance).

The authors measure the amount of ESG data disclosed by a firm using the Bloomberg ESG disclosure score. The Bloomberg ESG disclosure score assesses raw data from company-produced materials. The

Table 3

Typology of the decoupling measures.

		Substantive action / corporate performance					
		Content analysis		Rating-based		Environmental measure	
		Annual report	ESG news in media	Policy implementation based on selected ESG data points	ESG performance score	Greenhouse gas emission (A); Green investments, patents (B); Environmental violations, penalty (C); Green skill hire (D); Solid waste plan/efficient water usage (E)	
Symbolic action / Corporate communication	Content analysis (official corporate communication)	i) Number or length of reports			Table S7. Bazillier & Vauday (2009)	Table S7. Grewal et al. (2022) (A)	
		ii) Commitments discussed and their detailedness	Table S7. Walker & Wan (2012); Li et al. (2019); Li et al. (2023a)			Table S7. Tashman et al. (2019)	Table S7. Du et al. (2018) (B, C)
		iii) Commitments discussed and their measurability	Table S7. Khalil & O'sullivan (2017); Zhang et al. (2022f); Wang et al. (2023); Xu et al. (2023); Zhang et al. (2023b); Zhang et al. (2023g); Zhang et al. (2023h)			Table S7. Zahid et al. (2023)	Table S7. Gigante et al. (2023) (B); Li et al. (2023b) (B)
		iv) ESG focus (word frequency) and tone of the report				Table S7. Ruiz-Blanco et al. (2021); Breuer & Hass (2022); Andrikogiannopoulou et al. (2023); Attig et al. (2023); Kim et al. (2023); Lee & Raschke (2023)	Table S7. Grewal et al. (2022) (A); Hu et al. (2023a) (C); Li et al. (2023c) (B); Tang et al. (2023) (B); Zhou & Wang (2024) (B)
	Rating-based	Policy/ commitment based on selected ESG data points		Table S6A Barrymore (2022)	Table S6A. Roulet & Toubol (2015); Hawn & Ioannou (2016); Testa et al. (2017); Gull et al. (2023a); Ioannou et al. (2023); Kassins et al. (2023); Hussain et al. (2023); Pope et al. (2023); Yao et al. (2023)		
		Disclosure score				Table S5. (ESG disclosure) Yu et al. (2020) and 29 additional studies use the same methodology. Table S6B. Gull et al. (2024)	Table S8A. (carbon disclosure) Mateo-Márquez et al. (2022) (A); Frendy et al. (2023) (A)
		ESG performance score				Table S6B. Ghitti et al. (2023)	Table S6B. Darendeli et al (2022) (D); Ghitti et al. (2023) (C)
	Other	Self-claimed emission (1); Green bond issuance (2); ESG-news disclosed by the firm (3); Expected performance (4); Certifications (5)	Table S8B. Du et al. (2021) (4)	Table S8B. Capelle-Blancard & Petit (2019) (3)			Table S8A. Kim & Lyon (2015) (1A); Leung et al. (2023) (2A) Table S8B. Henao-Rodríguez et al. (2024) (5E)

Note: Additional information about the studies can be found in the supplementary tables referenced in each cell.

Bloomberg ESG disclosure score reflects the quantity of ESG data firms disclose to the public, irrespective of whether it reflects a favourable or negative ESG performance. Yu et al. (2020) measure the ESG performance of firms using the Asset4 ESG score published by Thomson Reuters.² The raw data (more than 400 data points) are summed up into 70 key performance indicators which are then combined into ten category scores. These ten category scores form the subcomponents of the three pillars: environmental, social, and corporate governance pillars (Thomson Reuters, 2017). To calculate the overall ESG score, weights specific to each industry are assigned to each category.

To assure a meaningful comparison between the disclosure and the performance scores, Yu et al. (2020) re-weight the performance scores using the weighting scheme of the disclosure scores. Then, the authors divide both scores by 100, and standardize them to the same scale by subtracting the sample mean and dividing it by the sample standard deviation. The authors then define the company's peer-relative greenwashing score as the ratio of the firm's standardized ESG disclosure and its standardized ESG performance scores. Formally:

$$GW_i = \frac{D_i - \bar{D}}{\sigma_D} - \frac{P_i - \bar{P}}{\sigma_P} \tag{7}$$

where D_i is the Bloomberg ESG disclosure score and P_i is the re-weighted Asset4 ESG performance score. \bar{D} and \bar{P} are the sample averages of the two indicators, while σ_D and σ_P are the corresponding standard deviations.

The authors label this measure as a peer-relative measure. The peer group is the whole sample. As the peer-relative greenwashing scores were highly industry-dependent, when using them in the regressions, the authors have also adjusted for the industry by subtracting the average greenwashing score of the sector to which the company belongs (Yu et al., 2020). Hence, the final greenwashing measure can be formally written as follows:

$$GW_{ij} = \frac{D_i - \bar{D}}{\sigma_D} - \frac{P_i - \bar{P}}{\sigma_P} - \overline{GW}_j \tag{8}$$

where \overline{GW}_j stands for the average of the greenwashing indicators in industry j .

The authors argue that their measure captures the magnitude of a firm's greenwashing behaviour in ESG matters. In particular, when a firm discloses more ESG information than its peers while at the same time its ESG performance is lower compared to its peers, the greenwashing score is positive, implying that the company is involved in greenwashing (Yu et al., 2020). The company might simply obscure its poor ESG performance by revealing large amount of ESG data.

The greenwashing score developed by Yu et al. (2020) has been used in 30 studies as of January 2024. Supplementary Material, Table S5 provides an overview of these studies. Studies use either the Bloomberg ESG disclosure score ($n = 27$) or the Bloomberg Environmental disclosure score ($n = 3$) when assessing the amount of information disclosed. The ESG performance is assessed through ratings granted by various rating agencies, including Asset4 ($n = 10$), Huazheng ($n = 9$), Thomson Reuters ($n = 5$), Wind ($n = 4$), and Refinitiv ($n = 2$). In most cases, the disclosure and performance scores are standardized by the mean and standard deviation of the sample ($n = 26$). In two cases, this standardization is done for each industry separately by the industry mean and standard deviation ($n = 2$), while in two cases no standardization is performed ($n = 2$). Yu et al. (2020) re-weight the performance scores using the weighting scheme for the disclosure scores in order to assure a meaningful comparison. This re-weighting is mentioned (and most probably applied) in only six studies (Supplementary Material, Table S5). When using the standardized peer-relative greenwashing

score in the regressions, Yu et al. (2020) have adjusted for the industry by subtracting the average greenwashing score of the sector to which the company belongs. Only two latter studies employ this adjustment. Instead of this industry-adjustment, the authors typically add industry dummies or industry-fixed effects to the regressions ($n = 22$).

The greenwashing measure of Yu et al. (2020) has several limitations. First, Yu et al. (2020) re-weight the performance scores using the same weighting scheme as for the disclosure scores. In our view, it would have been methodologically more appropriate to re-weight the disclosure scores using the same industry-specific weights as those applied to the Asset4 performance scores. Particular performance metrics, and hence communication about them, are more important in certain industries. The methodology of the Asset4 score considers this industry specificities when calculating the category weights for each industry, and hence these weights should have been kept and used for re-weighting the disclosure scores. Please note that in later studies this re-weighting is commonly not done; it is performed in only 6 out of the 30 studies (Supplementary Material, Table S5). In this way, as outlined by Yu et al. (2020), the comparison becomes less meaningful; the weights of the indicators used to calculate the disclosure and performance scores do not align.

Second, after re-weighting the performance scores, Yu et al. (2020) divide both scores by 100. This re-scaling is unnecessary; it does not change the fundamental relationships between the variables, the greenwashing measure in Equation (7) remains the same.

Third, Yu et al. (2020) label their measure as a peer-relative measure and standardize the disclosure and the performance scores with the sample mean and standard deviation. In this way, in their study, the peer group is the entire sample which includes companies from different industries. Standardizing the disclosure and the performance scores is necessary as these two quantities must be scaled in the same way when calculating their difference. However, this standardization should be performed at an industry-level. Without industry-level standardization, the greenwashing measure in Equation (7) cannot be regarded as "peer-relative" in the conventional sense of the term, see the next paragraph.

Fourth, as disclosure practices and ESG performance vary from industry to industry, it is inappropriate to standardize the disclosure and performance scores by the sample mean and standard deviation. The ESG performance score granted by reputable rating agencies (e.g., Bloomberg, Refinitiv) reflect several industry-specific aspects when selecting the relevant indicators for each industry and setting the weights for various categories (Bloomberg, 2023; Refinitiv, 2022). When Refinitiv claims that they let the data determine industry-based relative performance, it means that the selected indicators and the weights of the category scores are industry-specific, the latter showing the relative importance of each theme in each industry group (Refinitiv, 2022). In fact, the average ESG performance score shows high variability across industries. As a result, when standardizing the disclosure and performance scores, this standardization shall be performed for each industry group separately, akin to the recent studies of Di and Li (2023) and Li and Zheng (2024). It is worth noting that if industry fixed effects with clustered standard errors are included in the regressions, prior standardization of the variables is not necessary.

Fifth, Yu et al. (2020) subtracted the industry mean from the already standardized disclosure and performance scores when adding the greenwashing variable to the regressions, see Equation (8). This kind of transformation is done only in one later study (Erol & Çankaya, 2023). If the disclosure and performance scores had been standardized separately for each industry group, this transformation would be unnecessary. Moreover, this standardization is also unnecessary if industry dummies, or industry fixed effects with clustered standard errors are included in the regressions.

Sixth, the divergence in ESG ratings across various agencies is a well-documented issue, with differences arising from variations in methodologies such as measurement divergence (agencies using different

² Asset4 rating was acquired first by Thomson Reuters and then by Refinitiv.

indicators for the same attribute), scope divergence (agencies focusing on different sets of attributes), and weight divergence (agencies assigning varying importance to each attribute) (Berg et al., 2022). While this divergence cannot be fully resolved without a standardized framework for ESG performance, it can be mitigated by employing ratings from multiple agencies in robustness checks. However, a significant challenge remains in the inherent subjectivity of ESG performance assessments. Non-financial performance evaluations are influenced by subjective judgments, contributing to the observed divergences in ratings between various providers (e.g., ASSET4, MSCI, and Sustainalytics).

3.4.2. Greenwashing measures based on selected ESG data points ($n = 10$) or ESG ratings ($n = 4$)

Although decoupling might take several forms, one common characteristic is the disconnection between symbolic and substantive corporate behaviour. Supplementary Material, Table S6 (Panel A) reviews studies which categorize several ESG data points either as symbolic or substantive. In all studies ($n = 10$), the authors relied on various data points from Asset4 ratings. These data points are the individual metrics used to develop the firms' overall ESG scores, which are unavailable from other ESG rating agencies. A notable measure in the field is the one developed by [Hawn and Ioannou \(2016\)](#), which categorizes Thomson Reuters (Asset 4) data points into external or internal actions. This carefully developed classification, as argued by [Hawn and Ioannou \(2016\)](#), ensures high inter-coder reliability, Cronbach's alpha, and validity. While their absolute gap measure cannot be considered a greenwashing measure, their alternative real gap measure, which calculates the actual difference between external and internal actions relative to (the logarithm of) the asset size, can be seen as a greenwashing measure. Specifically, the authors argue that firms engaging in relatively more external actions but insufficient internal actions are more likely to be identified as greenwashers. In five studies ([Roulet & Touboul, 2015](#); [Gull et al., 2023a](#); [Ioannou et al., 2023](#); [Hussain et al., 2023](#); [Pope et al., 2023](#)), the methodology developed by [Hawn and Ioannou \(2016\)](#) is used to categorize Thomson Reuters (Asset 4) data points into external or internal actions. The selected data points for measuring greenwashing exhibit wide variability. Some authors focus on data points from very specific areas such as product innovation and product responsibility ([Ioannou et al., 2023](#); [Kassinis et al., 2022](#)), while others have a more general and wider coverage ([Roulet & Touboul, 2015](#); [Hawn & Ioannou, 2016](#); [Testa et al., 2018](#); [Barrymore, 2022](#); [Gull et al., 2023a](#); [Hussain et al., 2023](#); [Pope et al., 2023](#); [Yao et al., 2024](#)). The number of data points scored ranges from 11 ([Ioannou et al., 2023](#)) to 67 ([Barrymore, 2022](#)). In most cases ($n = 9$), the authors used selected ESG data points for measuring both symbolic and substantive corporate actions. In one study, the author assessed what the firm actually does in ESG domains using the sentiment of ESG-related news ([Barrymore, 2022](#)).

The advantage of this method lies in its standardized nature; it uses data points provided by a rating agency. The disadvantage of this method is that the differentiation between symbolic and substantive corporate actions might not be straightforward. For example, [Roulet and Touboul \(2015\)](#) consider community, human rights, diversity and opportunity, training and development, board structure, vision, and strategy as substantive actions. Nevertheless, all these concepts might include symbolic actions; measures to improve the ESG rating without improvements in actual sustainability performance. In addition, in some cases, the authors only provide hints about the Asset4 data points they consider symbolic or substantive, but do not list them in detail. For example, [Roulet and Touboul \(2015\)](#) list the data points for the substantive action but not for the symbolic actions, while [Barrymore \(2022\)](#) state that there are 67 policies the firms can adopt without naming them precisely. [Yao et al. \(2024\)](#) does not provide any details. Another drawback of this method that there might be several greenwashing incidents which cannot be captured by Asset4 datapoints at all. Finally, the measures of [Ioannou et al. \(2023\)](#) and [Kassinis et al. \(2022\)](#) are of

limited use as they focus exclusively on product policy and implementation.

Supplementary Material, Table S6 (Panel B) provides a summary of the studies measuring symbolic corporate actions with an (ex-ante) ESG rating or with an increase in the ESG rating. As shown in the table, there are four measures in this category. [Darendeli et al. \(2022\)](#) consider an increase in KLD environmental rating as positive corporate communication. The authors argue that firms may strategically improve their environmental rating without a corresponding increase in green human capital investment. If this is the case, firms are likely to engage in greenwashing; their communication is not in line with their action. It is important to note that this greenwashing measure has limited applicability; it can be only used for firms that explicitly invest in green human capital as evidenced in job postings.

Two other greenwashing measures shown in Supplementary Material, Table S6 (Panel B) have been developed by [Ghitti et al. \(2023\)](#). For both measures, [Ghitti et al. \(2023\)](#) use an ex-ante ESG rating as a proxy for communication given that this rating reflects the environmental commitment the company makes and communicates. The authors consider Refinitiv as an ex-ante oriented rating system; Refinitiv has the companies' environmental commitments in the focus rather than their actual performance.

In case of the first greenwashing measure developed by [Ghitti et al. \(2023\)](#), the authors use information about violations of environmental regulations as an environmental performance measure: their existence, number of violations, and fine amounts. [Ghitti et al. \(2023\)](#) argue that a company engages in greenwashing if it has a high ESG rating relative to its peers, while simultaneously facing more environmental violations than its peers. The authors develop three greenwashing definitions. According to the first definition, a firm is involved in greenwashing if its Refinitiv ESG controversies score is above the industry-year median while the firm was sanctioned for at least one environmental violation in that year. According to the second definition, a firm is involved in greenwashing if its Refinitiv ESG controversies score and the number of its registered environmental violations are both above the industry-year median. According to the third definition, a firm is involved in greenwashing if its Refinitiv ESG controversies score and the total amount of fines are both above the industry-year median. The major problem with this approach is that the authors use the Refinitiv ESG controversies score as a proxy for communicating commitments (ex-ante oriented rating). However, the ESG controversies score is a backward-looking measure; it is based on corporate scandals already reported in the media.

In case of the second greenwashing measure developed by [Ghitti et al. \(2023\)](#), the authors define an ESG-rating related greenwashing measure without using data on environmental violations. This greenwashing measure captures the difference between ex-ante inclined ESG ratings and ex-post oriented, externally validated ESG ratings. The former metric captures commitments and hence symbolic actions, while the latter reflects actual corporate performance. The underlying assumption is that the greater the disparity between the ex-ante and ex-post ratings, the more pronounced the greenwashing activity. The authors consider Refinitiv as an ex-ante oriented rating. The Newsweek Sustainability Rankings is considered as an ex-post rating; it measures whether firms are operating in line with particular sustainability goals. The differences between the ex-ante and ex-post ratings are captured in two ways: *i*) the difference between Refinitiv ESG controversies score and Newsweek Green score (NWG); *ii*) the difference between the raw ESG score (ex-ante, the one without the controversies) and the ESG combined score (ex-post, the one encompassing the controversies). The problem with approach *i*) is that the Refinitiv ESG controversies score is not an ex-ante measure; it is a backward-looking construct based on media scandals. The problem with approach *ii*) is that the ESG combined score does not only capture corporate performance (as reflected in the controversies published by the media) but it also reflects what the company communicates (ex-ante inclined ESG rating).

[Gull et al. \(2024\)](#) introduced a fourth greenwashing measure, termed

environmental decoupling. This measure quantifies the difference between Bloomberg's current environmental disclosure score and Asset4's lagged environmental performance score, divided by the logarithm of total assets. Notably, Gull et al. (2023a) employs the same measure as an alternative for CSR decoupling. The measure of Gull et al. (2024) uses the same input data as the greenwashing score of Yu et al. (2020). However, unlike Yu et al. (2020), the authors do not normalize the disclosure and performance scores before calculating their difference. Instead, they scale the variable by the logarithm of total assets, similar to the approach of Hawn and Ioannou (2016).

It is important to mention that several CSR decoupling measures could serve as a foundation for defining future greenwashing measures. For instance, the CSR decoupling measure used by Gull et al. (2023b, 2023c) and Qureshi et al. (2024) could be applied to quantify greenwashing. These approaches rely on the categorization and real gap measure developed by Hawn and Ioannou (2016), without adjusting for the absolute value of the difference. Please note that in our systematic review, we do not classify these CSR decoupling measures as greenwashing indicators, as the authors themselves do not explicitly refer to their measure as such.

3.4.3. Greenwashing measures based on content analysis (n = 27)

A highly popular approach to measuring greenwashing is based on content analysis; researchers contrast the corporate practice of exaggerating the firm's environmental sustainability with the actual implementation of environmentally friendly practices. Corporate communication is the key channel for exaggerating and misleadingly prompting environmental sustainability. Firms typically communicate their commitments and environmental and social policies in official corporate releases, such as annual reports, sustainability reports, and corporate websites. To measure symbolic action as reflected in corporate communication, researchers analyse the content of corporate releases and identify key themes and the overall emphasis on environmental sustainability. Symbolic action (corporate communication) is then contrasted with substantive action—the actual environmental performance of the firm as reflected in tangible outcomes. This involves evaluating the company's activities, initiatives, and achievements in sustainable and socially responsible operation.

Supplementary Material, Table S7 provides a summary of the studies employing content analysis. To evaluate exaggeration and the creation of a more positive corporate image, researchers search for specific elements in official corporate communications. They employ one of the three approaches outlined below.

Evaluating stated commitments and policies to environmental practices within the company (n = 7). Stated commitments and policies are examined in the following ways: *i)* counting the number of corporate reports (Bazillier & Vauday, 2009); *ii)* measuring the length of corporate reports (Bazillier & Vauday, 2009; Grewal et al., 2022); *iii)* identifying sustainability themes and then measuring the extent to which a firm discusses its commitment in official corporate releases. This measurement typically involves scoring various items by two independent researchers (Walker & Wan, 2012; Du et al., 2018; Li et al., 2019, 2023b; Tashman et al., 2019).

Identifying whether the official corporate releases include measurable metrics and targets for environmental performance (n = 11). This includes the following techniques: *i)* calculating the proportion of sentences with monetary and numerical values (Ruiz-Blanco et al., 2022); *ii)* measuring specificity and accountability of corporate communication (Gigante et al., 2023); *iii)* measuring the extent to which a firm discusses its environmental commitment and self-compliment without any proof (Khalil & O'sullivan, 2017; Zhang et al., 2022f; Li et al., 2023a; Wang et al., 2023; Xu et al., 2023; Zahid et al., 2023; Zhang et al., 2023b; Zhang et al., 2023g; Zhang et al., 2023h). Authors typically score various sustainability disclosure items on a binary scale: no disclosure or text qualitative description is considered as a symbolic corporate action.

Assessing the language and the tone of official corporate releases (n =

10). Authors following this approach typically analyse the use of positive and impactful language related to sustainability goals and commitments, and apply the following techniques: *i)* specificity of the language captured by the proportion of sustainability words (Beuer and Hass, 2022; Grewal et al., 2022; Andrikogiannopoulou et al., 2022; Hu et al., 2023; Kim et al., 2023; Lee & Raschke, 2023; Li et al., 2023c; Tang et al., 2023; Zhou & Wang, 2024) or ESG-related bigrams defined as two consecutive ESG-related words (Attig & Boshanna, 2023); *ii)* tone of the reports involving sentiment analysis (Andrikogiannopoulou et al., 2022; Grewal et al., 2022); *iii)* positioning, readability, and uniqueness of corporate communication (Andrikogiannopoulou et al., 2022).

Decoupling refers to the gap between commitments to sustainability and actual corporate practices. Hence, in addition to stated commitments and policies, researchers need to measure the actual sustainability practices of corporations as well. Authors measured the actual corporate performance by employing one of the four approaches outlined below.

Carefully selected or constructed performance metrics (n=5). One study uses the total carbon emission as an environmental performance metric (Grewal et al., 2022). Four studies rely on content analysis and develop a performance metric by scoring the environmental actions the company has taken to protect the environment (Walker & Wan, 2012; Li et al., 2019, 2023a; Zhang et al., 2022f; Li et al., 2023a). The number of actions scored ranges from 8 (Li et al., 2019) to 19 (Zhang et al., 2022f). Two study use a 7-point scale (Walker & Wan, 2012; Li et al., 2023a), one employs a binary scale (Zhang et al., 2022f), while one uses both scales (Li et al., 2019).

ESG ratings provided by rating agencies (n = 9). Eight studies used ratings from a particular rating agency: Bloomberg (Ruiz-Blanco et al., 2022), HEXUN-RKS (Zahid et al., 2023), KLD (Attig & Boshanna, 2023), Korea Institute of Corporate Governance and Sustainability, KCGS (Kim et al., 2023); MSCI (Tashman et al., 2019), Refinitiv/Thomson Reuters (Beuer & Hass, 2022—own calculation based on 750 data points; Lee & Raschke, 2023), and Vigeo (Bazillier & Vauday, 2009). One study used ESG rating from four rating providers (Andrikogiannopoulou et al., 2022).

Quantitative description of various sustainability items (n=6). Several authors argue that firms using quantitative descriptions in their environmental reports have undertaken substantive environmental actions (Khalil & O'sullivan, 2017; Wang et al., 2023; Xu et al., 2023; Zhang et al., 2023b; Zhang et al., 2023g; Zhang et al., 2023h). The number of corporate environmental actions assessed by content analysis ranges from 8 (Wang et al., 2023) to 25 (Zhang et al., 2023h). All authors employed a binary scale (0-no, 1-yes). In four studies, the authors assigned a score of 1, if the description of the sustainability action was detailed, quantitative, it included data, number or verifiable claim (Khalil & O'sullivan, 2017; Wang et al., 2023; Xu et al., 2023; Zhang et al., 2023h). In two studies, the authors assigned a score of 1, if a digital quantitative description or certificate proof was included in the reports.

Investments in sustainability (n=7). Seven studies assessed investments made in sustainable technologies, renewable energy, and other environmentally friendly practices. The authors extracted information on investments (or lack of it) from databases (Hu et al., 2023; Li et al., 2023b, 2023c), annual reports (Tang et al., 2023; Zhou & Wang, 2024) or they developed a measure by scoring various environmental spending related items, including fines (Du et al., 2018). In one study, the authors developed a measure applicable only to banks by assessing annual fossil fuel finance (Gigante et al., 2023).

As a next step, researchers evaluated greenwashing by contrasting the corporate communication about the firm's environmental sustainability with the actual environmental performance. In most cases (n = 14), the authors took the difference between the constructs of symbolic and substantive actions (Walker & Wan, 2012; Li et al., 2019; Tashman et al., 2019; Ruiz-Blanco et al., 2022; Breuer and Hass, 2022; Zahid et al., 2023; Zhang et al., 2022f; Attig & Boshanna, 2023; Gigante et al., 2023; Kim et al., 2023; Li et al., 2023a; Li et al., 2023b; Tang et al., 2023;

Zhang et al., 2023h). In some cases ($n = 6$), the authors calculated the ratio of the two constructs (Khalil & O’sullivan, 2017; Lee & Raschke, 2023; Wang et al., 2023; Xu et al., 2023; Zhang et al., 2023b; Zhang et al., 2023g). In a few cases ($n = 5$), the authors defined a peer-relative greenwashing measure by assessing whether the respective constructs are higher or lower than the sample mean, median, or particular percentile (Du et al., 2018; Grewal et al., 2022; Andriakogiannopoulou et al., 2022; Hu et al., 2023; Li et al., 2023c). In two cases ($n = 2$), the authors developed a highly specific greenwashing proxy concerning the observed negative association or the word frequency of environmental protection actions (Bazillier & Vauday, 2009; Zhou & Wang, 2024).

Measuring greenwashing through content analysis offers a lot of flexibility and hence it became a popular method. Despite its popularity, this approach has its limitations. In the following, we discuss the drawbacks of the approach when authors assess symbolic corporate actions by scoring various disclosure items based on the information reported in official corporate communications.

First, researchers shall obtain the complete texts of corporate reports by retrieving them one-by-one from the official corporate websites. Second, the assessment of the symbolic component of greenwashing relies on content analysis, a process that demands a considerable amount of time and effort. Each corporate report should be carefully screened; sustainability themes and reporting items should be identified, and then scored. Third, subjective biases may be introduced when researchers score the items. Employing two independent researchers for scoring might mitigate the subjectivity bias and improve the overall reliability of the scoring, a widely adopted practice in the field. Nevertheless, the process of scoring might involve unique consensus in case of scoring disagreement thereby leading to scores that are challenging to replicate if conducted by alternative researchers. Fourth, each scored disclosure item is considered equally relevant to every company across all industry. However, certain disclosure indicators are more pertinent than others in specific industries. Therefore, the number of disclosure indicators relevant to a particular industry should be evaluated separately. Fifth, when quantifying greenwashing, the authors typically take either the difference or the ratio of symbolic and substantive actions without considering the industry. Nevertheless, a company might communicate less information due to the irrelevance of particular disclosure items. As a result, it would be important to understand whether not disclosing (sufficient or quantitative) information about a sustainability item indeed involves deceptive manipulation. Comparing the symbolic actions (disclosure activity) of the firm with their peers might overcome this limitation.

In some recent studies, symbolic corporate action is proxied by the proportion of sustainability words ($n = 7$) (Grewal et al., 2022; Andriakogiannopoulou et al., 2022; Attig et al., 2023; Hu et al., 2023; Lee & Raschke, 2023; Li et al., 2023c; Zhou & Wang, 2024). The drawback of this approach is that a corporate report might discuss certain sustainability topics very lengthy (resulting in high proportion of sustainability words) while masking some other, maybe important, sustainability issues.

3.4.4. Other metrics of decoupling ($n = 7$)

In seven studies, the authors used very specific data for quantifying symbolic and substantive corporate actions. As shown in Supplementary Material, Table S8 (Panel A), in four cases the authors developed a climate change-related greenwashing measure. In one study, the symbolic action of the firm was captured by the self-claimed greenhouse gas emission reduction (Kim & Lyon, 2015), while in two studies the authors proxied it by the amount of information the firm disclosed as part of the Carbon Disclosure Project (CDP), a voluntary disclosure initiative encouraging firms to disclose their environmental impact (Mateo-Márquez et al., 2022; Frendy et al., 2023). Leung et al. (2023) considered the issuance of green bond as a symbolic action; green bond issuers send the signal that they are environmentally responsible. Authors evaluated the firm’s substantive action by its actual environmental

impact, including greenhouse gas emissions and energy consumption. The drawback of this approach lies in its specificity. First, it is only applicable to firms which report their greenhouse gas emission reduction, voluntarily submit environmental data to CDP, or issue green bonds. Second, the actual greenhouse gas emission of the firm needs to be measured which requires specific datasets and complex estimation methods.

Supplementary Material, Table S8 (Panel B) provides a summary of three additional studies measuring the disconnection between symbolic actions and corporate behaviour. Capelle-Blancard and Petit (2019) contrast the number of positive news the firm discloses to the total amount of positive news published about the firm. Du et al. (2021) estimate the firm’s environmental performance using a multivariate regression, with the independent variable derived from content analysis. If the actual performance is worse than the estimated, the difference is called greenwashing. Henaio-Rodríguez et al. (2024) consider holding certifications (e.g., ISO14001, international/regional environmental certifications) as symbolic actions, while the existence of comprehensive solid waste plan and efficient water use and savings program as substantive action. In case of the first study, it is debatable whether the construct actually captures greenwashing; certain companies might be in the media spotlight due to their importance or size, similarly to certain themes (e.g., diversity around the Black Life Matter movement). In case of the second study, it is questionable whether the estimation model is not biased because of omitted variables unrelated to greenwashing. Finally, the third study is only applicable to manufacturing firms with environmental certifications. In addition, the authors consider plans and programs as substantive actions instead of actual corporate performance.

3.5. Specific measures ($n = 19$)

Although greenwashing is a multifaceted phenomenon, selective disclosure and decoupling are the two aspects of greenwashing that are typically captured and operationalized by researchers. At the bottom line, most of the greenwashing measures reviewed in this section are related to selective disclosure or decoupling as well. However, the measures reviewed in this section differ significantly from the previous ones in their operationalization of greenwashing. Authors use either highly specific data, such as assessment by a third party or rating disagreements, or employ a very distinct methods, such as artificial intelligence or multiple-factor modelling.

3.5.1. Being defined as greenwasher by a third party ($n = 5$)

China Greenwashing List ($n = 1$). Since 2009, Southern Weekly, one of China’s most influential and widely circulated newspapers, releases annually the list of greenwashing companies in China. Grounded in decoupling theory, the list “names and shames” companies that have made promises about their environmental responsibilities but did not actually fulfil those responsibilities. The newspaper detects greenwashing among listed companies, China’s Top 500, and Fortune Global 500 companies operating within China. Companies are added to the list after considering ten criteria including deliberate concealment, blatant deception, and double standards. In 2022, nine companies appeared on the list, including Tesla, Xinhua Pharmaceutical, China Railway Group, China Shenhua Energy, and H&M (China Development Brief, 2023). Du (2015), in his prominent study in the field, considers a company being involved in greenwashing if the firm was included in China Greenwashing List published in the Southern Weekly. The major problem with China Greenwashing List, as argued by Liao et al. (2023), is that the number of companies published on the list is small and lacks representation.

RepRisk database ($n = 2$). RepRisk is an ESG research provider systematically identifying and assessing material ESG risks. RepRisk screens, on a daily basis, over 100,000 public sources in 23 languages and intentionally excludes company self-disclosures (RepRisk, 2024a).

The incident-based data might include environmental impacts, human rights issues, supply chain management, corruption, legal disputes, and regulatory violations. As stated by RepRisk, artificial intelligence and machine learning empower the size and scale of their dataset, while human intelligence adds depth and relevance (RepRisk, 2024a). At RepRisk, analysts curate and assess each risk incident according to a rules-based methodology. In particular, analysts review and approve the results of the screening process of automated tagging, relevancy scoring, and news analytics resulting from the machine learning predictions. Analysts take into account several circumstances, including the severity of the risk incident, reach of the information source, and novelty of the issue for the company (RepRisk, 2024a).

RepRisk's greenwashing classification methodology captures greenwashing through the intersection of two ESG issues: (1) misleading communication and (2) environmental problems (e.g., local pollution, impacts on ecosystems and biodiversity) (RepRisk, 2024b). Therefore, this measure is grounded in decoupling theory as well. RepRisk argues that their approach captures the straightforward cases of greenwashing (e.g., deceptive labelling) as well as more complex situations (e.g., political misalignment) (RepRisk, 2024b). Greenwashing incidents may include events such as criticism of an advertising campaign that misleads consumers about environmental impacts, reporting on company actions that directly contradict climate commitments, or research findings showing that a company is exaggerating the impact of an initiative (RepRisk, 2024c). Artificial intelligence, advanced machine learning and human intelligence (confirming or correcting machine learning predictions) all play a role in identifying greenwashing incidents.

As of January 24, 2024, two studies relied on the RepRisk database to identify greenwashers. Akyildirim et al. (2023) relied on the greenwashing classification methodology developed by RepRisk. The authors extracted 15,039 misleading communication events from RepRisk database for the period of 2010–2021. Of these events, 9952 were determined to be environmentally based, and hence aligned with the greenwashing definition of RepRisk (i.e., misleading communication on the environment). ESMA (2023) used the incident descriptions and employed two methods: an automatic and a manual identification. The automatic approach involved a string filtering technique, and firms were identified as being involved in a greenwashing controversy when the term “greenwashing” was found within the incident description and flag relevant instances. The manual approach involved manual revision and classification of the incident descriptions by two independent ESMA experts.

Relying on the RepRisk database when identifying greenwashers has its drawbacks. First, the greenwashing classification methodology of RepRisk is very complex and hence less transparent; it involves natural language processing, machine learning, and rule-based expert assessment. Second, RepRisk might miss classifying certain events as greenwashing, especially when a broader definition of greenwashing is used. In particular, when ESMA (2023) employed the manual identification method, it resulted in a much larger number of greenwashing controversies (630) than the text-based search (257). Third, RepRisk is fully financed by data subscription fees from clients and partners, and it is only available through Wharton Research Data Services. It is important to note that in spite of these drawbacks, the greenwashing identification strategy of RepRisk is a highly valuable and reliable measures given the carefully developed models and expert knowledge.

Refinitiv's responsible marketing policy variable (n = 2). Two studies use the responsible marketing policy variable as a proxy for the lack of greenwashing. (Fiechter et al., 2022; Hussain et al., 2023). The authors argue that misleading advertising is a very important aspect of greenwashing, whereas establishing a responsible advertising signals the firm's commitment to avoid greenwashing. The lack of responsible marketing policy and hence potentially misleading advertising is also connected to decoupling theory; there is inconsistency between the company's advertisements and actions. The responsible marketing policy variable is readily available from Refinitiv, and the authors use it as a

dummy variable showing whether the firm claims to have or mentions processes in place to maintain responsible marketing practices. The major drawback of this measure is its narrow focus on marketing policies. In addition, it captures only whether the firm has responsible marketing policies but does not assess its credibility and the actions taken. Firms might claim to have responsible marketing policy without actually implementing it.

3.5.2. ESG controversies and rating disagreements (n = 4)

In some recent works, the authors define a greenwashing measure based on an ESG-related construct. These constructs are very diverse and include the number of ESG controversies, the ESG controversies score, and the disagreement in ratings granted by various rating agencies. Although the measures reviewed in this subsection are also connected to decoupling theory, the authors do not define separate measures for symbolic and substantive corporate actions.

Fiechter et al. (2022) use the number of controversies published in the media linked to the firm's marketing practices as a proxy for greenwashing; a variable available from Refinitiv. In a robustness check, Hussain et al. (2023) use the same proxy for greenwashing. The authors argue that misleading marketing is a very important aspect of greenwashing, whereas establishing a responsible marketing policy signals the firm's commitment to avoid greenwashing. The major drawback of this greenwashing measure lies in its limited focus; it captures only one out of the 23 controversies assessed by Refinitiv (2022). In addition, greenwashing and controversies represent distinct phenomena within the realm of corporate behaviour and public perception as discussed in the next paragraph.

Nguyen et al. (2022) use the ESG controversies score from Refinitiv as a proxy for the level of greenwashing. The authors argue that the ESG controversies score captures a company's actions against commitments as reflected in the media sources. In essence, controversies imply that the firm's actions diverged from its communication, thus it can be regarded as a measure of decoupling. The higher the controversies score, the less controversies are published in relation to the firm, hence the lower the level of greenwashing. As a result, the authors employ the inverse of the controversies score as a proxy for greenwashing. The major drawback of this measure is equating controversies with greenwashing. Greenwashing refers to the deceptive practice employed by organizations to create a false or exaggerated perception of responsible and sustainable practices or commitments, often aimed at portraying a positive environmental image without substantial evidence or efforts. In contrast, controversies typically involve issues that generate public disagreement, criticism, or dispute, encompassing a broad spectrum of ethical, social, or legal concerns. Controversies can arise from various aspects of a company's operations. For example, Refinitiv (2022) defines 23 controversies topics, some of which can be linked to the broader definition of greenwashing (e.g., child labour, human rights, consumer, responsible marketing, environment, public health, employee safety), while others cannot (e.g., anti-competition, intellectual property, management compensation, accounting, insider dealings, shareholder rights, privacy).

The greenwashing measure of Ghitti et al. (2023) is based on ESG rating disagreement. Given the divergence of the ESG ratings, it is hard for investors to reliably assess the firm's ESG profile. Ghitti et al. (2023) postulate that the higher the rating disagreement, the higher the uncertainty about the firm's ESG performance, and hence the higher the probability of greenwashing. The underlying assumption is that the higher the ESG rating divergence, the lower the consensus on the company's environmental behaviour and thus higher the propensity to greenwash. The authors assess the differences in ESG ratings across three rating providers: Newsweek Green score, Refinitiv, and S&P. In brief, the authors compute pairwise rating uncertainty from the percentile rank of the firm's rating. The major drawback of this measure is that the ESG ratings granted by various rating agencies diverge mostly due to the lack of consensus on the scope and measurement of ESG performance

(Berg et al., 2022). In our view, equating the ESG rating disagreement resulting from the distinct coverage (scope) and different performance indicators (measurement) with greenwashing might be misleading. However, it is a testable hypothesis and therefore needs to be tested; currently, the supporting evidence is scarce.

3.5.3. Natural language processing (n = 6)

Moodaley and Telukdarie (2023) show that the number of studies using artificial intelligence to detect greenwashing is limited, yet increasing. In our systematic review, we identified six studies employing artificial intelligence, specifically natural language processing, to detect greenwashing. Supplementary Material, Table S9 provides an overview of these studies.

Similar to other methods, this measurement also has its limitations. First, this method is highly resource intensive in terms of data collection, modelling, and data analysis. Second, it is hard (if not impossible) to reproduce the greenwashing measurement reported in these studies due to the complex modelling, the usage of specific libraries and language processing software, and the expert input provided during the training phase of the machine learning algorithm. Third, human intelligence cannot be fully replaced by artificial intelligence; confirming and correcting the machine-predicted classifications are inevitable for reliable greenwashing measurement; a method followed by RepRisk. Fourth, the results might be sensitive to data source selection (corporate disclosure vs social media appearance). Fifth, the results might be sensitive to the keyword selection method or library used, and how the selected aspect of greenwashing is measured (e.g., commitment, exaggeration, specificity). Sixth, the greenwashing definitions used by some authors are debatable. For example, it is unclear why the textual similarity of the company's ESG report with other ESG reports should reflect greenwashing (Yu et al., 2023). Similarly, it is questionable why the dissimilarity of the sentiment scores of company disclosures versus company-related Twitter contents would capture greenwashing (Zhao et al., 2023).

3.5.4. Other (n = 4)

Four studies used a greenwashing metric which is very different from the ones outlined above.

Criteria-based greenwashing measure (n = 1). In one study, the authors analysed advertisements, CSR reports and corporate websites, and assessed greenwashing by scoring five items on a 5-point scale (Aggarwal & Kadyan, 2014). The environmental items scored included the lack of supporting evidence, use of vague words or images, false eco labels, hidden trade-off, and irrelevant claims. The items carried an ad hoc weight set by the authors. A company was labelled as greenwasher if its weighted average score was above the ad hoc threshold of 3. This measure captures both the selective disclosure and the decoupling aspects of greenwashing but has several limitations. First, it encompasses all the limitations listed for greenwashing measures based on content analysis. Second, the authors assign ad hoc weights to the five items they assess. Third, the threshold for defining greenwashers is also ad hoc.

Greenwashing variable derived from structural equation models (n = 2). In two studies, the authors captured greenwashing as a latent variable (Makrenko et al., 2023; Pimonenko et al., 2020). The authors argue that greenwashing is an abstract and complex phenomenon which are affected by several observable factors. Pimonenko et al. (2020) determined five, while Makrenko et al. (2023) eight observable indicators, and used content analysis to measure these indicators. In the former study, observable indicators were the following: existence of a CSR report, correctness and provability of information about green activities, exaggerating green achievements, masking economic goals. In the latter study, the authors scored observable indicators such as detailedness and accessibility of sustainability policy, regularity and comprehensiveness of disclosure, compliance with disclosure requirements, verification and opinion by auditors. Afterwards, the authors run partial least-squares structural equation models to determine the weights of the observable

indicators serving as an input for the latent greenwashing variable. In both studies, the majority of the observable indicators capture the selective disclosure aspect of greenwashing, while a few are based on decoupling theory (e.g., correctness of information about green activities). This measurement technique has several drawbacks. First, it includes all the limitations listed for greenwashing measures based on content analysis. Second, structural equation modelling assumes a linear relationship between the observable factors and the latent greenwashing variable; this linear relationship might not hold in reality.

Selecting a base year with high emissions (n = 1). Cenedese et al. (2023) defined greenwashers as firms deliberately selecting a base year with high carbon emissions for easy target completion. Relying on the CDP database, their greenwashing indicator was defined as follows: (Emissions in base year – Emissions in target setting year)/Emissions in base year divided by the percentage of emissions reduction over the target horizon. The base year is the year from which the emission data is taken and to which the reduction is compared; while the target setting year is the year when the emission reduction target was initially set as reported by CDP. The drawback of this greenwashing indicator is its applicability limited to firms that voluntarily submit target emission data to CDP. Moreover, it also considers eminent companies as greenwashers—companies taking serious actions to reduce their carbon footprint.

4. Discussion and limitations

4.1. Scope and coverage

While there are several systematic reviews focusing on the definitions, concepts, and drivers of greenwashing (Delmas & Burbano, 2011; de Freitas Netto et al., 2020; Gatti et al., 2019; Yang et al., 2020), to our knowledge, our study is the first to review and classify quantitative approaches for measuring greenwashing. In this systematic methodological review, we identified 111 studies in which scholars developed or adopted firm-level greenwashing measures. For comparison, the recent systematic review by Bernini et al. (2024) identified 52 studies in which a greenwashing measure was developed or employed. From these, 38 studies investigated subjective perceptions to measure greenwashing, typically by assessing the perceptions of consumers or customers. In our systematic review, studies measuring perceptions, and hence involving primary data collection (surveys, observations, experiments, and interviews) were not eligible for inclusion. At the end, Bernini et al. (2024) reviewed only 14 studies in which a greenwashing measure was calculated or employed, of which four did not meet our eligibility criteria, mainly because they lacked an explicit greenwashing measure. However, it is important to note that out of the 111 studies reviewed here, 61 were published after 2022, falling beyond the scope of assessment by Bernini et al. (2024). Overall, our systematic review encompasses a substantial number of studies in which researchers developed or adopted firm-level greenwashing measures, representing the largest pool of research to date. The high number of recently published studies in the field signals that, in addition to conceptualizing greenwashing, lately there has been significant advancement in its operationalization.

In terms of geographic coverage, nearly half of the reviewed studies (n = 52) assessed and quantified greenwashing among Chinese firms, while 20 studies focused on the US. Several factors might contribute to the prominence of greenwashing research focusing on Chinese firms. First, China has experienced rapid economic growth over the past few decades, leading to increased industrialization and environmental concerns which may have stipulated the interest among researchers to study how Chinese firms navigate environmental regulations and practices, including the phenomenon of greenwashing. Second, China is one of the world's largest producers and exporters of goods across various industries. With its significant global impact, there is considerable attention on the environmental practices of Chinese firms. Third, the Chinese government has implemented several environmental policies and

initiatives in recent years to address pollution and promote sustainability, and researchers studied how these policies influenced corporate behaviour and the prevalence of greenwashing practices.

In the environmental domain, greenwashing is defined as the act or practice of presenting a product, policy, or activity as more environmentally friendly or less environmentally harmful than it really is. In this review, in half of the studies ($n = 56$), researchers adhere to this definition, formulating a greenwashing measure exclusively as an environmental issue. However, in the other half of the studies ($n = 55$) researchers adopt a broader perspective, with greenwashing measures covering environmental, social, and corporate governance dimensions as well. In these studies, greenwashing extends beyond environmental concerns to encompass broader corporate social responsibility or sustainability issues.

We note that amalgamating E, S, and G dimensions is highly problematic for at least two reasons. First, governance has always been part of the traditional financial analysis toolkit, suggesting that classifying it as extra-financial is probably an error. Second, environmental and social concerns can often be in direct conflict (Berg et al., 2022; OECD, 2022b). For example, funding the construction of a new coal plant might be viewed as harmful from an environmental perspective due to pollution concerns. However, from a social perspective, the cheap and reliable electricity produced by such a plant may be highly desirable, highlighting the conflicting nature of ESG dimensions.

4.2. Greenwashing measures and their popularity

In the empirical literature, the greenwashing measures tend to focus on two aspects of the multifaceted phenomenon: selective disclosure and decoupling. As a result, we classified the firm-level greenwashing measurements in three major categories: measures of selective disclosure, measures of decoupling, and specific measures typically employing peculiar data or method while capturing the selective disclosure or decoupling aspect of greenwashing. Both measures of selective disclosure and decoupling compare communication against a benchmark. In case of measures focusing on the selective disclosure aspect of greenwashing, this benchmark is the expected, normal communication within the given industry. For example, in case of the selective disclosure magnitude developed by Marquis et al. (2016), the number of disclosed indicators is compared to a benchmark, which is the weighted average of the indicators. Here, the weights represent the (estimated) environmental costs related to the company's activities. If the former exceeds the latter, greenwashing is present. For example, if a company is a massive CO₂ emitter but does not engage in other forms of pollution, it is considered to greenwash if it mentions a variety of other indicators in its corporate communication (e.g., not contaminating rivers with cyanide) to signal how environmentally friendly the company is. In this case, the company's behaviour deviates from the benchmark, the expected communication. From this perspective, the idea of decoupling also appears in the selective disclosure magnitude variable, however, the measure considers only the aspects of corporate communication. In contrast, measures of decoupling depict the gap between stated values and commitments (communication), and actual corporate practices. But ultimately, these two concepts are similar and interconnected.

Table 4 shows the typology of the greenwashing measures developed in this systematic methodological review. The table also displays the popularity of various greenwashing measurement approaches, utilizing two simple indicators for assessing popularity: the number of studies in which a particular greenwashing measurement approach has been employed and the number of citations for those studies as of March 20, 2024. Overall, the table shows that measures of decoupling have become more popular than the measures capturing the selective disclosure aspect of greenwashing.

When looking at the number of studies, Table 4 reveals that a few measures are becoming more popular than others. The top four greenwashing measures are the following: i) the greenwashing score

developed by Yu et al. (2020) ($n = 30$); ii) greenwashing measures based on content analysis ($n = 27$); iii) greenwashing measures based on selected ESG data points or ESG ratings ($n = 14$); iv) selective disclosure magnitude based on Trucost developed by Marquis et al. (2016) ($n = 11$).

The most widely used greenwashing measure has been developed by Yu et al. (2020), a decoupling measure comparing the Bloomberg ESG disclosure score to the Asset4 ESG score. The popularity of this method can be explained by its reliance on widely used databases; researchers can easily access and retrieve the required data. Moreover, determining the greenwashing measure is a quick and simple process, with the methodology being resource-efficient. At the same time, as outlined in section 3.4.1, this greenwashing measurement approach suffers from several deficiencies (e.g., the lack of appropriate industry adjustments); and the majority of these deficiencies were copied by other researchers.

The second most widely used method for measuring greenwashing involves content analysis. Researchers compare the corporate communication about the firm's environmental sustainability, extracted from corporate releases, with its actual corporate performance. The primary advantage of this method lies in its flexibility and adaptability to researchers' needs, enabling greater depth of the analysis. At the same time, it is a highly resource-intensive method; it involves screening various topics within corporate communications and assigning scores typically by two independent researchers.

The greenwashing measures reliant on selected ESG data points or ESG ratings are also popular. Given the growing popularity of ESG, it is no surprise that these measures have gained significant importance.

The selective disclosure magnitude based on Trucost is also a widely used measure. In our view, this is a highly valuable and reliable measure of selective disclosure thanks to its carefully developed models and expert knowledge as discussed in Section 3.3.1. At the same time, this measure, like all selective disclosure measures, is one-sided by definition; the focus is solely on the communication side while neglecting the environmental outcome. The level of greenwashing remains the same if a firm discloses the same type and amount of environmental information while decreasing the pollutants emitted significantly.

When examining the number of citations received, studies employing the following greenwashing measurement approaches received over 500 citations: i) greenwashing measures based on content analysis ($ref = 1812$); ii) greenwashing measures based on selected ESG data points or ESG ratings ($ref = 996$); iii) the greenwashing score developed by Yu et al. (2020) ($ref = 985$); iv) selective disclosure magnitude based on Trucost developed by Marquis et al. (2016) ($ref = 976$); v) other measures of decoupling ($n = 973$); vi) being defined as a greenwasher by a third party ($ref = 542$). As shown in Supplementary Material, Table S2, Panel E, a few highly cited studies account for most of the citations. For example, when decoupling is assessed through content analysis, three (out of the 27) studies contribute to over 70% of the citations (1282 citations out of 1812).

4.3. Hypothetical vs incident-based measures

Almost all greenwashing measures included in this systematic methodological review are hypothetical; they identify firms which are more likely to be involved in greenwashing. In 111 out of 120 cases, researchers develop measures which suggests possible greenwashing incidents without identifying or assessing particular instances of greenwashing. In nine cases, the authors detect and evaluate actual instances of greenwashing.

Although the measures for identifying actual occurrences of greenwashing are diverse, they can be categorized in three groups. The first group includes measures where the company was identified as greenwasher by a third party ($n = 3$), either by China's Southern Weekly (Du, 2015) or by RepRisk (Akyildirim et al., 2023; ESMA, 2023). These third-party identifications are based on greenwashing incidents discussed in the media.

Table 4
Popularity of the various greenwashing measurement approaches.

Measures of selective disclosure	# studies	# citations	Measures of decoupling	# studies	# citations	Specific measures	# studies	# citations
Selective disclosure magnitude (Marquis et al., 2016)	11	976	Greenwashing score of Yu et al. (2020)	30	985	Being defined as green-washer by a third party	5	542
Selective disclosure & expressive manipulation (Huang et al., 2019)	10	96	Greenwashing measures based on selected ESG data points or ESG ratings	14	996	ESG controversies and rating disagreements	4	10
Other selective disclosure measures	2	45	Greenwashing measures based on content analysis	27	1821	Natural language processing	6	14
			Other decoupling measures	7	973	Other specific measures	4	334
Total for selective disclosure measures	23	1117	Total for decoupling measures	78	4475	Total for specific measures	19	900

The second group includes measures where the actual greenwashing incident is related to environmental violations; laws, regulations, or permits aimed at protecting the environment are violated due to actions or failures to act ($n = 3$). In this group, one measure captures selective disclosure (Xia et al., 2023), while two are based on decoupling theory (Ghitti et al., 2023; Hu et al., 2023). In the study of Xia et al. (2023), a greenwashing incident occurs when the company fails to disclose the environmental penalty it received. In the two other studies, a greenwashing incident occurs if the firm signals its environmental responsibility either through its ESG commitment (Ghitti et al., 2023) or the frequent usage of green or environmental terms in its reports (Hu et al., 2023), despite causing harm to the environment.

The third group comprises measures where the actual greenwashing incident is detected through controversies—incidents, or events linked to corporate activities that garner negative attention or criticism in the media concerning environmental, social, or governance issues ($n = 3$). Two studies focus solely on responsible marketing controversies out of the 23 controversy topics identified by Refintiv, consequently overlooking many important controversies associated with greenwashing (Fiechter et al., 2022; Hussain et al., 2023). In contrast, one study considers all 23 controversy topics, including many controversies which typically cannot be equated with greenwashing (Nguyen et al., 2022).

It is important to note that artificial intelligence might play an increasingly important role in greenwashing detection, thanks to the rapid development of large language models. Large language models are advanced artificial intelligence systems designed to understand and generate human-like text using deep learning techniques. When asked ChatGPT to list ten S&P500 companies that were involved in greenwashing, ChatGPT briefly described ten incidents where companies were engaging in greenwashing practices by selectively promoting their environmentally friendly initiatives while overlooking broader sustainability challenges inherent in their operations.

4.4. Which measure to use?

Detecting and measuring greenwashing is challenging due to its complexity, multifaceted nature, and dynamic qualities. In addition, the deceptive nature of greenwashing hinders direct observations. Essentially, researchers are tasked with unravelling whether companies are signalling their superior commitment and corporate performance by publishing more information or deceiving stakeholders with a favourable yet misleading image. In the empirical literature, researchers typically operationalize either the selective disclosure or the decoupling aspects of greenwashing. In our view, measures of decoupling shall be preferred over measures of selective disclosure. While measures of selective disclosure compare communication against a benchmark (expected communication within the industry), measures of decoupling contrast communication with the actual corporate performance. Hence, the former measures consider only the communication aspect, while the latter assesses the corporate environmental performance as well.

The greenwashing score of Yu et al. (2020), the most popular

measure as of January 2024, contrasts the amount of information disclosed (Bloomberg ESG disclosure score) with the firm’s corporate performance in ESG domains (Asset4 ESG performance score). The popularity of this approach can be attributed to its simplicity and straightforward nature, as well as its utilization of data readily available to researchers. Although the measure identifies firms which are more likely to be involved in greenwashing without detecting greenwashing incidents, we acknowledge its potential. Nevertheless, for identifying companies with higher probability of greenwashing, we find it essential that the company’s communication relative to its peers, is contrasted with the performance relative to peers, with the reference group comprising industry peers rather than the entire sample. Both the communication and the performance indicators shall be standardized for each industry separately, similar to Di and Li (2023) and Li and Zheng (2024).

Identifying firms more likely to engage in greenwashing through content analysis may also be a sound and reliable approach, and has its legitimacy in empirical research on greenwashing. Essentially, researchers must measure exaggeration and positive image creation in official corporate releases (annual reports, sustainability reports, and corporate websites) and contrast it with actual environmental performance of the firm as manifested in tangible outcomes. Again, given the industry specificities and regulatory requirements, either companies from the same industry shall be compared, or the measures of symbolic and substantive actions shall be standardized for each industry separately by the industry mean and standard deviation. However, as discussed in Section 3.4.3, the method is time and resource intensive (retrieving official corporate releases, identifying and scoring sustainability themes, etc.), which hinders its adoption on large samples of companies.

In our view, the incident-based RepRisk database, backed by a robust expert infrastructure, has a huge potential to be employed in future empirical research on greenwashing. The RepRisk database includes over 15 thousand misleading communication events for the period of 2010–2021; more than 1250 events per year on average. These are actual incidents detected by artificial intelligence and machine learning algorithms, and validated by experts (Akyildirim et al., 2023). Around two third of the incidents are environmental, while the remaining ones occurred in social or governance domains (Akyildirim et al., 2023). However, it is worth noting that RepRisk’s greenwashing classification methodology is very complex and hence rather opaque, and it is only available through Wharton Research Data Services.

In addition to the RepRisk database, measures based on actual greenwashing incidents are also promising. This approach constitutes a new branch of research, with the initial studies only just being published. One line of research defines greenwashing incidents as situations where the firm’s communication is excessively positive despite causing harm to the environment, as evidenced by environmental violations extracted from official databases (Ghitti et al., 2023; Hu et al., 2023). Another line of research suggests detecting actual greenwashing incidents through controversies; corporate activities that received

criticism or negative attention in the media (e.g., Fiechter et al., 2022; Hussain et al., 2023; Nguyen et al., 2022). The advantage of this latter method is that controversies are assessed and evaluated by ESG rating agencies, allowing researchers to utilize this readily available information. However, before its adoption in empirical research on greenwashing, researchers must come to a consensus on which controversy topics actually capture greenwashing.

4.5. Limitations

This systematic literature review has its limitations. Firstly, we focused solely on firm-level greenwashing measurement approaches which are scalable across a broad sample of firms. By research design, we excluded product-level measurement approaches and those capturing perceived greenwashing by surveying customers or other stakeholders. Nevertheless, these approaches are highly valuable as well, and might provide important insights on the multifaceted greenwashing phenomenon. For example, product-level approaches allow for a detailed examination of specific products and their environmental claims, providing a more granular understanding of greenwashing practices. In addition, by focusing on individual products, these approaches might help holding companies directly accountable for the accuracy and credibility of their environmental claims.

Secondly, although we have identified the final search terms after several iterations, we cannot exclude the possibility that we may have missed some keywords and hence some relevant studies.

Thirdly, by research design, we may have included some studies of potentially poor quality. Given that in Google Scholar documents are indexed without expert approval, it includes a much broader range of studies. Some of these studies may have potentially poor quality especially when compared to scientific databases (e.g., Web of Science, Scopus). While acknowledging that systematic literature reviews typically rely on scientific databases, we had to compare the benefits and costs of using Google Scholar. In terms of benefits, Google Scholar allows the inclusion of high-quality working papers and as-yet unpublished manuscripts. This is particularly important in the field of empirical greenwashing research, where their number is quite substantial. Inclusion of studies of potentially poor quality signifies the cost of using Google Scholar. To decrease the cost, we included non-peer reviewed working papers published by scholars while excluded BSc and MA theses. Overall, after careful considerations we concluded that the benefits of using Google Scholar outweighed its cost.

5. Conclusions

Greenwashing entails complexity, multifaceted characteristics, and dynamic aspects that extend across multiple disciplines and dimensions. Identifying and quantifying greenwashing is an extremely challenging task as the deceptive nature of greenwashing hinders direct observations. In this systematic methodological review, we provided an overview, a typology, and a critical analysis of firm-level greenwashing measures used in the empirical literature. We described each measure in detail, showed the data scholars use, and discussed the drawbacks of the measures.

We documented that the greenwashing measures tend to focus on two aspects of the multifaceted phenomenon: selective disclosure and decoupling. At present, measures of decoupling have become dominant in the literature; these measures capture the gap between stated values and actual corporate practices. The most widely used greenwashing measure has been developed by Yu et al. (2020) which contrasts the Bloomberg ESG disclosure score with the Asset4 ESG performance score. We argued that when employing this measure, both the communication and the performance indicators shall be standardized for each industry separately, instead of the whole sample, as commonly done. We also showed that in the majority of the cases, researchers take a wider perspective, and the greenwashing measure covers environmental,

social, and corporate governance dimensions as well. Additionally, we demonstrated that most greenwashing measures are hypothetical; they suggest possible greenwashing incidents. Finally, we argued that greenwashing measures based on actual incidents are promising, marking the emergence of a new branch of research. With the rapid development of large language models, artificial intelligence might play a more prominent role in detecting greenwashing. The insights from this systematic literature review might serve as an input for selecting or developing the most appropriate greenwashing measure in future empirical research on greenwashing.

CRedit authorship contribution statement

Ágnes Lublóy: Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Judit Lilla Keresztúri:** Visualization, Software, Methodology, Investigation, Formal analysis, Data curation. **Edina Berlinger:** Writing – review & editing, Validation, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvman.2024.123399>.

Data availability

Data will be made available on request.

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