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RESEARCH ARTICLE

Sustainability in the pharmaceutical industry—An assessment of sustainability maturity and effects of sustainability measure implementation on supply chain security

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Abstract

The pharmaceutical industry faces increased sustainability demands. The Environmental, Social, and Governance (ESG) framework is most widely accepted to discuss corporate sustainability, but little is known about the effects of ESG measure implementation on supply chain security. Understanding these effects is especially important in the face of drug shortages. Leveraging a quantitative and a qualitative method based on a grounded theory approach, we aim to investigate the state of ESG maturity of pharmaceutical corporations in Germany and develop a perspective on the effects of ESG measure implementation on supply chain security. We find publicly traded and larger companies having higher ESG target-setting maturity than privately-owned or smaller companies and that company priorities, costs, and regulatory processes limit ESG progress overall. Our findings suggest that ESG measure implementation can induce short-term supply disruption risks. A risk assessment considers current ESG maturity, implementation effects outside of own operations, short-term supply buffers, implementation timeline, and scope, and change management capabilities.

KEYWORDS

corporate sustainability, drug shortage, ESG, supply chain security, supply disruption, sustainability

1 | INTRODUCTION

Attention to sustainability has been increasing since the 1980s (Becker, 2012). Based on a United Nations report from 1987, it can be defined as “meeting the present needs without compromising the ability of future generations to meet their own needs” (Brundtland, 1987). The importance of sustainability today and its dimensions, beyond environmental sustainability, have been underlined by the United Nations 2030 Agenda for sustainable

development and the 17 Sustainable Development Goals (SDGs) (United Nations, 2015).

Today's sustainability debate often centers around corporations (de Rademaeker & Cozzani, 2012) due to their impact on the environment and society (Dunphy et al., 2014). Corporations are facing increasing requirements regarding the sustainability of their activities from multiple stakeholders (Villena & Gioia, 2018). Investors include sustainability criteria in their assessment of company performance (Mihaiu et al., 2021), customers push toward more sustainable products

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(Shnayder et al., 2016), and employee rights and working environments face more scrutiny by society as a whole (Milanesi et al., 2020).

These stakeholder needs are also reflected in the regulatory environment companies operate in. Regulatory bodies in the United States and the European Union are working on increasing the importance and standardization of non-financial reporting (Cinquini & de Luca, 2022; Monciardini et al., 2020). While concrete reporting requirements have so far been limited to greenhouse-gas (GHG) emissions (e.g., Non-financial Reporting Directive 2014/95/EU (European Parliament 2014, October 22), HGB §289c Abs. I and II (German Parliament, 2019), EC Guidelines on non-financial reporting—Supplement on reporting climate-related information (C/2019/4490) (European Commission 2019, June 20), companies will face more stringent reporting requirements across sustainability dimensions in the future. In the United States, the Securities and Exchange Commission (SEC) will impose disclosure on sustainability impacts and policies beyond the level of direct GHG emissions, even for small reporting companies, by 2025 (United States Securities and Exchange Commission 2022, March 21). The European Union goes even further with its corporate sustainability (CS) reporting directive (CSRD), which will be implemented in 2024, by making reporting on target-setting compulsory (European Commission 2022, June 29). Similarly, countries in the Asia-Pacific region, such as New Zealand, India, and Thailand, are sharpening regulations on the disclosure of sustainability impacts and targets (The Securities and Exchange Commission, Thailand 2021, March 22; New Zealand Parliament 2021, December 4; Securities and Exchange Board of India 2021, October 5). While most regulations focus on environmental sustainability, other dimensions, such as corporate governance and human rights, are also gaining regulatory attention. As of 2023, the German supply chain act will broaden due diligence regulations regarding human rights across the entire supply chain for companies with over 3000 employees (German Parliament, 2021). In line with these developments, the pharmaceutical industry has also witnessed an increase in attention to the sustainability of its activities (Schneider et al., 2010).

Research suggests a variety of methodologies to measure and discuss sustainability. The Environmental, Social, and Governance (ESG) framework is increasingly used in the business context to describe company performance on the three sustainability dimensions E, S, and G (Mihaiu et al., 2021), and governments refer to it in their sustainability regulations (European Commission, 2013). As the currently most widely accepted framework to look at firms' sustainability impact, ESG is also widely used in research on sustainability topics (Dai & Tang, 2022). While the general link of ESG measures to supply chain operations is widely accepted, limited research has been conducted on the effects of ESG measure implementation on supply chain security (Dai & Tang, 2022).

Understanding such effects is especially interesting in light of two significant transitions supply chains are going through. First, the switch toward a circular economy (Jaeger & Upadhyay, 2020) and the development of reverse supply chain networks (Jraisat et al., 2023). While there is a heterogeneity in making this shift between companies (Jaeger & Upadhyay, 2020), it is particularly challenging in industries in which product purity matters (Upadhyay, Laing, et al., 2021), such as the pharmaceutical industry. Second, the transition toward Industry 4.0

(Mukhuty et al., 2022), which entails the deployment of disruptive technologies, such as Blockchain or digital supply chain networks. On the one hand, these can support stronger sustainable performance and supply security (Bai & Sarkis, 2020; Nikolakis et al., 2018; Sharma et al., 2022). On the other hand, they come with challenges regarding socially sustainable implementation (Mukhuty et al., 2022; Upadhyay, Mukhuty, et al., 2021). In light of these significant transitions and given the high vulnerability of global pharmaceutical supply chains highlighted during the COVID-19 pandemic (Bade et al., 2023), a perspective on ESG measure implementation effects on supply chain security, as well as suggestions on how to prevent potential adverse effects, can support organizations in simultaneously improving sustainable performance while securing supply chains.

2 | OBJECTIVES

Two main research questions guide the objective of this study.

Research question nr 1: What is the current state of ESG target-setting and implementation maturity of pharmaceutical marketing authorization holders (MAHs) in Germany, and what is hindering further progress?

Research question nr 2: What are the effects of ESG measure implementation on supply chain security, and how can potential negative effects be limited?

3 | LITERATURE REVIEW

3.1 | Sustainability in the pharmaceutical industry

While certain dimensions of sustainability are inherent to pharmaceutical corporations, given that their products increase the health and well-being of people, other aspects such as the environmental impact of drugs across their life-cycle, inequality in access to medicines, as well as unethical sales practices are topics of debate (López-Toro et al., 2021; Milanesi et al., 2020; Sheldon, 2017). MAHs face these debates in an exceedingly complex system of stakeholders, including consumers, their employers, shareholders, regulators, medical doctors, and statutory health insurance (SHI). Due to the role of medical doctors as prescribers of drugs, pharmacists, as sellers of drugs, and SHIs, as payors and thus decision makers on what is paid for, MAHs have minimal ability to directly interact with consumers. Furthermore, the regulatory environment is challenging to navigate due to the vast amount of regulations and their regional variations. Across sustainability dimensions, areas for improvement exist in the pharmaceutical industry, such as in ecological sustainability of packaging, worker rights on manufacturing sites or board diversity (Belkhir & Elmeligi, 2019; Carli Lorenzini et al., 2018; Nematollahi et al., 2018). Actively pursuing more sustainable ways of working results in economic pay-offs across industries, for example, due to better alignment of actions with stakeholder interests or reputation effects (Grove et al., 2018; Orlitzky et al., 2003). Improving their



impact on sustainability dimensions is becoming even more critical for pharmaceutical companies as tender criteria are broadened to include sustainability aspects (Osterloh, 2022). While research clearly shows an opportunity for pharmaceutical companies to improve their impact across sustainability dimensions, and upcoming regulatory changes underline the urgency to act, especially in Europe and, more specifically, Germany, there has been little research on the current state of sustainability target-setting and implementation maturity of MAHs. Developing such perspective and understanding what is needed to enable progress is especially desirable due to MAHs' large impact across sustainability dimensions. Based on a 2019 study, the pharmaceutical industry has, for example, had a 55% higher CO₂ emission intensity than the automotive industry in 2015 (Belkhir & Elmelig, 2019; Forin & Scholz, 2022; Okereke, 2021). A lower degree of operations digitalization and the application of batch production, compared to continuous production, are some drivers of the difference between the emission values of 48.55 tons per \$million revenues in the pharmaceutical industry versus the 31.4 tons per \$million revenue in the automotive industry. Furthermore, it is one of the world's largest industries (Okereke, 2021), impacting vast amounts of lives and livelihoods through its activities and products. It is therefore in the MAHs' best interest to increase understanding of sustainability maturity, as it can support them to progress on ESG topics to build stronger trust in their industry and organizations. This is especially desirable as the pharmaceutical industry, despite its beneficial role for human health and well-being, often lacks trust in the wider population (Kessel, 2014).

3.2 | The ESG framework—a critical catalyst in driving sustainability of corporations and an important common ground in today's sustainability debate

The term ESG was coined in 2005 by the report “Who cares wins” (Knoepfel, 2005). The theoretical basis of ESG research mainly consists of institutional and stakeholder theory (Li et al., 2021). Depending on the regional or industrial focus of the assessment, different ESG factors matter more, which leads to a variety of specific ESG frameworks focusing on the most critical subset of factors in their context. Table 1 gives an overview of potential ESG factors companies could consider when optimizing their activities for sustainability.

Challenges with the ESG framework exist regarding the standardized use of data and reporting (Mihaiu et al., 2021) or the comparability and meaningfulness of the multiple available ratings of corporations' sustainability efforts (Berg et al., 2022). Nevertheless, the framework has significantly contributed to more sustainable ways of doing business across industries. It was the catalyst for the incorporation of non-financial aspects into company performance assessments (Knoepfel, 2005), and its wide acceptance across industries, as well as its link to financial performance, have driven companies toward more sustainable corporate behavior (Friede et al., 2015; Mihaiu et al., 2021). Furthermore, the ESG framework is the common ground of sustainability discussions when regulators and institutional investors develop new standards and push toward more sustainable corporations (Azarow et al., 2021). As the currently most widely

TABLE 1 ESG factors per dimension.

Dimension	Factors
Environmental (E)	<ul style="list-style-type: none"> • gGHG and other emissions to water, air, and soil • Energy and raw material consumption and efficiency • Exposure to fossil fuels • Water usage, management, and recycling • Land degradation, desertification, soil sealing, deforestation • Waste production and management • Impact and dependence on biodiversity and ecosystems • Innovation in environmentally-friendly products, technologies, and services
Social (S)	<ul style="list-style-type: none"> • Implementation of fundamental ILO Conventions and human rights policies: Forced and compulsory labor, trafficking in human beings, child labor • Workplace health and safety: accidents, injuries, fatalities, or illness • Employee relations and HR management: Discrimination, diversity, inclusion, equal opportunity, freedom of association, whistleblower protection • Training and education, investment in human capital • Poverty and community impact • Supply chain management • Exposure to controversial weapons • Customer privacy, health, and safety • Quality and innovation in customer relations, rights of customers to gain information about environmental issues • Personal data security • Access to credit and financial inclusion • Violation of UN Global Compact Principles
Governance (G)	<ul style="list-style-type: none"> • Codes of Conduct and business principles • Accountability • Transparency and disclosure • Executive pay, gender pay gap • Board diversity and structure, board of Directors independence • Bribery and corruption • Stakeholder engagement: Set of rules or principles defining rights, responsibilities, and expectations between different stakeholders in the governance of the entity/sovereign • Shareholder rights

Source: own synthesis based on Table 1 in (European Banking Authority, 2021).

accepted framework to look at firms' sustainability impact, ESG is also widely used in research on sustainability topics (Dai & Tang, 2022).

3.3 | Pursuing ESG targets impacts the supply chain and its security

As companies move toward more sustainability, they set targets on various ESG factors, such as GHG-emissions or sustainable procurement, and implement actions accordingly. In doing so, supply chain operations are impacted. The effect is even stronger when the operations of direct and indirect suppliers are considered (Dai & Tang, 2022). Research has shown that companies understand the importance of implementing sustainability measures but that their integration into operations poses difficulties (Kumar et al., 2019). ESG efforts and related reporting can increase supply chain transparency, thus reducing supply chain risks and improving supply chain efficiency (Fraser Johnson et al., 2007; Handfield, 2017). Such efforts are supported by the transition toward Industry 4.0 and related technologies, such as Blockchain, and the overall induced digitalization of supply chains (Upadhyay, Mukhuty, et al., 2021). However, in the face of various existing company targets and the high complexity of today's supply chains, ESG measures add additional complexity (Shafiq et al., 2017) and consume resources (Fraser Johnson et al., 2007). Mitigating potential negative effects on pharmaceutical supply chains is especially important given the global challenge of supply side driven drug shortages (Miljković et al., 2020; Shukar et al., 2021). The high quality and purity requirements additionally make the industry interesting to explore, as purity in materials is an important challenge for moving toward sustainable supply chains in the sense of circular economies (Upadhyay, Laing, et al., 2021). Furthermore, as pharmaceutical companies face some of the most global and complex supply chains across industries, they are an excellent example to explore measures required to limit potential negative effects of ESG implementation on supply chain security in complex supply chain settings.

4 | MATERIALS AND METHODS

4.1 | Theoretical foundation and conceptual framework

While several definitions of CS exist, adapting a definition with a tri-dimensional view, meaning the inclusion of economic, environmental, and social aspects, is most widely accepted (Montiel & Delgado-Ceballos, 2014). The theoretical concepts most frequently linked to CS are stakeholder and institutional theory (Montiel & Delgado-Ceballos, 2014). Stakeholder theory emphasizes the need for managers to account for interests of all parties affected by their business and not only those of direct shareholders (Freeman, 1984; Harrison & Freeman, 1999). Institutional theory in the context of CS supports the analysis of effects of institutional pressure on the implementation of sustainable corporate practices (Husted & Allen, 2006), as well as analyses of standard and reporting developments (Delmas & Montes-Sancho, 2011; Jensen & Berg, 2012). In order to account for these theoretical underpinnings and the tri-dimensional view, the ESG framework was applied to look at the current state of sustainability topics of pharmaceutical MAHs in Germany.

4.2 | Design

A research design, leveraging first a quantitative and then a qualitative method based on a grounded theory approach (Charmaz, 2000, 2014), was used. For the quantitative part, a tool to assess sustainability target-setting maturity was developed. Publicly available sustainability target-setting data from company reports and websites were assessed based on it and relationships of company characteristics with ESG target-setting maturity were analyzed statistically. For the qualitative analysis semi-structured interviews followed by thematic analysis were conducted. This allowed unearthing of the relationship between supply chain security and sustainability target-setting and implementation, as well as the perspective of MAHs on the current state of sustainability measure implementation. The Consolidated Criteria for Reporting Qualitative Research (COREQ) 32-item checklist (Tong et al., 2007) was used to report findings adequately (see Appendix A).

A purely quantitative research approach would not have been able to fully explore the research problem, due to limited data availability and the nature of the research question going beyond hypothesis testing. A purely qualitative research approach would not have enabled analysis of target-setting maturity differences based on statistical methods and thus would have limited the generalizability of such assessment. First using a quantitative method, allowed the assessment of the current state of sustainability target-setting maturity for MAHs in Germany based on a large sample. It thus enabled analysis of where differences in target-setting maturity lie and with what aspects these correlate. In order to reach the remaining research objectives, a qualitative method was better suited, as rich, detailed answers and the perspective of individuals in direct touch with the research topic were of interest. Using a grounded theory approach has a long history in healthcare research, as it allows researchers to capture the breadth and depth of insights needed to fully explore complex phenomena (Chapman et al., 2015). It is furthermore well established in organizational research as it enables understanding the complexity of under-researched phenomena while enabling the linking of theoretical contributions and practice (Locke, 2000). As the research questions at hand are positioned at the intersection of organizational and healthcare research, using a grounded theory approach was thus well-suited.

The ethics committee of the university Witten/Herdecke granted ethical approval for the study (no. S-267/2021).

4.3 | ESG target-setting maturity assessment

To explore the state of sustainability target-setting maturity of MAHs in the German pharmaceutical industry, publicly available data from 151 companies was assessed. The companies were selected so that the sample represents at least 80% of the German pharmaceutical market in revenue and volume. The selection was based on 2020 sales in USD and standardized unit sales volumes data from a dataset by the organization IQVIA (a well-established market insights company in the pharmaceutical industry). Additionally, all companies that faced supply



security issues regarding drug shortages in 2019 and 2021 or 2020 and 2021, according to the federal ministry for drug and medical products (BfArM), were included. Thus, representation of the views of different companies in terms of size and with a variety of exposure to supply chain security issues was ensured. Data was extracted from the latest available annual and sustainability report or, alternatively, company websites. If none of these sources contained information on ESG efforts, the company was contacted via email and asked for information.

Data for each company was assessed per ESG dimension based on the self-developed assessment tool shown in Appendix B. Four independent raters with expertise in the pharmaceutical industry and on the topic of ESG analyzed the data on all three dimensions. Interrater agreement (IRA) was assessed as a measure of reliability using the intraclass correlation coefficient (ICC) in the form “two-way mixed effect, absolute agreement, average measures” (Gisev et al., 2013; Hallgren, 2012) with a 95% confidence interval. The measure was calculated using RStudio Version: 2022.02.3. ICC was 0.988 (95% Confidence Interval: 0.986; 0.99), indicating excellent agreement based on the suggestion by Landis and Koch (Landis & Koch, 1977).

Furthermore, the maturity ratings were analyzed for potential differences related to company demographics and across dimensions. To do so, information on company ownership structure (family-owned, privately-owned, publicly traded, PE-owned), number of employees, and net sales was extracted from the latest available company report and the German federal gazette. To analyze the potential effects of ownership structure on ESG target-setting maturity scores (TMS) or across ESG dimensions, Kruskal–Wallis tests with posthoc Dunn–Bonferroni tests were conducted. This testing method was used as the aim was to test for statistically significant differences between 3 or more groups of an independent variable (3 ESG dimension groups, 4 ownership groups) on an ordinal dependent variable (ESG target-setting maturity). If H_0 (There is no difference in ESG TMS between groups) can be rejected based on the Kruskal–Wallis test ($\alpha = 0.05$), a Dunn test ($\alpha = 0.05$) helps to determine exactly which groups are different from each other. The Bonferroni p -value adjustment in the Dunn–Bonferroni test helps reduce the probability of committing a type I error. To analyze the relationship between reported net sales or number of employees and ESG target-setting maturity Spearman's rho (Bell et al., 2019) was used, as the aim was to analyze the effect of an interval variable (reported net sales, number of employees) on an ordinal variable (ESG TMS). H_0 (No relationship exists between ESG TMS and reported net sales or the number of employees) was rejected if $p < \alpha = 0.05$. The analysis was conducted using RStudio Version: 2022.02.3.

The research assumptions for the above-described hypothesis testing were developed based on existing literature. Previous research already demonstrated the existence of differences in corporate behavior between companies with different ownership structures (Duh et al., 2010; Gallo & Christensen, 2011). This research builds on these findings by uncovering potential connections between ownership structures and ESG target-setting maturity. Similarly, previous research already highlighted performance differences between the three ESG dimensions (Daugaard & Ding, 2022). Building on this, this research sheds light on target-setting maturity differences across dimensions for

MAHs in Germany. The hypothesis that ESG target-setting maturity correlates with company size in terms of the number of employees as well as net sales, is supported by previous research highlighting the impact of company size on corporate behavior (Gallo & Christensen, 2011).

4.4 | Semi-structured interviews

An interview guideline leveraging an expert panel was developed (for details on the research team, see Appendix A). The guideline was piloted in 2 interviews and refined afterward. The final version included 12 open questions in the categories “information on the interviewee”, “importance of sustainability in the pharmaceutical industry”, and “ESG measure implementation impact on supply chain security” (for complete interview guideline, see Appendix C).

Interview partners were sampled based on theoretical sampling, a form of purposive sampling (Bell et al., 2019), as part of the grounded theory approach (Charmaz, 2000), and snowball sampling. As the participants needed to have insights on ESG topics and their relationship to supply shortages, individuals were contacted at MAHs which reported shortages to BfArM in 2021 and 2019 or 2020 and 2019. Individuals had to work in business units that are most likely involved in preventing or managing supply shortages and had to be exposed to sustainability-related topics. Furthermore, two individuals from BfArM were included in the sample.

Individuals were contacted via their professional email addresses or [linkedin.com](https://www.linkedin.com) profiles. All participants received detailed information on the study objective and design before any interview. They were assured about data confidentiality and their right to withdraw at any time. Written informed consent from all participants was obtained.

One researcher conducted all interviews via telephone or video call. Interviews were recorded using OBS Studio Version 27.2.4 and transcribed verbatim using the software Trint. After transcription, all recordings were deleted. All transcripts were anonymized, and participants were offered to review their interview transcript for comments or corrections.

Two researchers coded and analyzed transcripts using MAXQDA software package, Version 22.2.0, as the data were collected. Thematic analysis as an approach in the context of grounded theory was used (Braun & Clarke, 2006; Chapman et al., 2015) to analyze the data, following the 6-steps of reflexive thematic analysis (Braun & Clarke, 2006). The sample size was determined by the moment of reaching theoretical saturation, according to Corbin & Strauss (2014).

5 | RESULTS

5.1 | Statistical analysis of ESG target-setting maturity

The sample assessed for ESG target-setting maturity included 151 companies. A total of 74.17% of companies are headquartered in Europe, 1.39% in the United States of America or Canada, and 1.19%

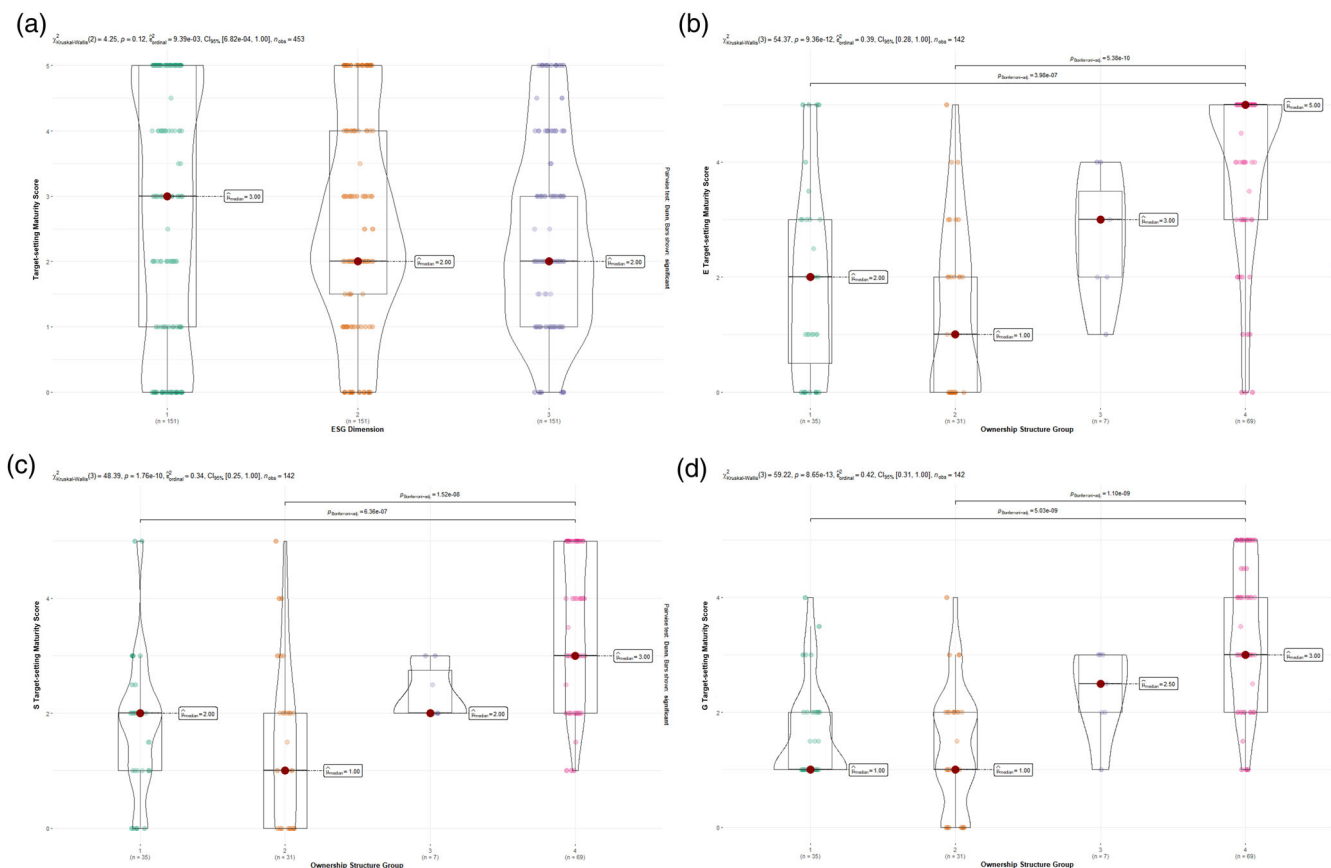


FIGURE 1 (A) The effect of ESG dimension on the target-setting maturity score. (B) Ownership structure effect on E target-setting maturity. (C) Ownership structure effect on S target-setting maturity. (D) Ownership structure effect on G target-setting maturity.

in other regions. Information on the ownership structure was available for 94.01% of the sample. The ownership structure categories were “family-owned” (coded as 1, 23.18% of the sample), “privately-owned – without clear family presence or self-identification as family business” (coded as 2, 20.53% of the sample), “PE-owned” (coded as 3, 0.05% of the sample), “publicly traded” (coded as 4, 45.70% of the sample). Reported net sales values were available for 78.15% of companies in the sample, ranging from 3.4 million USD to 268 billion USD, with a mean of 12,346,323.08. The number of employees was available for 87.42% of companies, with a maximum of 300,000 and a mean of 22,502.80.

5.1.1 | No significant difference in ESG target-setting maturity between dimensions exist

A Kruskal-Wallis test did not show that the ESG dimensions significantly affect the ESG TMS, $H(2) = 4.25, p = 0.120$. Neither the E (Mdn = 3), nor the S (Mdn = 2), nor the G (Mdn = 2) dimension reached higher scores than any of the other dimensions. Figure 1A gives an overview of the distribution of TMS across dimensions and the results of a Kruskal-Wallis test on the effect of the ESG dimension on the TMS.

5.1.2 | Publicly traded companies have higher maturity than privately- and family-owned companies across dimensions

E-dimension

A Kruskal-Wallis test showed that the ownership structure significantly affects the E TMS, $H(3) = 54.37, p < 0.001$. Publicly traded companies reached higher E-scores (Mdn = 5) than family-owned (Mdn = 2), privately-owned (Mdn = 1), and PE-owned (Mdn = 3) companies. The difference in E-scores was significant between publicly traded companies and family-owned companies, $Z(N_{publicly\ traded} = 69, N_{family-owned} = 35) = 5.40, p < 0.001$, as well as between publicly traded companies and privately-owned companies, $Z(N_{publicly\ traded} = 69, N_{privately-owned} = 31) = 6.48, p < 0.001$. None of the other comparisons were significant after Bonferroni-adjustment (all $p_s > 0.351$). Figure 1B summarizes the results.

S-dimension

A Kruskal-Wallis test showed that the ownership structure significantly affects the S TMS, $H(3) = 48.39, p < 0.001$. Publicly traded companies reached higher S-scores (Mdn = 3) than family-owned (Mdn = 2), privately-owned (Mdn = 1), and PE-owned (Mdn = 2)

companies. The difference in *S*-scores was significant between publicly traded companies and family-owned companies $Z(N_{\text{publicly traded}} = 69, N_{\text{family-owned}} = 35) = 5.32, p < 0.001$, as well as between publicly traded companies and privately-owned companies $Z(N_{\text{publicly traded}} = 69, N_{\text{privately-owned}} = 31) = 5.96, p < 0.001$. None of the other comparisons were significant after Bonferroni-adjustment (all $ps > 0.611$). Figure 1C summarizes the results.

G-dimension

A Kruskal–Wallis test showed that the ownership structure significantly affects the *G* TMS, $H(3) = 59.22, p < 0.001$. Publicly traded companies reached higher *G*-scores (Mdn = 3) than family-owned (Mdn = 1), privately-owned (Mdn = 1), and PE-owned (Mdn = 2.5) companies. The difference in *G*-scores was significant between publicly traded companies and family-owned companies $Z(N_{\text{publicly traded}} = 69, N_{\text{family-owned}} = 35) = 6.14, p < 0.001$, as well as between publicly traded companies and privately-owned companies $Z(N_{\text{publicly traded}} = 69, N_{\text{privately-owned}} = 31) = 6.37, p < 0.001$. None of the other comparisons were significant after Bonferroni-adjustment (all $ps > 0.405$). Figure 1D summarizes the results.

5.1.3 | Company size correlates positively with ESG target-setting maturity across ESG dimensions

Spearman's rho correlation coefficient was used to assess the relationship between ESG TMS per ESG dimension and company size measured as reported net sales, as well as number of employees. There was a significant positive correlation between all three dimensions and reported net sales, as well as number of employees. Table 2 gives an overview of the results. While the stronger correlation was found between reported net sales and the *E*-dimension, the correlation with the number of employees was stronger for the *S*- and *G*-dimensions. For both reported net sales and the number of employees, the correlation with the *E*-dimension was strongest compared to other dimensions.

5.2 | Semi-structured interviews

Between April and July 2022, 14 interviews were held, which lasted 62 min on average. 78.6% of participants were male, 21.4% female.

TABLE 2 Spearman's rho correlation coefficients between ESG target-setting maturity scores per dimension and reported net sales, as well as number of employees.

	Reported net sales ($N = 118$)	Number of employees ($N = 132$)
<i>E</i> target-setting maturity score	0.781*	0.729*
<i>S</i> target-setting maturity score	0.701*	0.724*
<i>G</i> target-setting maturity score	0.631*	0.658*

* $p < 0.001$.

Participants have worked in the pharmaceutical industry for 5–38 years (Mdn = 18.5) and have been with the same employer as at the time of the interview for 2–26 years (Mdn = 7). Their employers reported USD 37 million to USD 45 billion in net sales and employed 13–99,580 employees. 71.4% have headquarters in Europe, 14.3% in Asia, and 14.2% in other regions. Participants held roles such as COO, Country Head, Head of Strategy, or Supply Chain Director.

Using thematic analysis five themes were developed. Figure 2 conceptually visualizes the findings and brings them into a connected framework.

Two themes were developed regarding the current state of ESG implementation maturity of pharmaceutical MAHs.

5.2.1 | ESG implementation maturity has overall increased over the last years, but the progress varies depending on the ESG dimension and company

Participants see sustainability as a topic that matters to MAHs (“Everyone is working on sustainability today.”) and that has gained increasing attention over the last years (“There are a lot of initiatives that have developed especially in the last three years or so.”). While a wide array of measures has already been implemented, according to participants, such as ecological optimization of transportation, supplier auditing on ESG topics, or the implementation of green chemistry approaches, they see the industry as more advanced on the *S*- and *G*-dimensions than the *E*-dimension (“I would say governance in pharma companies is very strong.”; “Topics around access to patients is running for a long time already. That's also why companies are more advanced here than in the whole environmental area.”). Participants also identified a set of new initiatives gaining traction in the more established *S*- and *G*-dimensions, such as those aiming to increase diversity in clinical trials and R&D spending. They identified company external forces, such as the black lives matter movement or the COVID-19 pandemic, as key drivers for these new initiatives (“A new important aim is to diversify the R&D spend. Until today the whole system is based on male Caucasians and we do not test our medicine with other groups.”). While the industry is seen as moving toward more sustainability, participants see clear differences among companies in the market (“The level of progress varies. Some are further ahead.”). The key drivers of these differences, according to participants, are company values, company location, and, for the *E*-dimension, the nature of business (“It will depend a lot on the values of the company.”; “Other countries are much ahead on the topic, such as France or the Netherlands.”; “As we don't produce ourselves, this is not a major topic for us.”).

5.2.2 | ESG implementation progress in the pharmaceutical industry is rather slow and should become a higher priority

Participants evaluate progress on sustainability topics as relatively slow (“I would say it started, people are working on it, but it is still



FIGURE 2 Findings and the related identified themes from semi-structured interviews. Participants' views on the current state of ESG implementation maturity, ambitions for the future, and potential effects on supply chain security when implementing ESG measures.

early days in the pharmaceutical industry.”) and agree that ambitions should be increased (“There is still way too little ambition to really make a change and put more research effort into this.”). Three sub-themes linked to the reasons for the limited progress on ESG topics were developed.

ESG is often deprioritized compared to other internal priorities

While the priority of ESG topics differs between companies, participants agreed that topics, such as delivering products to the patient or generating profits, are often higher prioritized than ESG progress (“In my experience, pharmaceutical companies will always choose the patient. If there is a trade-off, they will choose not to deliver on ESG but to deliver the product to the patient.”).

MAHs can only share costs of ESG measure implementation to a limited extent with customers

Participants see limited ability to share the cost of ESG measures with customers due to price setting particularities in the industry (“You are not allowed to say ‘okay I pay 2€ more if the product is sustainable.’”) and the inability to leverage ESG in branding (“In the consumer health space it is more advanced because it is a competitive advantage, you know it is part of the branding, but that's not the case for pharmaceuticals.”). While for some measures MAHs bear the costs, as they prioritize the measures (“This is crazy expensive, but it is something that we at all costs need to continue doing.”), for others, they deprioritize progressing, as changes seem expensive and of limited benefit (“If you cannot see a return on investment, you would never do it.”).

Changes to products and production processes require extensive testing and approval work

Participants see MAHs as moving carefully with changes in products, packaging, and production processes due to the implications of changes

from a regulatory perspective (“Pharmaceutical companies tend to be more careful. Every little change has to be planned, tested, retested, registered. In this industry every change is kind of traumatic.”).

Furthermore, one theme and four subthemes regarding the effect of ESG measure implementation on supply chain security were developed.

5.2.3 | ESG measure implementation effects on supply chain security vary

While participants identify mutually beneficial developments for supply chain security and sustainability for some measures (“Route optimization in delivery, for example, it's better for you economically but also ecologically.”), they also see risks to supply chain security when setting ESG targets and implementing measures accordingly (“If companies don't prepare enough, I am pretty sure it will come to a moment that shortages will be happening.”). Participants see four main factors that impact how ESG measure implementation affects supply chain security.

Measure implementation on more advanced ESG dimensions has a lower risk of negatively impacting supply chain security

While measures across dimensions could lead to negative effects on supply chain security, participants see more risk in the *E*-dimension as the progress is limited and implementation of most measures requires substantive changes (“I don't see much reason for measures other than on the *E*-dimension to negatively affect supply chain security.”).

Measures have a higher risk of negatively impacting supply chain security when targeting issues outside of own operations

While participants expect limited to no negative effect on supply chain security for measures focusing on their own operations, they

see risks for measures targeting the entire supply chain. In particular the potential exclusion of suppliers is seen as a significant risk (“If we only consider our own operations, I think it’s a relatively secure undertaking. If we broaden this to all suppliers, however, this would be a much bigger challenge.”).

In the short-term, negative effects on supply chain security are more likely

Participants anticipate a short-term adaptation period for companies when new measures are implemented (“There is a transition phase where it might be a little bit tighter.”); but also see ESG measure implementation as potentially beneficial to supply chain security in the long term due to better collaboration, transparency, and the increase of viable options (“In the long term, the ESG targets, I think, they could even improve, what I call, supply security. Generating and not excluding options, it’s adding better alternatives.”; “So that could lead to improvements of availability, less risky supply chains, shorter supply chains.”).

Implementation preparation, timeline, and scope impact the effect on supply chain security

According to participants, a crucial factor that affects whether and how much of a negative effect ESG measure implementation has on supply chain security is how well-planned and managed the implementation is and whether companies provide enough time for a step-by-step change process. How drastic the required change is also impacts potential effects (“It is also a question of how disruptive the implementation is. If you go fast enough and big enough, of course, this will disrupt your supply.”).

Finally, the interviews led to the development of two themes on how to enable more progress on sustainability in the pharmaceutical industry while limiting potential negative effects on supply chain security.

Participants see a need for stronger motivation of MAHs to account for ESG topics in their decision-making, as well as for a more favorable industry environment for measure implementation.

5.2.4 | Regulatory bodies play an essential role in incentivizing ESG progress and in limiting negative impact on supply chain security

Participants see regulatory bodies in a key position to, on the one hand, foster more progress on ESG target-setting and implementation and, on the other hand, limit the extent of negative impact on the supply chain. Four subthemes based on areas through which regulators can advance progress were developed.

Regulatory bodies can actively contribute to solving issues in the healthcare system that hinder ESG progress

Issues such as the increasing cost pressure on hospitals, the limited existence of sustainable alternatives in a nearly monopolistic market of certain supplies, or the existence of regulations that lead to stock mismanagement and, thus, waste, are systemic issues that should be

worked on by regulatory bodies (“As long as the economic pressure on our healthcare system, on hospitals, is so high, everyone will need to look for savings in the first place.”; “You can incentivize all you want. In a monopolistic structure, you have no choice.”; “Right now in the German market, return policies lead to 2.5% waste of product.”).

Regulations are a key motivator for companies and can be leveraged to push toward more sustainability

Participants see a clear need for more incentives so that companies see ESG as a critical matter to progress. Such incentives can be financial, such as rewarding sustainability in tenders (“If you find a way to connect more clearly economic benefits with ecologic benefits, you create a win-win, and this will certainly be more attractive.”). Furthermore, a need for some pressure on the system is seen as a catalyst for further change. Such pressure could be exercised by enforcing regulations more strictly or raising regulatory requirements (“In pharma, this needs to be pushed more by authorities, rather than the consumer, they can’t like in other industries.”; “There needs to be some pressure on the system. Otherwise, there is a lack of imagination to see how things could actually be done differently.”).

Increasing regulatory process speed and including MAHs in the development of regulations fosters motivation and progress on ESG topics

There is a need for faster and more accessible ways to approve changes (“They should make it easier for manufacturing companies to change things. They should not change the rules, but work better and faster.”). The development of new processes and regulations, as a collaborative effort between MAHs and regulators, is strongly favored by participants to ensure industry intricacies are considered (“So it would have to be a combination of the regulatory and the companies working together to make that happen.”).

Regulations can impact progress pace and scope and can create a more equal playing field in the industry

Regulations are seen as a way to limit negative impacts on supply chain security, as they affect all players and limit the extent to which players face competitive disadvantages when using resources for ESG topics (“In general, such regulations ensure that there is no unfair competition and that also suppliers are generally more ready to change.”). However, regulations set a benchmark pace and scope of implementation, and participants see it as crucial that regulators consider industry dynamics when setting these. If regulators enforce too fast-paced or bold measures, participants see high risks of supply disruptions (“The regulations need to be set with an adequate change speed.”).

5.2.5 | Company values and leadership priorities foster progress on ESG topics and play a crucial role in limiting negative impact on supply chain security

Progress depends on employee awareness regarding ESG topics and their importance in decision-making, which can be driven by the

inclusion of sustainability in the company value system. Furthermore, participants see a crucial role in underlining these values through leadership role modeling (“We have made significant progress, as our managing director has set this as clear priority.”). They also see leadership in a position to limit negative impact on supply chain security by ensuring timely progress on the topics and fostering adequate change management in terms of planning and resource allocation (“If I have enough time, and that depends also on when I have started, the negative impact is much lower.”).

6 | DISCUSSION

Overall, our findings suggest that if stakeholders, such as regulators, consumers, and corporations, work together toward more progress on ESG topics of MAHs in Germany, negative effects on supply chain security can be limited. In the long term, such implementations can even benefit supply chain security, as transparency across the various supply chain players is increased, collaboration and communication ameliorates, and a larger option space is created. This was especially highlighted by interviewees who had experienced positive supply chain security effects of ESG measures in the transportation system (moving from air freight to sea freight) and in packaging (using standard white cartons and sticky labels instead of high-resolution printed cardboard) within their companies. This potential positive effect also aligns with previous research (Fraser Johnson et al., 2007; Handfield, 2017).

6.1 | Theoretical contributions

In line with the stronger regulatory focus on sustainability (Cinquini & de Luca, 2022) and the establishment of the SDGs (United Nations, 2015), our results, as evidenced by the target-setting maturity assessment and interviewee perspectives, suggest that in the pharmaceutical industry, major progress on ESG target-setting and implementation has been made in the recent past.

While the target-setting maturity assessment results suggest that the target-setting maturity of MAHs does not vary significantly across the ESG dimensions, implementation maturity was seen as more advanced on the S- and G-dimension by interviewees. This discrepancy in measure implementation between ESG dimensions can be explained by the fact that governance issues, such as marketing practices, as well as social topics, such as access to medicine, are at the center of attention of debates in the pharmaceutical industry for over 20 years already (Chohen et al., 2007). In contrast, the debate around regulatory requirements on the ecological impact of pharmaceuticals has only recently gained traction (Cinquini & de Luca, 2022). Thus, companies started setting targets on the E-dimension but are not yet as advanced in the measure implementation as on the S- and G-dimension. However, regulatory requirements linked to the German supply chain act will enforce measure implementation maturity on the E-dimension in the coming years (German Parliament, 2021).

Furthermore, target-setting maturity assessment results suggest that important differences exist in target-setting maturity between companies. First, we found that publicly traded companies reach higher target-setting maturity than family-owned or otherwise privately-owned companies and that larger companies reach higher maturity than smaller ones. These findings are supported by previous research that suggests that reporting requirements can impact the ESG focus of companies (Leong & Hazelton, 2019), as publicly traded and larger companies undergo stronger reporting requirements. The positive relationship between the number of employees and ESG target-setting is furthermore in line with research on the importance of a company's focus on ESG and Corporate Social Responsibility (CSR) topics when attracting and retaining employees (Liu & Nemoto, 2021; Won & Hong Gao, 2014). The high importance of ESG aspects in talent acquisition was also supported by an interviewee's experience with recruiting, according to which a clear difference is noticeable in the importance of company sustainability for Gen Z recruiting candidates compared to candidates from other generations.

Second, interviewees identified company location as a factor driving differences in measure implementation maturity. This finding is in line with previous research on sustainability advancements globally, which suggests that ESG performance varies among geographic regions (Daugaard & Ding, 2022). While Europe is the leading region in terms of ESG performance globally, eastern Europe lags behind western Europe, and among western European countries, France, Spain, Portugal, Finland, and Sweden clearly outperform Germany (Daugaard & Ding, 2022).

Third, the nature of business, in terms of companies with their own manufacturing plants versus companies that operate on a fully outsourced model, was identified as a driver of differences in measure implementation maturity for the E-dimension during interviews. The current scope of regulations supports this finding. Including suppliers and aspects beyond own operations regarding ecological impact will only be a strict requirement with the implementation of the supply chain act in 2023 (German Parliament, 2021).

Interviewees identified company values as a last factor driving different levels of implementation maturity. This is supported by research linking company culture to CSR (Won & Hong Gao, 2014). As previous research suggested, company culture and associated leadership practices are crucial factors in change management (Al-Ali et al., 2017; van Ess Coeling & Wilcox, 1988), as they support priority setting and decision-making. The importance of leadership and culture was especially underlined by the fact that interviewees, who see their company values as prioritizing sustainability and supply chain security next to each other, all underlined the importance leadership plays in uniting employees to move toward this common goal. Furthermore, all of these interviewees were flustered that this is yet to be a shared joint priority in the industry.

Thematic analysis of the interview results led to the identification of five main factors that impact supply chain security risks induced by the implementation of ESG measures. First, implementation maturity in an ESG dimension: the higher the maturity on a dimension is, the lower the potential impact on supply chain security. This factor can be



linked to knowledge building as maturity progress is made. On a dimension with low maturity, little knowledge of best practices is at hand, which leads to higher risks during measure implementation. Research finding that the availability of “green knowledge” positively impacts corporate environmental performance (Sahoo et al., 2023) supports this argument. Second, a higher implementation effect outside of own operations can mean higher risks for supply chain security. As the level of collaboration and communication between players in a supply chain can vary (Jraisat et al., 2021), getting partners in the network on board can pose difficulties and thus induce risks. Third, purposefully chosen short-term supply buffer existence can reduce supply chain risks. This finding is supported by research highlighting the importance of inventory management in developing sustainable supply chains (Jæger et al., 2021). Lastly, the two closely linked factors, implementation timeline & scope and change management capabilities, impact supply chain security risks, as they impact the level of disruptiveness a change has, and the ability to manage it. This finding is supported by research showing the importance of resource availability and management support in manufacturing transitions (Srivastava et al., 2022).

6.2 | Managerial and regulatory implications

Our findings suggest that, in general, more progress of MAHs on ESG topics is desirable, which is aligned with the increased attention that sustainability of the pharmaceutical industry has gained in recent years (Milanesi et al., 2020). To enable such progress while limiting potential negative effects on supply chain security, our findings suggest that a joint effort of stakeholders, such as corporations, consumers, and regulators, is needed. The importance of collaborative efforts among players when moving toward more sustainable supply chains, and the need to include consumers in such changes, which often encompass digitalization efforts, is supported by earlier research (Agrawal et al., 2022; Jraisat et al., 2021).

For pharmaceutical corporations, it is crucial to close the implementation gap on the *E*-dimension so that supply chain security is not risked when regulations force certain measures upon them. Closing this gap can be supported by leveraging technologies and tools, such as Blockchain or digital supply chain networks, to work against the challenge of traceability in emissions and pollution (Jraisat et al., 2023; Sharma et al., 2022). Considering the strong interconnection among different types of companies in the pharmaceutical supply chain, it is essential to close existing maturity gaps between companies to limit the potential negative supply chain security impact of upcoming regulatory enforcements. These regulatory enforcements target the entire supply chain and thus require every player to react accordingly to limit supply chain disruptions. The argument that supply chains will become more and more interconnected in the move toward sustainability is in line with the increasing transition toward circular economies and reversed supply chain networks (Agrawal et al., 2022; Jraisat et al., 2023).

Furthermore, it would be beneficial if companies rooted sustainability in their corporate culture and leadership priorities to enable

adequate change management and day-to-day decision-making. Putting sustainability on the top of decision-makers' agendas can ensure that decisions on measure implementation consider the impact on the entire company and that company-wide strategies are developed. Previous research supports the importance of such company-wide strategies when working toward more sustainable supply chains while keeping in mind the triple bottom line (Laing et al., 2019).

While previous research suggests that consumers care about ESG adherence in the pharmaceutical industry (Milanesi et al., 2020), expressing these preferences via paying a premium is currently impossible. The inability of consumers to express preferences through price premiums and share cost burdens with corporations is one example of how regulators can enable progress on ESG maturity by solving systemic issues. There are three key intermediaries between the consumer and the MAHs in the purchasing process that regulators can address to enable such expression of consumer preferences. The intermediaries directly in touch with the consumer are medical doctors who prescribe a certain drug and pharmacists who sell the prescribed drug or, based on the “*aut idem*” regulation, a cheaper drug with the same active ingredient to the patient. Regulators could enforce stronger patient education on the ESG impact of prescribed medications through these two parties to raise patient awareness.

Furthermore, they could enforce that doctors always prescribe the medication by the company with the stronger ESG focus if equally good alternatives exist on the market and that the “*aut idem*” regulation is adjusted to not only encourage cost saving for statutory health insurances (SHI) but also ESG criteria. The third intermediary is SHIs which impact pricing and availability through tenders. While in other European countries, such as the United Kingdom, Denmark, or Norway, ESG criteria are already a set part of tender processes, Germany lags behind on the issue with one SHI only including certain environmental aspects on antibiotic tenders. Regulators in Germany could speed up this process by enforcing the inclusion of ESG criteria in tender processes. Furthermore, our finding that MAHs consider regulation adherence a key motivator for corporate decisions is supported by research on motivators for CSR, which indicates that external pressure through regulation is indeed a key motivator (Shnyder et al., 2016). Regulatory bodies can thus furthermore incentivize companies to increase the priority of ESG topics. According to our findings, such regulations would be especially impactful in terms of ESG progress if corporations are included in the regulation development process.

Our study and its findings have several limitations. First, our assessment of ESG target-setting maturity was based on the collection of public data. Companies may choose not to disclose certain information and may leverage communication to benefit their business purposes. Thus the analysis has limitations based on the underlying data. The ESG rating scale reliability was assessed using ICC. Limitations of the ICC in our case are that estimates depend on the range of the measuring scale and the number of observers. To analyze the data on potential relationships between company ownership structure and ESG target-setting maturity, we leveraged a Kruskal-Wallis test. In this case, the analysis is limited by the differences in

sample group sizes, with one group only containing 7 subjects, which is rather small but still bigger than the necessary group size of 5. As the second part of the data was collected through interviews and analyzed leveraging thematic analysis, limitations of such an approach arise. While theoretical saturation was reached, the generalizability of results is limited by the sample size ($N = 14$). Furthermore, we focused our research on the German context. It is unclear to what extent results can be transferred to other countries.

7 | CONCLUSION

The results of our study answer the call for research on the current state of sustainability target-setting and implementation maturity of pharmaceutical MAHs in Germany. In line with this, we developed an ESG target-setting maturity assessment tool, which corporations can leverage in the future to track their progress or understand their position compared to the market they operate in, as well as by research when assessing ESG target-setting maturity. We further give a perspective on the effects of ESG measure implementation on supply chain security and what needs to be ensured to limit potential negative effects going forward. Our findings support what has been previously suggested by other researchers: sustainability measures can make supply chains more secure. However, risk factors have been identified that need to be considered in order to make MAHs more sustainable while limiting potential negative effects on supply chain security. We underline the importance of a collaborative effort between stakeholders, such as corporations, regulators, and consumers, to move toward more progress on ESG topics of MAHs in Germany. Corporations should leverage corporate culture and leadership to enable smooth change processes and start measure implementation timely to limit supply chain disruptions. Consumers play a crucial role in expressing their preferences in purchasing decisions, thus further incentivizing companies. However, both these parties must be enabled by regulatory bodies, as current pricing regulations, approval processes, and industry structures limit their ability to move forward on ESG topics effectively. Thus, we call for regulatory bodies to carefully revise current frameworks that MAHs are operating in for potential ESG-progress burdens and work collaboratively on enabling effective measure implementation without risking supply security.

Building on our work and its limitations, future research could leverage the developed ESG target-setting maturity assessment tool to investigate the topic in different country settings. Understanding potential differences between countries and why these exist would support a deeper understanding of sustainability efforts on a global scale and enhance the development of best practices. Furthermore, future research could develop an assessment tool for ESG measure implementation maturity so that gap analyses between target-setting and implementation maturity can be conducted to better understand the progress made. The comparison of supply chain risk-inducing factors when implementing ESG measures across industries is another research angle to follow in order to foster cross-industry learnings and best practice developments.

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APPENDIX A: CONSOLIDATED CRITERIA FOR REPORTING QUALITATIVE STUDIES (COREQ): 32-ITEM CHECKLIST

No.	Item	Guide question	Response
<i>Domain 1: Research team and reflexivity</i>			
Personal characteristics			
1.	Interviewer/facilitator	Which author/s conducted the interview or focus group?	Celina Bade carried out the interviews.
2.	Credentials	What were the researcher's credentials? e.g., PhD, MD	Celina Bade, M.Sc.; Philip Boehme, MD PhD; Leonard Fehring, MD; Hubert Trübel, MD PhD MBA; Alexandra Olsacher, M.Sc.; Lena Bürger, M.Sc.
3.	Occupation	What was their occupation at the time of the study?	Please see affiliations.
4.	Gender	Was the researcher male or female?	3 females, 3 males
5.	Experience and training	What experience or training did the researcher have?	Most of the researchers have years of experience in clinical and academic research.
Relationship with participants			
6.	Relationship established	Was a relationship established prior to study commencement?	There was no relationship established to the participants prior to the study commencement.
7.	Participant knowledge of the interviewer	What did the participants know about the researcher? e.g., personal goals, reasons for doing the research	The participants were aware that the interviewer was a researcher at the University of Witten/Herdecke pursuing a PhD with a research focus on sustainability and supply shortages for drugs in Germany. Additionally, the participants had a brief overview of the interviewer's professional background.
8.	Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g., Bias, assumptions, reasons and interests in the research topic	The interviewer reported information on their interest in the research topic as well as affiliation to the university and previous working experience.
<i>Domain 2: Study design</i>			
Theoretical framework			
9.	Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g., grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Grounded theory with data collection in form of semi-structured interviews and publicly available ESG target-setting data.
Participant selection			
10.	Sampling	How were participants selected? e.g., purposive, convenience, consecutive, snowball	Purposive sampling and more precisely theoretical sampling, as well as snowball sampling were used.
11.	Method of approach	How were participants approached? e.g., face-to-face, telephone, mail, email	Participants were approached via their professional E-Mail or linkedin.com profile.

(Continues)

No.	Item	Guide question	Response
12.	Sample size	How many participants were in the study?	After 14 participants (2 pilot participants not included), theoretical saturation was reached.
13.	Non-participation	How many people refused to participate or dropped out? Reasons?	13 participants refused to participate. The main reason for not participating was lack of time. 99 people never responded to the researchers.
Setting			
14.	Setting of data collection	Where was the data collected? e.g., home, clinic, workplace	Via telephone or video call. Most participants were at their office or at home.
15.	Presence of non-participants	Was anyone else present besides the participants and researchers?	No.
16.	Description of sample	What are the important characteristics of the sample? e.g., demographic data, date	78.6% of participants were male, 21.4% female. The number of years of experience in the pharmaceutical industry ranged from 5 to 38, with 18.5 being the median. Participants worked between 2 and 26 years for the same company they worked for at the time of the interview, the median amount of years was 7. The companies participants worked for reported between USD 37 million and USD 45 billion in net sales and employed between 13 and 99,580 employees, according to their most recent publicly available reporting. 71.4% of these companies have headquarters in Europe (35.7% in Germany), 14.3% in Asia, 7.1% in MENA and 7.1% in Africa outside MENA. 64.3% of companies are publicly traded, 21.4% family-owned and 14.3% PE-owned or publicly traded with family influence. Within their companies participants held roles such as COO, country head, head of strategy, supply chain director, sales director, or regulatory affairs manager. 71.4% of participants reported to be in touch with shortage related topics on a daily, 14.3% on a weekly and another 14.3% on a monthly basis.
Data collection			
17.	Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	No interview guideline was provided previous to the interview. The Interview guideline was previously tested in 2 pilot interviews.
18.	Repeat interviews	Were repeat interviews carried out? If yes, how many?	No.
19.	Audio/visual recording	Did the research use audio or visual recording to collect the data?	Each interview was audio recorded with the participant's consent.
20.	Field notes	Were field notes made during and/or after the interview or focus group?	Yes. Memos were used to record additional information emerging during the interview.
21.	Duration	What was the duration of the interviews or focus group?	Average duration of 62 minutes.
22.	Data saturation	Was data saturation discussed?	Yes.

No.	Item	Guide question	Response
23.	Transcripts returned	Were transcripts returned to participants for comment and/or correction?	Yes. 3 Participants requested to review transcripts. One participant requested language corrections.
<i>Domain 3: Analysis and findings</i>			
Data analysis			
24.	Number of data coders	How many data coders coded the data?	Two.
25.	Description of the coding tree	Did authors provide a description of the coding tree?	No.
26.	Derivation of themes	Were themes identified in advance or derived from the data?	Themes were then derived from the data.
27.	Software	What software, if applicable, was used to manage the data?	Audio recordings were done using OBS Studio Version 27.2.4, transcription was done using Trint, interviews were coded by using software MAXQDA® Software package 22.2.0
28.	Participant checking	Did participants provide feedback on the findings?	Participants did not receive findings prior to publishing.
Reporting			
29.	Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g., <i>participant number</i>	Quotations from interviews were anonymously presented in the results section to illustrate themes.
30.	Data and findings consistent	Was there consistency between the data presented and the findings?	Yes.
31.	Clarity of major themes	Were major themes clearly presented in the findings?	Yes.
32.	Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes.

APPENDIX B: ASSESSMENT OF ESG TARGET-SETTING MATURITY—MATURITY LEVEL ASSESSMENT SYSTEM

Maturity level	Definition	Example
0	The researched documents do not address any ESG related topics. Upon request the company did not provide additional information nor comment on the importance of ESG related topics.	
1	The researched documents address ESG topics or the company upon request stresses the importance of ESG to the firm without being able to provide concrete documents. However, there is no reporting of past progress or future ambitions available.	“Sustainability is of course a topic of high importance and its importance is increasing more and more.”
2	The researched documents include a reporting on past progress/ initiatives on ESG topics, however no ambitions for the future are communicated.	“A great example was the implementation of Veeva Vault PromoMats, which is a comprehensive solution for compliant, commercial content and digital asset management.”
3	The researched documents include a reporting on past progress/ initiatives on ESG topics and ambitions for the future. However, these ambitions are not quantified.	“It is, nevertheless, important to us to further increase the share of women in leadership positions.”
4	The researched documents include a reporting on past progress/ initiatives on ESG topics and ambitions for the future. However, these ambitions are only partially quantified.	“We plan a further 40% reduction on our 2019 carbon emissions by 2025.”
	For E: Only GHG emissions quantified	
	For S: Only employee diversity OR access to healthcare NOT both quantified	
	For G: Only board/top management diversity quantified	
5	The researched documents include a reporting on past progress/ initiatives on ESG topics and quantified ambitions for the future going beyond what is mentioned under level 4	“Reduce the amount of waste sent for disposal by half by 2025.”

APPENDIX C: INTERVIEW GUIDELINE SEMI-STRUCTURED INTERVIEWS

Intro

- Welcome and introduction of the interviewer; Notes on the interview procedure

Introductory questions

- How long have you been working in the pharmaceutical industry?
- How long have you been with your current company?
- How long have you been in supply chain related roles and how long have you been in your current role?
- What are your daily tasks and responsibilities?
- What kind of education have you undergone (diploma program, master's degree, etc.)?
- How did you become an expert in your field (e.g., through various positions, specialized additional training (specialized course, master's degree, etc.)?)

Main questions

For the upcoming question section, I would like to reflect with you on the influence of sustainability objectives. Sustainability is often associated with ESG factors, which are defined as environmental (E), social(S) and governance(G) factors that lead to sustainable corporate actions and operations. For example, E—water consumption, S—social engagement, G—ethical behavior and corruption.

a clear strategy for the dimensions E, S, and G and how strongly is this prioritized over other topics?

- In how far do you see sustainability being a priority in the pharmaceutical industry as a whole? Is it equally important to all players?
- What do you think drives ESG implementation and target setting in the pharmaceutical industry? What would it need to make it more of a priority for players?
- In general, do you think ESG objectives influence the occurrence of supply shortages? Are they in general more likely to lead to increased or decreased occurrence? Are any of the dimensions particularly impactful?
- What do you think is necessary to ensure a fast ESG progress while ensuring supply security in the short and long term?

Recap and Thank you

- Finally, could you point me to colleagues or others you know who might be able to support this research based on their expertise in supply chain or ESG topics?
- Do you have any other sources of information in mind that I should consult for the purpose of this research?

Outlook what happens next in the research with the answers.