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RESEARCH IN BRIEF

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RESEARCH IN BRIEF

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Abstract: Our study examines the sustainability communication of German stock index-listed (DAX) companies on X (formerly Twitter) and Instagram. We examine the frequency and content of sustainability-related posts and seek to answer two main questions: The frequency and topics of sustainability communication among the 40 DAX companies (RQ1), and any patterns or differences based on their proximity to consumers (RQ2). We analyzed all tweets and Instagram posts of these companies from their inception to November 2022 (N_X = 642,897, $N_{Instagram}$ = 66,867), using a combination of machine learning classifiers to identify sustainability-related content and topic modeling to identify sustainability-related topics. Our findings highlight a significant pent-up demand in the prioritization of sustainability in the public communications of DAX-listed companies on social media.

Keywords: Sustainability communication, social media, topic modeling, supervised machine learning

Zusammenfassung: Die Studie untersucht die Nachhaltigkeitskommunikation von im Deutschen Aktienindex (DAX) gelisteten Unternehmen auf X (ehemals Twitter) und Instagram. Die Studie adressiert dabei explorativ zwei Forschungsfragen: Wie häufig und zu welchen Themen kommunizieren die 40 DAX Unternehmen in ihrer Nachhaltigkeitskommunikation (FF1)? Welche Muster und Unterschiede zeigen sich zwischen Unternehmen mit einer unterschiedlichen Nähe zu den Verbrauchern (FF2)? Um diese Fragen zu beantworten, analysieren wir alle Tweets und Instagram-Posts dieser Unternehmen vom Beginn der Account-Erstellung bis November 2022 (N_X = 642.897, $N_{Instagram}$ = 66.867), wobei wir eine Kombination aus Machine Learning Classifier zur Identifizierung von nachhaltigkeitsbezogenen Inhalten und Topic Modeling zur Identifizierung von Nachhaltigkeitsthemen verwendeten. Unsere Ergebnisse zeigen einen signifikanten Nachholbedarf bei der Priorisierung von Nachhaltigkeit in der öffentlichen Kommunikation auf sozialen Medien der im DAX gelisteten Unternehmen.

Schlagwörter: Nachhaltigkeitskommunikation, soziale Medien, Topic Modeling, Supervised Machine Learning

1. Introduction

We are currently witnessing many climate records being broken year after year, significant increases in ocean heat and sea level rise, as well as continued devastating weather hazards (Kennedy et al., 2024). The prevailing economic trajectories, characterized by relentless growth, are incompatible with the finite resources and delicate balance of our planet, yet financial contributions that directly harm the environment still exceed investments in nature-based solutions by a factor of 30 (United Nations Environment Programme, 2023). Minimizing emissions and limiting global warming require holistic solutions that involve public, political and economic actors. As major contributors to the climate crisis, companies are expected to act accordingly. Addressing sustainability has therefore become standard practice for companies in their internal and external communications (Seele & Lock, 2015).

Going beyond economic responsibility and addressing social and political concerns, such as sustainability efforts, is connected to a company's corporate social responsibility (CSR) (Halkos & Nomikos, 2021; Stohl et al., 2017) and thus CSR and sustainability are not only "closely related", but also "often used interchangeably" (Reilly & Larya, 2018, p. 1). External communication about sustainability can enhance a company's image, reputation, and consumer choices (Parguel et al., 2011, 2015). It can thus be used as a strategic tool for companies to operate socially legitimately. Communicating sustainability efforts is a relevant part of companies' annual CSR reports to improve reputation among external stakeholders (Reilly & Larya, 2018). Beyond these formal reports, companies also rely on other channels to communicate their sustainability agenda, in particular, social media (Etter, 2014). Social media is described as a channel of informal communication, as it is a potentially two-way interactive exchange with consumers and is not moderated or revised by other communicating agents such as journalists (Etter et al., 2018; Lundgaard & Etter, 2023; Reilly & Larya, 2018).

Social media is, therefore, another way for companies to position themselves publicly on issues such as their sustainability agenda, and how they do so is crucial to capturing the public discourse on this relevant and complex topic (Lock et al., 2024). And while previous studies have highlighted the importance of social media as a platform for companies to publicly position themselves on sustainability issues (DiRusso & Myrick, 2021; Lock et al., 2024; Reilly & Larya, 2018), there is limited understanding of how different types of companies strategically communicate their sustainability agendas on different social media channels. The topics discussed and the relevance of sustainability communication may vary depending on a company's proximity to consumers, with high consumer proximity (B2C) industries often relying more heavily on social media to engage key stakeholders than low consumer proximity (B2B) industries (Reilly & Larya, 2018). Despite these initial findings, little research has examined the nuances of sustainability communication across different social media channels and the differences in topics discussed concerning a company's consumer proximity. This study addresses this gap by analyzing the frequency, content, and industry-

specific strategies of sustainability-related posts among German stock index-listed (DAX) companies, shedding light on the different approaches companies take when using social media for sustainability communication.

2. Literature review

Discussions around sustainability have become a common focus for businesses, with sustainability efforts often being used interchangeably with CSR in academic literature (Seele & Lock, 2015) or at least considered a central aspect of CSR (Halkos & Nomikos, 2021; Stohl et al., 2017). It may be necessary to specifically define the discussion of sustainability in the context of a profit-driven business: In for-profit companies, sustainability is often aligned with financial growth, hence understanding environmental sustainability as a manageable long-term goal compatible with financial success (Kemper et al., 2019).

In a comparison of how different actors (i.e., the media, companies and consumers) discuss sustainability, Lock et al. (2024) show that the externally communicated corporate perspective on sustainability appears to be balanced. The analysis of the websites of the 100 biggest Dutch companies reveals that sustainability is discussed holistically as it covers societal, economic and environmental aspects. However, the results also indicate that it is still often used as a buzzword (Lock et al., 2024), pointing out a strategic and egocentric view of companies' sustainability efforts that might indicate the foremost goal of a company to bolster one's reputation (Parguel et al., 2011, 2015).

Although companies have responded to societal demands by actively promoting their environmental efforts, a recent content analysis of social media advertising by leading global companies shows that more than 70% of the claims made in advertising were misleading (Kwon et al., 2024), indicating a so-called greenwashing strategy (de Freitas Netto et al., 2020; Parguel et al., 2015). This strategy aims to enhance a company's image as environmentally friendly but often does not provide real insights into a company's environmental practices. Due to results like Kwon's (2024), it is particularly important to examine how companies communicate their sustainability efforts (de Freitas Netto et al., 2020) to determine their authenticity. More specifically, which issues related to sustainability elements companies refer to in their sustainability communication. For example, Lock et al. (2024) distinguish between six elements, namely environment (e.g., air quality), economy (e.g., production), society (e.g., politics), individual (e.g., health), development (e.g., research), and time (e.g., future generations), that communicators might refer to when discussing sustainability. By prioritizing certain topics over others, companies influence the public's perception of sustainability and may direct attention, resources, and collective efforts to specific areas (Etter et al., 2018; Scherer et al., 2016).

As Fernández et al. (2022), have observed, companies are guided by a number of factors when selecting which sustainability topics to prioritize in their online communications. The communication channel undoubtedly plays a pivotal role, particularly on social media, where interactivity and appeals that are oriented towards humanity play a significant part. However, social media also carries the risk of losing control of the public perception,

which could impact how companies position themselves on these platforms (Illia et al., 2017) or whether companies avoid positioning a sensitive topic like sustainability on social media altogether (Lundgaard & Etter, 2023).

Based on these assumptions, we want to understand the frequency (RQ1a) and, more importantly, what aspects (RQ1b) the 40 German DAX companies communicate about sustainability in their social media channels.

Yet, the relevance of communicating environmental, social, and philanthropic aspects (Byrum, 2019) might also vary depending on the type of company. Particularly, whether a company's profit comes from direct sales to customers or distribution to other companies may influence its public communication. So-called high-consumer-proximity industries (Fernandez-Feijoo et al., 2014) or business-to-consumer (B2C) industries need to engage customers as key stakeholders and might use communication channels such as social media for CSR and sustainability communication differently than low-consumer-proximity or business-to-business (B2B) industries (Reilly & Larya, 2018). While the use of social media for CSR purposes is well established (Etter, 2014), Reilly and Larya (2018) found that high-consumer-proximity industries seem to rely much more on social media for their external sustainability communication. Yet, it might be relevant to communicate sustainability efforts cautiously through social media, as they can create a backlash from the audience, particularly if consumers suspect a greenwashing intention (Topal et al., 2020).

Secondly, we thus want to understand whether we can find any patterns or differences in their communication depending on their consumer proximity (RQ2).

X and Instagram are among the most widely used social media platforms, both in Germany and worldwide. Moreover, both platforms are central venues for corporate communication and specifically CSR (Reilly & Larya, 2018). Therefore, we decided to analyze sustainability communication on these platforms, as this will provide valuable insights into the characteristics of corporate communication within today's hybrid media system.

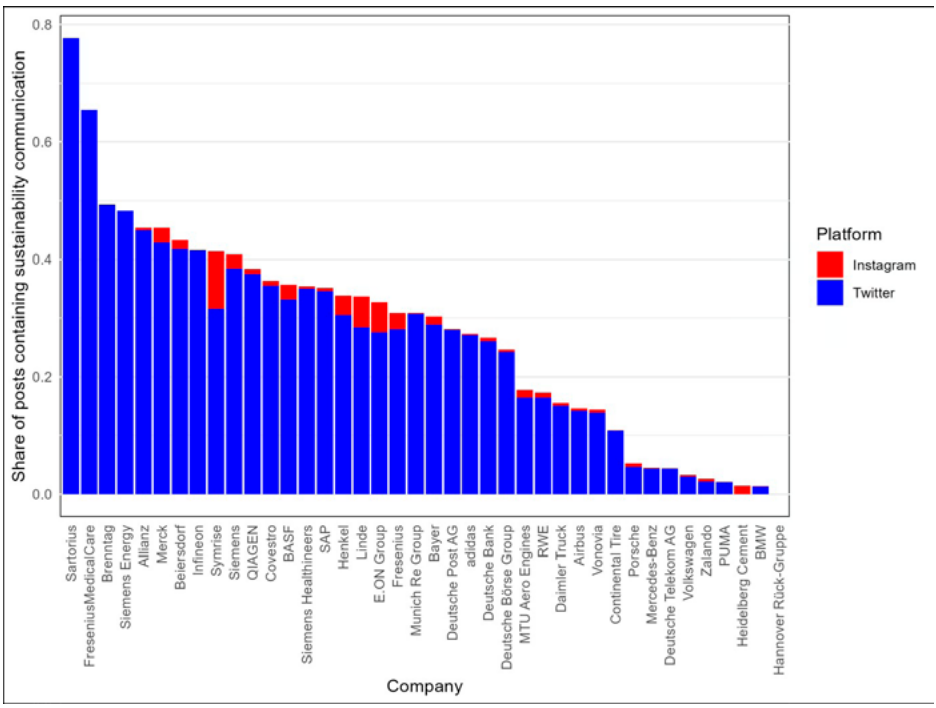
3. Method

To answer these research questions, we downloaded all tweets and Instagram posts from official accounts of the 40 German DAX corporations from their initial startup until the end of November 2022 (N_X = 642,897, $N_{Instagram}$ = 66,867)[1]. For Twitter, we relied on the then-available Twitter Developer API (data accessed on 01.12.2022) and for Instagram, we used CrowdTangle (data accessed on 07.12.2022) to acquire data.

We trained a naïve Bayes, a support vector machine and a maximum likelihood machine learning classifier to identify posts that can be labeled as sustainability communication. Finally, we combined our classifiers into an ensemble classifier, where a post is considered to contain sustainability communication if the majority of classifiers predict this. The classifiers were trained using a 75/25 test-training split on

1 We machine translated all non-English texts to English with the googletranslateAPI ($n_{non\text{-}English}$ = 124,082). The final sample size after preprocessing and exclusion of empty posts is N = 709,448.

Figure 1. Share of posts containing sustainability communication across German DAX40 companies on Twitter and Instagram



2,500 manually coded posts. A trained student coder was provided with a definition of sustainability communication and relevant examples to determine whether a post contained sustainability communication. Intercoder reliability between the coder and one of the authors was satisfactory (n = 100, α = .89). The ensemble classifier was chosen for its superior performance, which was within acceptable limits (*Accuracy* = .83, *Precision* = .63, *Recall* = .69, *F1* = .66, see: Pilny et al., 2019). Still, despite this overall acceptable performance, the comparatively high false-positive and false-negative rates call for a cautious interpretation of results.

We then ran a series of unconstrained STM-topic models on posts that were labeled sustainability communication.[2] Based on semantic coherence, exclusivity and interpretability, we decided to use a model with five topics. The topics were then validated by a trained student coder who was provided with brief descriptions of the five topics and a few salient examples. The coder reviewed 500 posts (100 per topic) to identify the dominant topic, with Krippendorff's Alpha (α = .76) indicating satisfactory agreement between the human coder and automated classification. All data and scripts can be found on OSF (https://osf.io/64xbs/?view_only=3448b722f3394bf1ad93e77cea672f89).

2 We ran models for k = 2, 3, 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95 and 100.

4. Results

To answer RQ1a, we first analyzed the frequency of sustainability posts. Overall, 16.6% of the posts were classified as sustainability communication (n = 117,721). Interestingly, the share of tweets (17.8%) that talks about sustainability is significantly larger than the share of Instagram posts (5,4%, $\chi^2(1) = 66680.58$, $p < .001$, $V = .01$). Moreover, the share of posts that contain sustainability communication varies largely across companies from 0% (Hannover Rück-Gruppe) to up to 78% (Sartorius). Figure 1 provides an overview of the share of posts on sustainability across accounts.

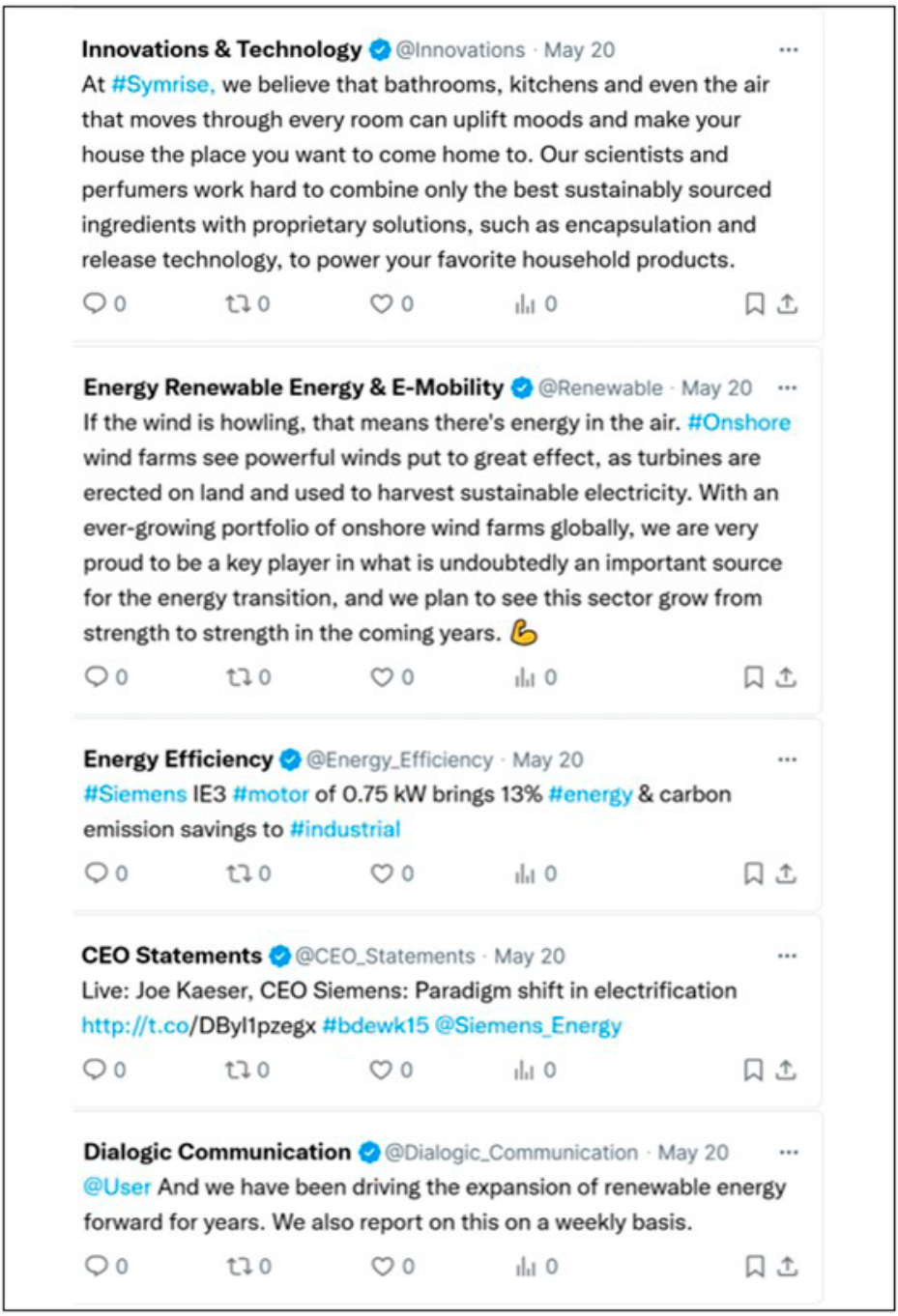
RQ1b asks about the topics that companies talk about when they post about sustainability. Our topic model identified five different topics, which we interpreted based on relevant features and texts with a strong presence of a topic. The first topic mentions sustainability when talking about "*Innovations and Technologies*". Here, sustainability is not at the center of attention but rather presented as one out of a set of features of new developments. This topic has an average topic loading of .61 and making it by far the most dominant topic in the corpus. The second topic talks about "*Renewable Energy & E-Mobility*" and has an average topic loading of .19. The third topic was called "*Energy Efficiency*" and has an average topic loading of .11. Next, the fourth topic consists of "*CEO statements, press releases, awards and competitions*" and has an average topic loading of .05. Lastly, there is a topic called "*Dialogic Communication*" in which companies either ask users for their opinion or engage in a dialogue with users about sustainability topics. This topic also has an average topic loading of .05. Figure 2 provides an overview with salient examples of the five topics.

RQ2 asks about differences in sustainability communication based on companies' consumer proximity. To do so, we compare the communication of companies that only deal directly with customers (B2C) and those that also or exclusively deal with other companies (non-B2C). First, the analysis indicates that the share of posts of B2C companies (10.3%) that refer to sustainability is significantly smaller than of those that do not only directly deal with costumers (30.3%, $\chi^2(1) = 44122.27$, $p < .001$, $V = .25$). To unravel differences in topic prevalence, we computed unpaired t-tests to compare the average topic loadings between the two groups of companies.[3] The results indicate that B2C companies rely significantly less on the topics "*Innovations and Technologies*", "*Renewable Energy & E-Mobility*" and "*CEO statements, press releases, awards and competitions"*, while they significantly stronger rely on the topics "*Energy Efficiency*" and "*Dialogic Communication"* (see Table 1).[4]

3 We are aware of the ongoing debate about the necessity of using inferential statistics on superpopulation data. In this context, we primarily follow the suggestions of Broscheid & Gschwend (2005), who argue that even when working with full population data, inferential statistics are necessary to empirically test general explanations.

4 As requested by one of the reviewers we created figures on the temporal dynamics of the share and number of sustainable post (Figure A1) and on the relative relevance of topics across time (Figure A2). These figures can be found on OSF.

Figure 2. Visualization of examples of posts containing the five identified topics



Note: Due to privacy and copyright concerns, visualizations were created through mock-up posts from www.tweetsim.com.

Table 1. Unpaired t-test for differences in average topic loadings between business to consumer business to business (B2C) and non-B2C companies

Topic	B2C-companies *M*(*SD*)	Non B2C-companies *M*(*SD*)	*t*(df), *p*, *d*
Innovations and Technologies	.54(.24)	.65(.14)	*t*(117717) = -96.1, *p* < .001, *d* = -.5
Renewable Energy & E-Mobility	.16(.12)	.20(.10)	*t*(117717) = -63.5, *p* < .001, *d* = -.3
Energy Efficiency	.19(.32)	.04(.06)	*t*(117717) = 119, *p* < .001, *d* = .7
CEO statements, press releases, awards and competitions	.05(.06)	.06(.07)	*t*(117717) = -28.9, *p* < .001, *d* = -.1
Dialogic Communication	.05(.11)	.04(.07)	*t*(117717) = 20.5, *p* < .001, *d* = .1

Notes. *n* = 117.719

5. Discussion

Our analysis of DAX-listed companies' communication gives a first indication that they do not prioritize sustainability communication on their social media channels. Indeed, only 17% of all posts focus on this issue. This may be attributed to the fact that social media is a potentially discursive platform where prospective consumers may disseminate their appraisals of a company's stance on social issues, and potentially also offer constructive criticism of the organizational activity. Therefore, the content shared within the public discourse must be carefully considered (Etter et al., 2018; Lundgaard & Etter, 2023).

When companies in our study do engage in informal communication of their CSR activities and their attitudes and measures towards sustainability (Reilly & Larya, 2018), the predominant topic focus is on innovations and technologies. In this context, sustainability is frequently subsumed by the focus on the technical specifications of new developments. This indicates that companies in our sample utilize sustainability as a means of advancing innovation, thereby potentially prioritizing economic growth and progress over genuine sustainability endeavors (Kemper et al., 2019). This is consistent with the findings of Angst and Strauß (2023), who, in their study of European Twitter discourses between 2010 and 2021 on digitalization and sustainability, show a predominant focus on an efficiency-driven discourse with little critical reflection on economic growth.

Other focal points include "Renewable Energy and E-Mobility," "Energy Efficiency," "CEO statements, press releases, awards and competitions," and finally "Dialogic Communication." Thus, the least utilized approach in our study is that of companies soliciting user opinions or engaging in discussions about sustainability topics. These findings indicate that DAX-listed companies tend to present information in a one-sided manner, focusing on presenting sustainable innovations and practices, as well as the promotion of third-party recognition. This adds to the observation of Lock et

al. (2024) that companies simply buzzword sustainability in the public communication without having a meaningful exchange with consumers. This contrasts with the use of social media as a tool for two-way communication (Topal et al., 2020).

A somewhat surprising result of our analysis is that the examined B2C companies rely less on sustainability communication than non-B2C companies. This finding is contradictory to previous research (Reilly & Larya, 2018). However, as Etter et al. (2018) point out, social media increases a company's transparency and accountability to its stakeholders. In the case of B2C companies, consumers are the most important stakeholders, which explains why B2C companies still rely more on dialogic communication than non-B2C companies. Nevertheless, the dialogic potential is generally limited. We argue that while B2C companies are expected to be transparent, it is more difficult for them to present a polished image without exposing themselves to outside scrutiny. Furthermore, the company cannot fully control the public discourse, as consumers can influence communications. Consumer feedback can force companies to address issues they had not previously prioritized, leading to a reallocation of resources or reputational risk. This reluctance to engage in sustainability messaging may also stem from greenhushing – a tactic that, unlike greenwashing, downplays environmental efforts to avoid scrutiny (Font et al., 2017). Companies may find it challenging to steer or respond effectively, leading to hesitation to prioritize social media for sensitive topics like sustainability (Lundgaard & Etter, 2023). Thus, the observed avoidance of using social media for sustainability messaging may reflect a strategic calculation to minimize reputational risks while maximizing control over the public image through other forms of communication (Illia et al., 2017). Companies may therefore prefer to emphasize marketing channels that offer more control, balancing their sustainability goals with reputation management strategies.

Moreover, B2C companies tend to discuss sustainability in slightly different topics than non-B2C companies, putting a stronger focus on energy efficiency as a topic that directly affects consumer costs and a lower focus on more abstract aspects like the use of renewable energy in production, CEO awards for sustainability, or innovative technologies in product processes. This is because these issues relate less strongly to the stakeholders these companies prioritize.

6. Practical implications

The results indicate that DAX companies currently provide only limited information about their sustainability efforts and rarely engage in dialogue with social media users. Instead, the focus is on sustainability as a means of promoting innovation, possibly prioritizing economic growth and progress over genuine sustainability efforts. These efforts may erode the credibility and effectiveness of companies in engaging consumers. It is recommended that companies adopt a more balanced approach that includes dialogic communication in order to foster a more interactive and trust-building relationship with their audience. In light of the growing recognition of corporate responsibility, it is worth considering whether companies should accept that their sus-

tainability messaging may not necessarily result in immediate persuasion. Rather, it may contribute to a broader deliberative process by influencing public opinion and stakeholder expectations over time (Lundgaard & Etter, 2023). Businesses, in particular those with a high degree of consumer proximity, need to utilize a diverse array of communication channels, extending their social media presence, to more effectively convey their sustainability initiatives and thereby enhance their contribution to societal discourse on sustainability (Etter et al., 2018; Illia et al., 2017; Lundgaard & Etter, 2023).

In our study, we observe a tendency for companies to favor innovation and economic benefits over genuine sustainability initiatives in social media communication (Kemper et al., 2019). This goes along with a lack of interest in dialogic forms of sustainability communication. Together, these aspects have the potential to mislead or misdirect consumers. It is the responsibility of policymakers to monitor this behavior and the reasons behind it. Furthermore, literacy efforts to educate social media users about companies' persuasion intentions and tactics seem warranted (Naderer & Opree, 2021).

7. Limitations

The present paper offers a descriptive overview and exploratory examination of two social media channels utilized by DAX-listed companies. While X and Instagram are relevant, X has significantly changed since the data collection for this study, with numerous companies and advertisers having left the platform. Moreover, this analysis does not encompass other communication channels, such as formal advertising, formal CSR reports, or public relations efforts in the news media. Consequently, only one aspect of sustainability communication was assessed in this study. Additionally, since we only analyzed the frequency and topics of sustainability communication, we cannot determine how much of it includes concrete measures versus greenwashing or strategic ambiguity (Sim & Fernando, 2010). Thus, our analysis reflects the companies' communication, not their actual actions.

Methodologically, for the sake of reproducibility and simplicity, we chose to use a machine learning classifier to identify sustainability communication. While the classifier performed within an acceptable range of validity, it is important to acknowledge the implications of the performance measures, specifically that the false positive and false negative rates are approximately one-third. These figures suggest that a significant portion of posts may be misclassified, and this should be considered when interpreting the findings. Future research could focus on refining the model or exploring advanced methods, such as incorporating Large Language Models, to enhance performance and address these limitations.

Finally, our topic model may have captured results on two different conceptual levels. The topics "Dialogic Communication" and "CEO statements, press releases, awards, and competitions" seem to have a distinct conceptual nature, focusing on the form of communication rather than solely its content. This could explain the overall low topic loadings for these categories, as CEOs, for instance, often address substantive topics in their statements, while the topic itself may only load on terms indicating the pre-

sence of a CEO statement. Although these topics remain computationally valid and were identified through manual content analysis, further exploration of their co-occurrence with other topics would be a valuable next step.

8. Conclusion

Reducing greenhouse gas emissions and keeping global temperature rise within manageable limits requires holistic solutions involving public, political, and economic stakeholders. Since companies are significant contributors to the climate crisis, there is a public expectation for them to take responsible actions. Our findings suggest that there is still some way to go in making sustainability efforts a priority, as evidenced by the lack of consideration of this aspect in the public communication of DAX-listed companies on social media.

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