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Minding the gap-relating disclosure to contexts of sustainability reporting in the automotive industry

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Abstract

Sustainability is a major issue in the automotive sector and players are at different points in their transition. Adopting a multi-method approach, we identify the positioning of automotive manufacturers in relation to sustainability, highlighting the main foci of their sustainability strategies. This is achieved using a topic model based on automated language processing. Subsequently, we use a Seemingly Unrelated Regression model, applied to manufacturers' operational data, to establish the degree of alignment between sustainability strategies and operations. Results show that sustainability in the automotive sector is highly differentiated and manufacturers emphasize diverging topics in their communication strategy and have different production practices. In relation to sustainability reporting, we identify certain operational variables, which are significantly related with certain dominant sustainability narratives.

KEYWORDS
automotive industry, corporate social responsibility, seemingly unrelated regression, sustainability reporting, text analysis

1 | INTRODUCTION

Clean mobility and sustainable technologies in the automotive sector present a major opportunity to contribute significantly to reaching not only national but also global climate goals (Hochfeld et al., 2017). However, the transition is also a challenge for the sector, in that it implies large-scale changes to their supply chains, business models, and wider operations (KPMG, 2021). With increasing electrification of propulsion technologies and hydrogen-based energy generation as well as new options for battery packs, multiple automotive manufacturers position themselves at the forefront of the sustainable mobility movement (IEA & Clean Energy Ministerial, 2019; MIT Energy Initiative, 2019). Still, this development must be seen alongside the emissions scandals of the not-so-distant past, where technological tricks and devices were used to conceal the actual emissions of vehicles (Bundesgerichtshof, 2020). The so-called Diesel-Scandal (Lin et al., 2020; Markowitz et al., 2017) increased the public focus on the automotive industry and also highlighted the challenges posed by the production processes involved in the manufacturing of the vehicles - an area in which little progress on sustainability had been made (Wolff et al., 2020).

Original equipment manufacturers' (OEMs') sustainability efforts are characterized by (i) a strategic dimension and (ii) an implementation dimension, with the latter representing a major research gap (Engert et al., 2016; Nathan, 2010; Wolff et al., 2020). The strategic concepts of sustainability must be implemented (Epstein & Roy, 2001; Raps, 2008) with strategy and implementation complementing one another. Here, corporate communication provides an important tool for offering transparency and accountability, although there exists potential for bias (Sukitsch et al., 2015). It is precisely dealing with this gap that we address in our analysis and we consider internal and external perspectives on OEMs' sustainability.

We investigate sustainability reports (SRs) of OEMs and use topic modeling, a technique for analyzing and classifying the contents of documents, to identify the focus of manufacturers' sustainability efforts. Accounting for each focus, we build a model to back the identified topics up with data about sustainability measures taken and use additional composite indicators of sustainability. Our approach can illustrate the focus of their sustainability efforts and identify subtopics. We use a specific sustainability measure from the production process and further external sustainability indicators. This aims at capturing emissions generated by the manufacturing process, which are also important to address (Kehbila et al., 2009). The model should be able to identify the manufacturers' main sustainability foci and uncover which factors, from the quantitative measures and indicators, correspond to their chosen narratives and which do not. This way a possible mismatch between communication about and implementation of measures can be identified. Furthermore, we investigate whether renowned sustainability indicators align with the OEMs' sustainability focus. By combining the topic model with operational data, we can suggest levers to steer toward increased climate awareness and accounting for policy makers and industry alike.

The paper is structured as follows: section 2 provides an overview of research in the area of sustainability in the automotive sector and underlines the need for a sustainable automotive sector. Section 3 delineates the methodology and presents the data, which is evaluated for results and discussed in section 4. Section 5 concludes and presents possible implications from the results.

2 | SUSTAINABILITY AND REPORTING

There exist several different ways to assess sustainability in the automotive industry due to the intangible nature of the concept of sustainability. While it is defined, for example, as an exchange of intergenerational needs and conservation efforts in the Brundtland report (Brundtland et al., 1987), it is mainly understood via the equality of ecological, economic, and social dimensions according to the narrative of the United Nations Sustainable Development (1992). Nevertheless, the fuzzy quality of the term "sustainability" makes relating different dimensions of sustainability to one another difficult and, in addition to a common understanding of sustainability, responsibility for goals and adequate measures are needed (Belkhir et al., 2017). A systemic approach is required that is able to equate the mobility system, extended life cycle considerations of the products, value and supply chains under a sustainable perspective (Weber et al., 2011).

Wolff et al. (2020) propose that while these changes have been external—policy-induced or are subject to public pressures—a shift toward intrinsic motivators for increased sustainability has taken place. In addition to technological advances, from an institutional view internal and external factors shape the outcome of managerial strategies (Damert & Baumgartner, 2018). OEMs but also other industries increasingly develop their own strategies, as technological progress through innovation can be understood as a competitive advantage and motivation (Salvado et al., 2015). Nevertheless, innovation economics reveals that path dependencies have constrained the long-term trajectory of the automobile industry and led to technological lock-ins (Aghion et al., 2019; Altenburg, 2014; Altenburg et al., 2016; Clausen et al., 2017).

Incorporating sustainability is further in line with the theory of signaling, which makes a plea in favor of the legitimation of actions and benefits from disclosure (Toms, 2002). This can be seen as an important factor in managerial strategies, as disclosure enables accountability and secures or increases market share and improves relations with stakeholders (Daub, 2007; Morhardt et al., 2002). From a strategic viewpoint, signaling is therefore positive for business (Luo & Bhattacharya, 2006; McElhaney, 2009; Porter & Kramer, 2006).

While the body of research has focused on the transition at the system level, there has been little focus on the gap between the individual manufacturers' sustainability strategies and their actual performance or implementation. The practice of sustainability reporting as a management tool is used to measure and disclose information relevant to sustainability via a strategy that lays down guiding principles (Fifka, 2014; Weber et al., 2011). It can also be regarded as a measure to improve communication, increase brand value and reputation by increasing transparency and conveying sustainability ambitions, which can be associated with successful sustainability performance (Beretta et al., 2021). Companies can use these practices to increase transparency to enhance their firm's value (Sutantoputra, 2009) and they must also decide on which information is important enough for stakeholders to merit inclusion in the report, as per the principle of materiality (Machado et al., 2021).

Shinkle and Spencer (2012) associate sustainability reports mostly with rhetorical resources to construct a corporate identity, to legitimate and authorize company behavior. These self-reports are, therefore, to be understood as strategic. At the same time, they are distinct across the companies to which they apply and the stakeholders to which they are addressed (Shinkle & Spencer, 2012). There exists no common framework for sustainability reporting and manufacturers can select how much they want to disclose in reporting. This also applies to the choice of whether they want to follow the Global Reporting Initiative's (GRI's) standards (Global Reporting Initiative, 2021), refer to the SDGs (United Nations, 2021a), or develop individual reporting schemes. This means that the comparability and reliability of the statements can be challenging despite partly mandatory obligations, and this has to be taken into account when interpreting the results of the models (Dietsche et al., 2019; Held et al., 2018; Siew, 2015). Additionally, this also applies regarding a limited transferability of strategic management of sustainability, which is why results from the automotive sector are not to be generalized easily (Salzmann et al., 2005).

Still, verification is not mandatory for this voluntary type of reporting, although auditing and assessment are theoretically part of the management process (Fifka, 2014), which leads to issues that can be labeled as "greenwashing." For instance, there are criticisms of TESLA concerning the failure to take into account the lifecycle environmental impacts of producing electric cars from, for example, material mining (Taffel, 2018). Credibility of the statements is often subject

to undisclosed internal processes of reporting in companies, which is why the possibility for independent assessment is limited. Still, it is seen as essential for stakeholder information and communication to foster understanding and participation (Aarseth et al., 2017; de Villiers et al., 2016; Engert et al., 2016; Lock & Seele, 2016; Sabini et al., 2019; Sukitsch et al., 2015).

In recent years, the research on sustainability reporting in the automotive industry has been investigated by a multitude of approaches (Engert & Baumgartner, 2016; Folkens & Schneider, 2019; Sukitsch et al., 2015; Truant et al., 2017). A main focus of analyses are OEMs, although there exist studies integrating the perspective of supplier industries as well (Damert & Baumgartner, 2018; Kehbila et al., 2009). OEMs face a "sensemaking" challenge of deciding in which bundles of technologies they should invest, namely connected cars, personal mobility, or autonomous vehicles (Teece, 2018). Lukin et al. (2022) also state that trends toward battery electric vehicles, hydrogen-fuel cell vehicles, and forms of hybrid vehicles pose important challenges for OEMs. They also find that the OEMs are more likely to focus on areas that are close to their strategies and where media attention is higher.

Wolff et al. (2020) propose to close the gap between strategy and implementation of sustainability practices via an "SDG Owner" responsible for shaping the change in the company. Engert and Baumgartner (2016) also suggest to bridge the gap by adding communication as a new factor essential to successful sustainability practice. Beretta et al. (2021) investigate the tone of environmental matters in non-financial reporting and find a positive relationship between performance and positive reporting narratives. Looking at GRIs, Bernard et al. (2015) also find a positive impact of of GRI reporting on sustainability performance. Russo-Spena et al. (2018) investigate corporate social responsibility (CSR) reports of companies with regard to common trends in disclosure practices, which is also supported by Damert and Baumgartner (2018), who look at clustering OEMs and suppliers and find different scopes of sustainability and a regionally differentiated effect, showing that the country of origin has importance in determining strategies of OEMs. This is also found by Levy and Kolk (2002). Sukitsch et al. (2015) define common categories of sustainability from reporting of OEMs, where besides awareness, initiatives involving mainly ecological, economic, and social topics are identified. Topics including energy consumption, education, and emissions are mentioned and prove to be main drivers of sustainability actions.

The divergence between the strategic vision of sustainability and its implementation within companies is the research gap that we seek to address. In particular, we aim to identify links between contextual topics and (i) performance indicators from the production processes and (ii) prominent sustainability indicators. This helps to identify the extent to which the communication of sustainability corresponds to the actual implementation of sustainability by OEMs. In summary, we target the following research questions: Based on their sustainability reports, how can automotive manufacturers' approaches to sustainability be characterized? Which selected external sustainability indicators can explain these topics and how are selected performance indicators of the OEMs related to the topics?

3 | METHODOLOGY

3.1 | Topic modeling

To cover most of the automotive market, 22 OEMs are selected. Together, these account for 90% of the total automotive market share (OICA, 2017). As a result of dissimilar reporting practices concerning the SRs, excerpts on sustainability matters from CSR reports are used where no SR is available. For the analysis, SRs or comparable reports (extracts) from up to 8 years during the period from 2013 to 2020 are analyzed.

Latent Dirichlet allocation (LDA) modeling allows the processing of large amounts of documents containing text and the modeling of a discrete number of topics from these documents. Blei et al. (2003) propose LDA topic modeling as an efficient generative probabilistic model, which considers each document as a random collection of topics. The method can be applied not only to documents but also to various other data sources, including for example, images. Topic modeling and text mining are widely applied to a multitude of different contexts, for example, in evaluating scientific literature and patent analyses and in relation to different industries, enterprises, or legal settings (Greene & Cross, 2017; Te Liew et al., 2014; Wang et al., 2020).

The SRs can be classified into different topics, illustrating the different foci of sustainability in the automobile manufacturers' strategies. The order of words (terms) in the SRs is neglected and the main outcomes are distributions of frequencies of different terms to topics and topics to documents. Results from modeling are reliable, effective, and efficient and provide valuable information about underlying contexts and topics of a set of documents (Blei et al., 2003). Furthermore, topic modeling is a type of unsupervised text modeling which allows the analysis of documents without biasing the outcome beforehand (Welbers et al., 2017). The only way to influence the outcome is by specifying the number of topics to be created, but the topics themselves are detected by the algorithm classifying the terms and cannot be prompted.

For our topic model of the automotive industry's sustainability standpoints, 113 SRs from 22 manufacturers are compiled into one document per manufacturer. This follows the assumption that the standpoints do not change significantly over the timeframe, as sustainability strategies and changes in their vision take time to be implemented (Kiesnere & Baumgartner, 2019). Moreover, for most of the manufacturers, only a few SRs are available. After calculating the words per topic and probabilities of manufacturers belonging to a topic, we determine the final number of topics and fix it at six. The topics consist of terms that point to a distinct sustainability focus that can be extracted from the SRs. The designations found by the algorithm are then validated by looking at the contents of specific SRs that are assigned to the particular topic by the LDA algorithm.

3.2 | Identification of sustainability standpoints

In Table 1, the final six topics and the most frequent words of each topic are listed. With LDA, terms are permitted to overlap between topics, which is reasonable, as sustainability is often broad and

TABLE 1 Topic model overview for 6-topic-model with the 6 most frequent words/themes, source: Own illustration

Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6
environment	product	vehicl	vehicl	compani	manag
plant	sustain	plant	sustain	activ	sustain
emiss	manag	emiss	employe	vehicl	product
vehicl	employe	product	global	manag	compani
challeng	vehicl	environment	program	product	activ
recycl	emiss	manag	emiss	employe	qualiti

TABLE 2 Designated topic themes, source: Own illustration

Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6
Environment	Production	Emissions	Globalization	Company Development	Management

TABLE 3 Results of the topic model: Focus of manufacturer's sustainability efforts, source: Own illustration

Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6
Environment	Sustainable Production	Emissions	Sustainable Globalization	Sustainable Company Development	Sustainable Management
Suzuki	BMW	Peugeot	Ford	Mazda	Honda
Mitsubishi	Volkswagen	Fiat/Chrysler	General Motors	Nissan	Hyundai
Dongfeng Motor	Daimler	BYD Auto	Tesla		Kia
Toyota			Geely		Beijing Automotive (BAIC)
Chongqing Changan			Renault		

consists of a multitude of issues. Still, this has to be taken into account when interpreting the results. A general theme emerges based on all of the most frequent words of the topics, which leads to the overarching themes named in Table 2.

For topic 1, the main theme is assigned a focus on *environment* and environmental considerations as a subtopic of sustainability. The second topic is designated *sustainable production*, whereas the third topic's focus is *emissions* as a major consideration; with emissions to be minimized within sustainability efforts. The fourth topic's emphasis is on a sustainable perspective about *globalization* and internationalization of strategies, while the fifth topic revolves around *sustainable company development* for internal development in the future. The final topic is assigned the focus of *sustainable management* of all company processes. With our topic model insights about the differing approaches of OEMs regarding sustainability in their reporting strategies can be given. The six topics all illustrate a different facet of sustainability. Additionally, it can be stated which documents, meaning which manufacturers, can be attributed to each topic. This decision is also made by the LDA algorithm and is exclusive—that is, a manufacturer can be assigned to only one topic. While terms can reoccur in multiple topics, documents are attributed uniquely. This leads to the distribution in Table 3. The documents by manufacturers Suzuki, Mitsubishi, Dongfeng Motor, Toyota, and Chonqing Changan can be assumed to all have a sustainability specialization focused on the environment (based on the LDA). A focus on sustainable production can be identified for BMW, Volkswagen, and Daimler. This is also in line with findings in literature, for example, regarding Daimler, Volkswagen and Toyota (see e.g., Shinkle & Spencer, 2012). The LDA estimates allocation probabilities for each of the topics, so that the results of Table 3 show the manufacturers according to the topic to which they have the highest probability of belonging.

Furthermore, it is apparent that manufacturers with a similar societal background seem to cluster together. This allocation may result from the different ways topics and issues are addressed in different societal/cultural environments and thus may also be a reason for forming the topics in the step before. This can also be aligned with findings of a 'home-country' effect (Damert & Baumgartner, 2018; Levy & Kolk, 2002).

3.3 | Seemingly unrelated regression

To build a model based on our six topics we back them up with further data about external indicators of sustainability and internal performance data of the OEMs and we collect data for three different composite sustainability indicators. We use the narrative assessment indicator from the World Benchmarking Alliance (WBA). The WBA ranks 25 automotive manufacturers according to their degree of alignment with the transition to a low-carbon economy. The narrative score (*WBAn*) analyses the companies' reporting under a holistic viewpoint, collecting commitments, transition planning, activities, and consistency. For the model, we transformed the ordinal ranking of *WBAn*

TABLE 4 Variable description, source: Own calculations

Short cut	Description	Min	Max	Average
T_i	Topic probability of a document belonging to a topic in % (T_1 = Environment, T_2 = Production, T_3 = Emissions, T_4 = Globalization, T_5 = Company Development, T_6 = Management)	0	1	-
CO2v	CO_2 emissions per vehicle produced in t/vehicle	0.27	1.18	0.62
Rev	Revenues (million €)	8150	234,107	80,499
Soci	Dummy for socio-cultural origin of the manufacturer (1 = Chinese, 2 = European, 3 = US-American, 4 = Japanese/Korean)	1	4	2.73
WBAn	World Benchmarking Alliance Automotive (WBA) narrative assessment score, where rankings A to E are converted with E = 1, D = 2, C = 3, B = 4, A = 5	1	4	2.5
ACTp	Assessing low-Carbon Transition (ACT) performance score	3.5	13.2	8.16
CSRhub	Environment, Social, Governance Ranking by CSRhub (%) compared with 28,485 companies	34	96	79.45

to a numeric scale. The WBA also provides a performance score that comprises company data like investment, product performance, supplier engagement and business model. The WBA metrics are based on the methodology from the organization assessing low carbon transition (ACT) that also provide a transition alignment metric. Due to multicollinearity and because the ACT score is available for more OEMs, the WBA performance score is omitted for our model (World Benchmarking Alliance, 2022). The ACT performance score (ACTp) includes emission indicators, investment, R&D as well as fleet efficiency (Assessing low-Carbon Transition, 2020). The final indicator we use is the ratings from CSRhub (*CSRhub*), where corporate social responsibility is sourced according to a common schema of categories where companies are investigated. After conversion to a numeric scale, data is normalized and aggregated and this results in a rating for each company. The latter is only produced if sufficient information is available to give a reliable value, which we use as a measure of general corporate performance (CSRhub, 2022).

For the internal performance dimensions, the SRs and accompanying material, as well as financial reports give information about the actual sustainability and environmental friendliness of the automotive manufacturers' production processes. The SRs alone present only visions and plans, but do not reveal whether or not the production is sustainable. However, data rely on the reporting accuracy of the manufacturers and the latter do not all report every available sustainability indicator. For example, only in some SRs, there are detailed reports about energy and water consumption per vehicle produced, or information about process wastewater of volatile organic compounds is provided. In the production processes, these are the major negative environmental aspects (Nunes & Bennett, 2010). Unfortunately, these data are not available consistently for all OEMs. All used covariates are listed in Table 4.

CO2v shows the CO_2 emissions generated by the production of vehicles, divided by the number of vehicles produced. This covers the CO_2 emissions according to scope 1 and scope 2 of the GHG protocol (GHG Protocol, 2004), which also includes the indirect emissions, for example, electricity used for the operation of the production processes, excluding transport-related emissions of the use-phase of the vehicle, which explains why battery electric vehicles have a slightly higher *CO2v* than combustion engines (Qiao et al., 2017, p. 3588). We assume a negative relationship between CO_2 emissions and the sustainability topics, as lower emissions are favorable, although literature is not clear about this point (Belkhir et al., 2017; Nazari et al., 2015). Revenue of manufacturers is used to approximate the economic influence of a manufacturer, as it is assumed that higher revenues go hand in hand with larger and more successful companies. This can influence the extensiveness of the reports (Damert & Baumgartner, 2018; Lee, 2012). The covariate for societal factors accounts for cultural differences in general management, company philosophy, and is, thus, expected to influence sustainability communication (Mohamed Adnan et al., 2018), where Damert and Baumgartner (2018) find a home-country effect influencing the sustainability strategies of corporations. To ensure normality in the distribution of the data and the residuals, all variables are logarithmized.

As the six topics that are generated also give information about the documents' probability of belonging to a particular topic, in other words, the manufacturers' alignment with a certain sustainability focus, this information is used to form the dependent variable of the regression model, T_i with $i = 1, \ldots, 6$ for each of the six topics. We approach the different probabilities of a manufacturer belonging to a particular topic by estimating a seemingly unrelated regression (SUR) model. A SUR is an estimation procedure for a system of multiple equations whose error terms are contemporaneously correlated. Unknown factors influencing the error term in one equation possibly additionally influence the error terms of the other equations. Ignoring these influences leads to inefficient estimates. The SUR can comply with these challenges and estimates the parameters of all equations simultaneously so that the parameters of each equation also take into account the other equations. In addition, there exist efficiency gains that increase according to the correlation among the error terms, higher multi-collinearity, as well as the larger sample size

(Henningsen & Hamann, 2008; Zellner, 1962). Using a SUR, equations for the six topics can be estimated simultaneously. This is reasonable, as the topics are assumed to be related to each other because they all exhibit different sides or interpretations of sustainability. A single equation model is not supported under this premise.

The SUR model can be written as $Y = X\beta + \varepsilon$, where the dependent variables are a stacked vector $Y = (y'_1, y'_2, ..., y'_6)$ and the covariates X are a diagonal matrix, where the *i*th design matrix *X_i* is on the *ii*th block, and $\beta = (\beta'_1, \beta'_2, ..., \beta'_6)$ is the stacked coefficient vector for all equations. For our six topics a total of six submodels are estimated $K = \sum_{i=1}^{6} k_i$ and the stacked error terms of all equations are $\varepsilon = (\varepsilon'_1, \varepsilon'_2, ..., \varepsilon'_6)$ (Henningsen & Hamann, 2008).

In our case, one exemplary equation of the SUR is presented by Equation (1), where ε_i with $i = 1, ..., 6$ show the contemporaneously correlated disturbance terms across the equations. Each equation stands for one of the topics, where we relate the covariates to the communicated sustainability subtopics of the manufacturers. In doing this, the model can answer how the external sustainability indicators and the internal performance data of the manufacturers correspond to their sustainability reporting strategy.

$$K_i = \beta_0 + \beta_1 CO2v_i + \beta_2 rev_i + \beta_3 soci_i + \beta_4 WBAn_i + \beta_5 ACTp_i + \beta_6 CSRhub_i + \varepsilon_i \quad (1)$$

4 | RESULTS AND DISCUSSION

The estimates of the variables related to the likelihood of belonging to a particular sustainability topic are listed in Table 5 (for supplementary estimation results see Table A1).

Among the estimates, significant and negative on 10% level are the *CSRhub* score and *WBAn* score for topic 1 (*environment*). For topic 5 (*sustainable company development*) the *societal factor* is relevant, as well as the *WBAn* score (positive). For topic 6 (*sustainable management*), *CO_2 per vehicle produced* is significant and positive. The reduced model improves the significances for topic 3, 4, 5, and 6.

Lower emissions in the production process per produced vehicle affect the topics globalization and management positively and significantly. For these topics, higher production emissions are detrimental to the narratives of their sustainability strategies. What is notable is the negative estimated effect on the topic environment, where the narrative does not seem to be suffering. Generally, though, the relation of CO_2 emissions and reporting has to be treated with caution, as Bernard et al. (2015) states, as it is only one of many factors that can be used to attribute sustainability.

The societal dimension seems to affect topics differently. Some of these dummy variables for the topic *globalization* are significant, hinting at a global scope in the sustainable narrative, where cultural differences nevertheless seem not to be as relevant. This is underlined by the effects' significance for sustainable company development, as they are often subject to cultural differences. The direction of the effects varies and is only consistently negative for *environment* and *sustainable company development*. Thus, it can be reasoned that especially these sustainability strategies and companies assigned to these strategies are relatively more dependent on a home country effect and can exhibit distinctions (Levy & Kolk, 2002). The results further show that especially European and US-American OEMs differ from OEMs from Asian countries regarding these strategies, which is due to different historic cultural developments (Chikudate, 2009; Wong, 2009).

Regarding the internal performance indicators, *revenue*, which can approximate the size of the OEM, seems to be positively related to environment, production, and globalization. This can point to larger, possibly multi-national corporations being more aware toward the environment and sustainable production processes as border-crossing strategic issues. This is in line with Damert and Baumgartner (2018), who also state that larger firms seem to be more elaborate in their strategies. This can be used to explain variation in the sustainability strategies (Engau & Hoffmann, 2009; Lee, 2012; Weinhofer & Hoffmann, 2010). Beretta et al. (2021) also reflect on this issue and see it of high relevance concerning the automotive industry. Additionally, disclosure is seen as price elastic here, that is, able to influence demand and reflected in willingness to pay (Beretta et al., 2021; Hahn & Lülfs, 2014). However, the relationship with financial capabilities is not necessarily observed (Damert & Baumgartner, 2018).

Concerning the external sustainability indicators selected, their effects vary like the other covariates. The indicator for the CSRhub is positively related to all topics except *environment*, *globalization*, and *mangement*. A closer link to matters of corporate scope like company development or production issues makes sense as CSR is also a broader topic that focuses on societal and economic sustainability dimensions as well. CSR strategies relate directly to for example, reputation, improved profitability, and lower cost (Dhaliwal et al., 2011; Eccles et al., 2011; Guenster et al., 2011), as well as management (Barnett & Salomon, 2012). However, it is only significant for the topic environment, where it exhibits a negative coefficient. The WBA narrative indicator is significant for topic environment and also related to sustainable company development. Whereas it seems to relate to environment negatively, for sustainable company development the relationship is positive. A better narrative seems to be congruent with better company development regarding sustainability, which coincides with Beretta et al. (2021) that point out tone is important for reporting. Approximating these strategies via this indicator can be a proposal resulting from our model. Nevertheless, the reduced model is not able to increase this indicator's significance. The ACT performance indicator seems to be positively related to management on a 13% significance level, but the effect's direction varies across topics. Environment as defined via our topic thus is rather inversely related to the CSRhub score. As the indicators' effects vary across the topics in direction, a general application of the indicators we used for matters of approximating our topics cannot be demonstrated.

This points to the topics being diversified enough to warrant a distinguished consideration as differing strategies and focal points within sustainability. Sustainability should not, according to the model's outcome, be regarded as a uniform matter for OEMs, as different topics seem to justify different sustainability performance indicators. Therefore, not all manufacturers concentrate on the same

TABLE 5 Estimation results of the SUR model, source: Own calculations

		Topic 1: Environment		Topic 2: Sustainable production		Topic 3: Emissions		Topic 4: Globalization		Topic 5: Sustainable company development		Topic 6: Sustainable management	
		Full model	Reduced model	Full model	Reduced model	Full model	Reduced model	Full model	Reduced model	Full model	Reduced model	Full model	Reduced model
Intercept	Estimate	3.689	6.683	−2.723	−1.137	3.188	4.614	−1.789	−0.855	1.091	−1.624	−5.499	−1.511
	SE	5.139	4.399	4.103	0.294	4.614	2.142	3.138	0.265	3.819	0.406	4.709	1.311
	t-Value	0.718	1.519	−0.664	−3.875	0.691	2.155	−0.570	−3.226	0.286	−4.005	−1.168	−1.152
	Pr(>|t|)	0.485	0.149	0.519	0.001***	0.502	0.044*	0.578	0.005**	0.780	0.001***	0.264	0.263
CO2v	Estimate	−2.765	−1.383	1.376	1.545	1.113		1.515	1.685	−0.695		2.951	2.330
	SE	1.785	1.401	1.245	0.944	1.405		0.952	0.576	1.165		1.428	1.090
	t-Value	−1.549	−0.987	1.105	1.637	0.792		1.591	2.927	−0.597		2.066	2.138
	Pr(>|t|)	0.144	0.339	0.289	0.117	0.443		0.136	0.009**	0.561		0.059.	0.046*
rev	Estimate	0.637		0.059		−0.547	−0.584	0.100		−0.052		−0.264	
	SE	0.526		0.372		0.419	0.196	0.284		0.348		0.427	
	t-Value	1.212		0.159		−1.305	−2.983	0.350		−0.149		−0.620	
	Pr(>|t|)	0.246		0.876		0.215	0.007**	0.732		0.884		0.546	
soci_2 eu	Estimate	−1.724	−1.079	0.503		0.819		−0.145	0.216	−1.466	−1.487	−0.943	
	SE	1.183	0.943	0.821		0.926		0.628	0.326	0.768	0.500	0.942	
	t-Value	−1.457	−1.144	0.614		0.884		−0.231	0.660	−1.909	−2.974	−1.001	
	Pr(>|t|)	0.167	0.270	0.550		0.393		0.821	0.518	0.079.	0.009**	0.335	
soci_3 us	Estimate	−1.566	−1.128	−0.406		−0.253		0.731	1.181	−0.949	−1.069	−1.055	
	SE	0.945	0.850	0.659		0.743		0.504	0.342	0.616	0.494	0.756	
	t-Value	−1.657	−1.326	−0.616		−0.340		1.452	3.453	−1.541	−2.163	−1.396	
	Pr(>|t|)	0.120	0.205	0.548		0.739		0.170	0.003**	0.147	0.045*	0.186	
soci_4 jpkr	Estimate	−1.445	−0.445	−0.736		−0.734		−0.363	0.141	−0.413	−0.265	0.043	
	SE	1.079	0.818	0.755		0.852		0.577	0.309	0.706	0.425	0.866	
	t-Value	−1.339	−0.545	−0.975		−0.862		−0.628	0.455	−0.585	−0.624	0.049	
	Pr(>|t|)	0.202	0.594	0.348		0.404		0.541	0.655	0.569	0.541	0.961	
CSRhub	Estimate	−5.649	−3.931	0.058		0.569		−0.071		−0.632		2.742	
	SE	2.908	2.522	2.186		2.462		1.672		2.039		2.508	
	t-value	−1.943	−1.559	0.027		0.231		−0.043		−0.310		1.093	
	Pr(>|t|)	0.072	0.140	0.979		0.821		0.967		0.762		0.294	

TABLE 5 (Continued)

		Topic 1: Environment		Topic 2: Sustainable production		Topic 3: Emissions		Topic 4: Globalization		Topic 5: Sustainable company development		Topic 6: Sustainable management	
		Full model	Reduced model	Full model	Reduced model	Full model	Reduced model	Full model	Reduced model	Full model	Reduced model	Full model	Reduced model
WBAn	Estimate	−4.507	−3.377	−0.915		−1.084		0.640		3.035	1.616	−0.260	
	SE	2.195	1.939	1.629		1.836		1.246		1.521	0.991	1.870	
	t-Value	−2.053	−1.742	−0.562		−0.590		0.514		1.996	1.630	−0.139	
	Pr(>|t|)	0.059.	0.102	0.584		0.565		0.616		0.067.	0.121	0.892	
ACTp	Estimate	−3.62		1.496		0.806		0.074		−1.829		3.068	0.408
	SE	2.454		1.636		1.821		1.250		1.498		1.879	1.418
	t-Value	−0.280		0.914		0.443		0.059		−1.221		1.633	0.288
	Pr(>|t|)	0.784		0.377		0.665		0.954		0.244		0.127	0.777

Note: Signif. codes: 0 "***" 0.001 "**" 0.01 "*" 0.05 "." 0.1 "" 1.

indicators, as there are distinct points of emphasis observable. For instance, *CO_2 per vehicle produced* seems to be negatively related to the topics *environment* and *sustainable company development*, and positively to *sustainable production*, *sustainable globalization*, *emissions* and *sustainable management*, which can be understood from the different emphases of the topics. This is in line with research that investigates the role of emission measurements in sustainability strategies (see e.g., Bernard et al., 2015; Damert & Baumgartner, 2018; Nazari et al., 2015). Additionally, this illustrates that emissions of the OEMs' production are only one component of sustainability. As our variable only measures emissions according to a scope that might be too focused on the production, it is necessary to consider a broader concept. For OEMs, the complete process of production, including the whole supply chain, is relevant. This is further increasing uncertainty considering the interpretation (Nunes & Bennett, 2010; Salvado et al., 2015).

We did extensive model testing regarding the benefit of incorporating the different covariates and applied likelihood ratio tests on all the different model specifications. The reduced model contains all covariates on a significance level of 20% or lower, as results regarding significance varied across topics and we did not want to eliminate relevant influences or remove complete equations (Cadavez & Henningsen, 2012). Still, this leads to a considerably worse model fit, although significance is positively impacted. The final full model is able to explain 71% of the variation in the topics (McElroy-R^2), which surpasses the fit of the OLS model ($R^2 = 57\%$). The necessity for the SUR model is based on theoretical considerations and did produce a better or an at least comparable fit. The likelihood ratio test also suggested that the model is preferred to various other variations of the model (e.g., reduced model, model without societal factor, model without additional sustainability indicators at all). The fitting quality was further checked by evaluating the individual equations' coefficients of estimation, where topic 1 produces the best fit, followed by topic 3. This suggests that the set of covariates is deemed best for analyzing sustainability topics concerning the *emissions* and *environment* in general. Topics with a low individual fit like topic 5 (sustainable company development) and 6 (sustainable management) can illustrate that these specific strategic points need to be addressed differently.

5 | CONCLUSION AND IMPLICATIONS

The results from the topic model together with the SUR are able to offer insights into the emphasis the automotive industry places on sustainability, in general, while they also allow an assessment of the degree of alignment between claims made and indicators measuring OEMs' actual performance. Our categorization can lead to a better understanding of the strategic objectives of manufacturers in relation to sustainability and how policy levers could better target certain groups to achieve decarbonization goals. Nevertheless, the scope of the reports varies in terms of their coverage of sustainability and this is due to different strategic background processes. This represents a weakness of SRs than can be alleviated by collecting several reports

from OEMs, increasing the data for our model (Daub, 2007; Mendes et al., 2019).

However, the consistency of manufacturers' statements is only evaluated by comparing the claims of the SRs with the sustainability indicators, which are two sources from the same origin. Thus, the analyses rely on the trustworthiness of these statements. If either is inaccurate or incomplete, this is by design and decision of the OEMs and where they avoided disclosure, the interpretations of the analyses are also affected (Sukitsch et al., 2015). As Nazari et al. (2015) find, the sustainability reporting addresses stated performance, which fuels a feedback loop where credibility of the statements becomes an issue. A reason can be attributed to a failure of management tools. This can be traced back to the increasingly difficult challenges OEMs face while they are held accountable by stakeholders regarding sustainability, namely: uncertainty, complexity and ambiguity in a highly dynamic field (Bennett & Lemoine, 2014a; Bennett & Lemoine, 2014b). This instability makes causal interpretations difficult, which are also not necessarily positively affected by external auditing (Truant et al., 2017). Nevertheless, without measures to hold companies to account, reliability will continue to be an issue (Russo-Spena et al., 2018). Additionally, international presence, experience in reporting and optimistic tones in reporting are, therefore, seen as favorable (Beretta et al., 2021; Truant et al., 2017). For practitioners in the automotive sector, these would be major points to consider during strategy development.

A standardization of reporting practices also needs industry-wide consistency across time, as highly subjective reporting does not necessarily enable evaluation and comparison and might incentivize greenwashing (Bernard et al., 2015). Several claims regarding manipulated disclosure arise, even before the latest scandals considering Volkswagen and other manufacturers (Arena et al., 2015; Lyon & Maxwell, 2011). An environmental management system or audit/certification structure would potentially address these concerns. However, the success of external audits is likely to vary, so external pressure from the public should not be ignored (Truant et al., 2017), as literature suggests that increased transparency and truthfulness should benefit business (Wolff et al., 2020). Emission standards relating to average-fleet values are not sufficient, as vehicle models can offset one another (Hörmandinger, 2020). It is, furthermore, important that that the manufacturing practices are taken into account. This becomes especially relevant for battery-electric vehicles, where a life-cycle emissions assessment of vehicles is needed to account for unsustainable manufacturing processes (Philippot et al., 2019). Nevertheless, funds allocated should address sustainable innovations to reach goals and not lead to end-of-pipe technologies. Concerning German manufacturers, at COP26, only Daimler signed up to a pledge to phase out conventional vehicles by 2035, with Volkswagen and others refusing to explicitly do so (United Nations, 2021b). Our analysis supporting distinct categorization of sustainability could help to understand how to persuade these manufacturers to shift fully toward alternative powertrains. Summing up, we suggest these issues as main targets for policy makers striving to persuade the automotive sector to move toward climate neutrality.

We can state that the results from the topic model offer distinctly different insights into manufacturers' sustainability efforts. The core dimensions of sustainability—ecological, social, economic—are mirrored in our results. We can further support the notion of different strategic sustainability positions of the OEMs, which correlate to a varying degree with internal performance as well as external sustainability measures such as the scores by CSRhub or the WBA. Nevertheless, there are no single indicators that prove an equal direction of effect across all sustainability strategies. The indicator from CSRhub seems to be positively related to the more social and economic strategies of sustainability. Additionally, we find that societal "home-country" effects explain some of the variation in these strategies, especially between Asian OEMs and OEMs of other cultural origins, even though most OEMs operate internationally.

Concluding our analyses, we can support the notion of a differentiated view of sustainability in OEMs that results from divergent core strategies. Internal performance is able to capture variation in the strategies, but external pressure through, for example, independent sustainability indicators is essential for increasing the reliability of OEMs' sustainability reporting. Composite indicators, despite often covering a broad array of measures, are often only a partial view of the dimension of sustainability. To guide the automotive sector on its path toward contributing further to reaching climate goals, we suggest a differentiated set of external indicators, corresponding to the different sustainability focal points of OEMs, in combination with mandatory reporting standards comparable across regions and time.

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APPENDIX

SUR RESULTS OF THE 5-EQUATION-MODEL

TABLE A1 Augmented results of the SUR model

	N	DF	SSR	detRCov	OLS-R^2	McElroy-R^2
System	110	65	46.2	0.026	0.568	0.714
	N	**DF**	**SSR**	**MSE**	**RMSE**	**R^2**	**Adj. R^2**
Topic 1	22	110	65	46.2	0.026	0.568	0.714
Topic 2	22	110	65	46.2	0.026	0.568	0.714
Topic 3	22	110	65	46.2	0.026	0.568	0.714
Topic 4	22	110	65	46.2	0.026	0.568	0.714
Topic 5	22	110	65	46.2	0.026	0.568	0.714
The covariance matrix of the residuals used for estimation							
	Topic 1	**Topic 2**	**Topic 3**	**Topic 4**	**Topic 5**		
Topic 1	1.327	0.091	0.195	0.074	0.191		
Topic 2	0.091	0.596	−0.221	0.145	0.231		
Topic 3	0.195	−0.221	0.759	0.270	−0.034		
Topic 4	0.074	0.145	0.270	0.349	0.192		
Topic 5	0.191	0.231	−0.034	0.192	0.522		
The covariance matrix of the residuals							
	Topic 1	**Topic 2**	**Topic 3**	**Topic 4**	**Topic 5**		
Topic 1	1.327	0.091	0.195	0.074	0.191		
Topic 2	0.091	0.596	−0.221	0.145	0.231		
Topic 3	0.195	−0.221	0.759	0.270	−0.034		
Topic 4	0.074	0.145	0.270	0.349	0.192		
Topic 5	0.191	0.231	−0.034	0.192	0.522		
The correlations of the residuals							
	Topic 1	**Topic 2**	**Topic 3**	**Topic 4**	**Topic 5**		
Topic 1	1	0.102	0.194	0.109	0.229		
Topic 2	0.102	1	−0.328	0.317	0.415		
Topic 3	0.194	−0.328	1	0.524	−0.053		
Topic 4	0.109	0.317	0.524	1	0.449		
Topic 5	0.229	0.415	−0.053	0.449	1		