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SUSTAINABLE AND TRANSPARENT PURCHASING IN THE AUTOMOTIVE INDUSTRY[*]

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Abstract. Sustainable purchasing in the automotive industry is present as never before. The Supply Chain Act in Germany and the European Green Deal (EGD) are legal incentives to focus on sustainability across industries. The automotive industry is large and important in Europe, which implements new purchasing channels through the supply chains. Suppliers are usually Small and medium-sized enterprises (SMEs), which account for 99% of the European economy (Europäische Kommission, 2003). Original Equipment Manufacturers (OEMs) have already passed on their climate neutrality targets to suppliers and called for worldwide engagement throughout the supply chain. In addition to the necessary emission reductions in the individual parts of the value chain, there are growing demands for a product footprint to show the CO_2 emissions for the supplied parts. The CO_2 emissions should be systematically reduced. This study shows how transparency in purchasing can be created and how this transparency can be used to impact sustainable purchasing. This study continues different studies chronologically from 2016 until March 2022. The results are confirmed by ten expert interviews with specialists in the automotive industry. The focus is on digitisation in purchasing and is linked to the resulting transparency. Transparency shows how the impact on sustainable purchasing can be increased by using cost brake downs (CBD) and provides an outlook on CO_2 CBD (Product Carbon Footprint) to reduce CO_2 emissions.

Keywords: Automotive Industry; Purchasing 4.0; Purchasing; Sustainibility; Product Carbon Footprint

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1. Introduction

Governments and business leaders worldwide are working together to create policies and procurement processes that encourage using sustainable materials, components and products, aiming to decrease greenhouse gas emissions and support sustainable development initiatives (Rebane, Reihan, 2016; Marcysiak, 2020; Gubíniová, et al. 2019). The continuous carbon emissions from the manufacturing sector raise concerns among industrialists and policymakers about the effectiveness of operational adjustments and current or proposed strategies in meeting the Paris Agreement targets. Addressing the complex nature of industrial challenges and opportunities requires collaboration and the development of open-source toolboxes that span all business disciplines, supported by a common language, enabling professionals to communicate easily, which will foster responsible consumption and production practices more readily (Huaccho Huatuco, Ball, 2019; Mishra, Singh, 2021). Low-carbon manufacturing, which focuses on reducing emissions through efficient resource utilisation, has become an important research area due to increasing public concern (Holotová, et al. 2023; Peráček, 2020). Numerous researchers explore the triple bottom line and low-carbon supply chains, developing four decentralised supply chain models to determine optimal pricing decisions, carbon emissions, sales quantities, and profits (Miklosik et al. 2021; Lorincova, et al. 2022). These models provide a reliable theoretical foundation for low-carbon firms to select emission reduction strategies while considering stakeholder approaches and adapting to evolving customer perceptions (Gubíniová et al., 2019). The automotive industry is a critical actor in implementing and realising new technologies and new sustainable requirements. The current situation of regulations, restrictions and supply chain disruptions presents unprecedented challenges for the industry (Spieske et al., 2022). The demand for climate neutrality is no longer just a matter of CSR requirements but is now regulated by law (Ma, Lu, 2023). One measure is a registration stop for vehicles with gasoline engines from 2035, except for vehicles that can be operated with e-fuel or CO_2-neutral (Die Bundesregierung, 2023). The transformation from the classic combustion engine to the electric vehicle must be achieved to meet the Paris Agreement's legal requirements to limit the temperature increase to 1.5°C if possible (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, 2015). The European Parliament defines climate neutrality as the balance between generated carbon emissions and the absorption capacity from the atmosphere. Net-zero emissions are achieved when greenhouse gas emissions vs carbon capture are balanced globally (Europäisches Parlament, 2022). This includes not only carbon dioxide (CO_2) but also gases such as methane (CH4), nitrous oxide (N2O), and various fluorinated greenhouse gases (F-gas) (Umweltbundesamt, 2020). Climate neutrality is scientifically clear, but companies can buy certificates certifying their own production's climate neutrality (Werner, 2021 & Climate Extender, 2023).

According to Table 1 from its direct suppliers, the automotive industry claims climate neutrality. The European economy consists of 99% SMEs, which have to realise this task within the supply chains (Europäische Kommission, 2003). In this context, purchasing is given a particular role and, in addition to cost reduction programs, must also implement the new legal regulations of the Supply Chain Act and guarantee climate neutrality in the supply chain. The OEMs have already defined carbon neutrality goals (Mercedes Benz Group, 2023; BMW, 2023; Volkswagen Group, 2023; Volvo, 2023 & General Motors, 2023), in some cases scaled according to Scope 1, Scope 2 and Scope 3 (see Table 1). Scope 1 emissions are generated directly in the company's value chain at the production facilities. Scope 2 is emissions that are related to electricity consumption. Scope 3 are external emissions, e.g. at suppliers or on the transport from suppliers or to customers (Hertwich, Wood, 2018 & Ganda, Milondzo, 2018). The development of new powertrain technologies takes place all the time. It is a double challenge for the supplier industry: conventional technologies must continue to be supplied, and at the same time, high investments must be made in the new technologies.

Table 1. OEMs Carbon Neutrality Goals

OEM | Organization | County	The goal of Carbon Neutrality	Special Term for Scope 1 & 2
Daimler AG	2039 | 2040	
BMW AG	2050	
Volkswagen AG	2050	2035
Volvo	2040	2025
General Motors	2040	
Paris Agreement	2050	
Germany	2050	

Source: Own Table

The Greenhouse Gas Protocol defines Scope 1 as emissions of gases directly produced by a company through heating, operation of vehicles and so on. Scope 2 includes the greenhouse gases that were generated for the production of the electricity that is used. Scope 3 includes external indirect emissions, such as purchased materials or greenhouse gas emissions generated by transport (Greenhouse Gas Protocol, 2004).

A cross-sector benchmark by the Carbon Disclosure Project from 2014 surveyed different industries. The study was evaluated on the share of CO_2 emissions from Scope 1-3. Based on the automotive sector's values, Scope 1, with 2% and Scope 2, with 4%, have a tiny part in CO_2 emissions. Scope 3, with a share of 94%, is the most critical lever for CO_2 reduction in the automotive industry (Carbon Disclosure Project, 2014). The automotive industry focuses on making the emissions from Scope 3 transparent and reducing them significantly, as the leverage is very high in relation to Scope 1 & 2. The other industry sectors differ in emission levels and are not analysed and considered further in this study.

Transparency is special in this context because it enables accurate tracking and management of emissions across the entire value chain (Miklosik et al., 2021). This, in turn, fosters informed decision-making and targeted actions for reducing CO_2 emissions more effectively. Different levels of fabricated products must be considered to define the greatest possible impact factors in manufacturing. Purchasing is critical if emissions are to be impacted in Scope 3. Sustainability must be focused on along the whole supply chain to achieve a balanced emission ratio. Purchasing must guarantee that the use of resources for the purchased products is specified so that future generations are not restricted in the availability of these resources (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, 2023).

This study identifies how transparency can be created in purchasing and how this transparency can be used to impact sustainable purchasing. For this purpose, existing studies are used, as well as data from the own survey.

2. Theoretical background

The challenge is creating transparency that makes measuring and influencing emission levels possible. Since Mr. José Ignacio López de Arriortúa Lopez implemented cost transparency in sourcing decisions as chief buyer of Volkswagen AG in 1993, the transparency of product costs has increased through Cost Break-Downs (CBD) (Meissner, 2012). Today, this instrument has been developed to the extent that supplier nominations can be made with the help of a variety of decision criteria. Besides material and manufacturing costs, logistics costs, packaging costs, quality factors, or overhead costs can be included in the strategic decisions.

Within the theoretical framework of cost transparency in the automotive supply chain, new tools and innovations are paving the way for companies to attain enhanced supply chain transparency (Singh, 2015). This, in turn, significantly bolsters organisational endeavours in achieving cost transparency. By leveraging cutting-edge technologies and innovative solutions, businesses can access and analyse accurate, real-time information, fostering trust and collaboration among supply chain partners. (Stacho et. al., 2023, Kohnova, Salajova, 2023). IoT technologies, such as barcoding, RFIDs, and carbon labelling, enable tracking of product components and raw materials throughout the product life cycle, streamlining production and logistics processes while monitoring real-time carbon emissions. The data from central repositories can be used to evaluate product life expectancy and potential carbon emissions during use, helping management make informed decisions about raw materials and components to minimise environmental impacts (Mishra, Singh, 2021).

Consequently, this transparency enables stakeholders to identify inefficiencies, optimise processes, and make informed decisions, ultimately contributing to cost reductions and increased competitiveness in the automotive industry. Digital technologies and innovative tools foster flexibility and agility in the supply chain by enabling real-time data collection, monitoring, and analysis (Qamar, Hall, Collinson, 2018). Companies can quickly identify trends, respond to changes, and make informed decisions, enhancing their ability to adapt to varying customer demands and market conditions, not only in the corporate world (Iqbal, Ahmad, 2022). Industry 4.0 technologies, such as IoT, AI, blockchain, and big data analytics, facilitate communication and collaboration among supply chain partners, leading to leaner and more efficient processes while reducing waste. By integrating digital solutions, smart supply chains become more flexible, agile, and responsive, driving efficiency and promoting circular economy strategies that lead to joint emission reduction decisions, improved profits, and better collaboration among all supply chain members for a multi-win outcome (Mishra, Singh, 2021; Gažová et al., 2022; Yousaf et al., 2023)

Integrating lean and agile methodologies has been demonstrated to enhance a firm's performance by offering benefits such as increased efficiency, waste elimination, and rapid adaptation to diverse and unpredictable customer demands (Raji et al., 2021). The primary objective of implementing digital technologies, such as Industry 4.0, is to boost operational efficiency, leading to improved performance (Kohnova, Salajova, 2023). Managers contemplating the adoption of these technologies require a compelling incentive. The potential performance impacts of integrating digital technologies with supply chain operations warrant investigation, as previous studies have seldom explored the implications on performance (Adhi Santharm, Ramanathan, 2022).

The professionalisation of purchasing has occurred since ancient times when purchasing knowledge was already taught at trading schools (Hillenberg, 2017). The stages of the 4th industrial revolution were publicised at the Hanover Fair in 2011 with the presentation of Industry 4.0, the "*High-Strategy 2020*" of the German Federal Government (Deutscher Bundestag, 2016). In this context, Prof. Wolfgang Wahlster, Prof. Henning Kagermann and Prof. Wolf-Dieter Lukas called the 4th Industrial Revolution "4." linked to the World Wide Web as ".0" (VDI Nachrichten, 2011). This can be taken as the basis for comprehensive digitisation opportunities in purchasing.

The independent of Frauenhofer-Institut für Materialfluss und Logistik IML & Bundesverband Materialwirtschaft und Logistik IML e.V study confirms that digitisation is seen as an added value and is also being implemented in practice. Digitisation generates a large amount of data that significantly impacts transparency in the supply chain. In the pre-study on Purchasing 4.0, 72% of respondents agreed that purchasing has the role of active creator and supporter, while 28% agreed that it has the function of leader and driver. The survey focused on transferring the 4.0 idea to purchasing (Frauenhofer-Institut für Materialfluss und Logistik IML & Bundesverband Materialwirtschaft und Logistik IML e.V., 2016, p. 25). Bogaschewsky and Müller (2021, p.98) confirm purchasing as a key factor in impacting sustainable performance. The participants were asked about the future importance and role of purchasing concerning environmental and social sustainability tasks. 78.5% of the participants (n=219) rated the importance of purchasing as "much stronger" (28.3%) and "stronger" (50.2%)

(Bogaschewsky, Müller, 2021, p. 98). The results of the question "*How important is it for you shortly that information on the environmental sustainability of suppliers/service providers is available on the platform*?" (Number 17, page 88 of the survey) can be used as an indicator of further digital development in the area of transparent information on sustainability for suppliers. The analysis of the question focusing on the use of digital platforms indicates that the provision of environmental sustainability information of suppliers is rated as "very important" by 27.6% and as necessary by 48.1% (n=224). The SME score (n=126) shows a similar score to the population, with 25.4 % "very important" and 52.4 % "important". In the same way, the importance/relevance of providing the information is asked in a further question (Number 18, page 89 of the survey). The results show a value of 25.2% "very important" and 48.1% "important" in the basic population of n=214 (Bogaschewsky, Müller, 2021, pp. 88-89).

The University of Würzburg, in collaboration with the University of Leipzig, supported by the German Association of Materials Management, Purchasing and Logistics (BME) has examined the "ELECTRONIC PROCUREMENT 2020" in his study in March 2020. This empirical study focuses on the effects of digitalisation on purchasing and compares the survey from 2019 with the results from 2020. Participants could rate different categories as "yes" or "no" according to the need for digitalisation. Specifically, the category "supplier management" was seen as a necessary category of digitisation in 2019 (n=264) with 92.4% and in 2020 (n=159) with 90.6%. Similarly, the category "quality management" was rated as an important area of digitisation in 2019 (n=263) with 70 % and in 2020 (n=157) with 75.2 % (Bogaschewsky, Müller, 2020, p. 6).

The studies indicate that purchasing has a particular function in sustainable procurement and is seen as a driver. Digitalisation and the use of platforms increase transparency through greater data availability. Based on the results of the studies, digital transformation has a significant impact on purchasing. The own study from 2022 asked the participants how advanced digital transformation is in the different business units in the company (Figure 1). Except for production, all companies confirm that more than 65% of the departments have implemented digitalisation or are already optimising it.
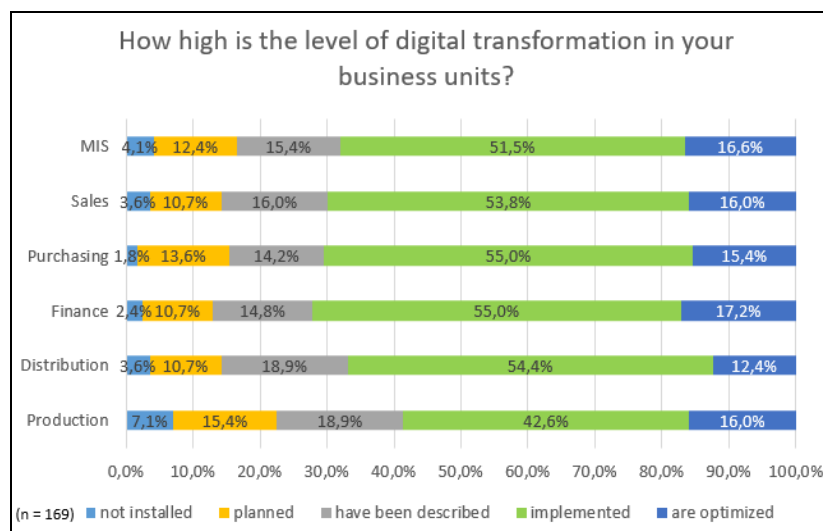

Figure 1. How high is the level of digital transformation in your business unit?

Source: Own Survey 2022

With the use of digitalisation, transparency is being created that allows a direct impact on sustainable purchasing.

Digitalisation provides new opportunities to create transparency with the help of the 4.0 idea. Proven tools can be applied in a new form. In the automotive industry, the Cost Break-Down (CBD) is a proven purchasing tool that provides cost transparency for goods. The CBD, which Mr Lopez introduced as a purchasing tool based on costs, is referenced significantly. Implementing and using the tool in purchasing creates transparency in the supply chain in combination with digitalisation. In this study, the resulting benefits are demonstrated to have an impact on sustainable purchasing. The OEMs' carbon neutrality targets are forwarded to the supply chain, as shown in Table 1. Compliance with the Supply Chain Act and the EGD are also affected and must be considered. OEMs will demand a Product Carbon Footprint in the future to control CO_2 emissions and have the most significant leverage for reducing emissions. The current state of research and the level of readiness for implementation in the industry will be highlighted.

This study identifies the current state of purchasing methods to create transparency in the context of advancing digitalisation. Based on the 4.0 idea, connecting internal data with data from the Internet of Things (IoT) is a significant step forward in creating transparency.

3. Research objective and methodology

This study is based on literature research as secondary research and an own survey as primary research. The literature research is valuable for systematically identifying the scientific research state and the research questions (Adam et al., 2007, p. 56-57). Secondary data in this study are public statistics and existing empirical surveys. Secondary data are suitable for answering research questions (Saunders, Lewis, Thornhil, 2009, pp. 256-257). The survey result will be used to define the impact of purchasing on sustainable purchasing in more detail. Important here is the rising transparency by digitisation and the research if this supports the effect on sustainability. The primary research is accompanied by secondary surveys, from which the results will be taken to the next stage. The Vorstudie "Einkauf 4.0 - Digitalisierung im Einkauf" of the BME from the year 2016, the study "Elektronische Beschaffung 2020" of the BME-Barometer from the year 2019 and 2020 as well as the study "Fortgeschrittene Digitale Lösungen zur Unterstützung von Einkauf und SCM 2021" of the BME from the year 2021 will be used and developed further with our survey dated on March 2022.

The literature research focused on the keywords "Automotive Industry", "Purchasing 4.0", "Sustainability" and "Product Carbon Footprint". The following search programs were used: Google Scholar | Research Gate | Scopus | SpringerLink. Since Purchasing 4.0 has not been thoroughly researched scientifically, the essential elements are summarised in Figure 6 with the purchasing levels. The compiled results are the authors' representations from a literature of 143 relevant publications.

This study is based on a survey of March 2022 based on sustainable purchasing in the automotive industry. The structure of the questions was based on the Likert Scale; the participants were invited to give feedback on their relevance. Furthermore, open questions were asked, categorised and evaluated with the program MaxQDA. The population for the study was based on an average of 933 companies in the German automotive industry (Statista, 2022). 169 representatives of the companies participated in the survey. The confidence level was assumed to be 90 %, with a 6 % margin of error. Under these conditions, 158 responses were required (Questionstar, 2023). Participants from the automotive supply industry worldwide were approached to achieve an empirically usable result. The suppliers can supply directly to the OEM (Tier-1) or be involved in the supply chain further in the supply chain (Tier-n). All participants are in the automotive industry and are familiar with the requirements of sustainability aspects and the special responsibility of purchasing.

To make the results even more reliable, 10 experts from the purchasing department were interviewed based on the results of the surveys. Expert interviews were selected to validate the survey results and represent a qualitative research method (Baur, N., Blasius, J., 2014, p. 970). All interview experts are CEOs or in leading purchasing positions in the automotive industry. The interviews were done in January 2023. The questions focus on transparency and sustainability as well as AI technology. All answers were categorised with MaxQDA Software to compare the answers. The results of the survey and the expert interviews provide the foundation for the study. The mixed methodology represents the comparison of the primary research studies.

To evaluate the dependencies of the questions, the Chi-Square test and Pearson correlation coefficient were determined. For this purpose, the Microsoft SPSS program (CHAID Function or F-Test based on the data) was used to perform the calculations. To determine the correlation, corresponding hypotheses are formed. The hypotheses are repeated in the comparative analysis to highlight the correlation in detail. Hypotheses H_0 and H_1 are represented here.

H_0: Question X and question Y **are not** dependent on each other

H_1: Question X and question Y are dependent on each other

As a result of Pearson's correlation analysis, values from -1 to + 1 (r-value) can be obtained. The calculation was performed with the SPSS program according to the formula:

$$\text{r-value} = \frac{\text{ã}(\,x_i - X\text{Ģ...})\,(y_i - \text{ÓÆ})}{(N-1)s_x\,s_y}$$

Table 2. Legend of the variables

r-value	xi	yi	$\bar{X}$	$\bar{y}$	N	Sx	Sy
correlation	Value xi	Value yi	Arithmetic average x	Arithmetic average y	Total population	standard deviation x	standard deviation y

Source: Scribber, 2020

According to Cohen, the classification is used to interpret the strength of expression correctly. The interpretation was based on the effect size (Scribber, 2020). The "Cohen" evaluation in this study has a range of

$\pm\,0 - 0.1$ = low correlation (effect)
$\pm\,0.1 - 0.5$ = medium correlation (effect)
$\pm\,0.5 - 1$ = strong correlation (effect)

4. Results and discussion

The EU member states must transpose the new guidelines from the Green Deal and the national supply chain law into national law. This is included in the European Green Deal goals as a target for 2030 (Deutscher Nachhaltigkeits Kodex, 2023 & Akzente kommunikation und beratung GmbH, 2022 & European Commission, 2023).

The survey focuses on the sustainability of the automotive industry and whether the companies have already fulfilled this obligation. Figure 2 contains the survey results and shows the level of readiness that companies have achieved in the supply chain in 2022.
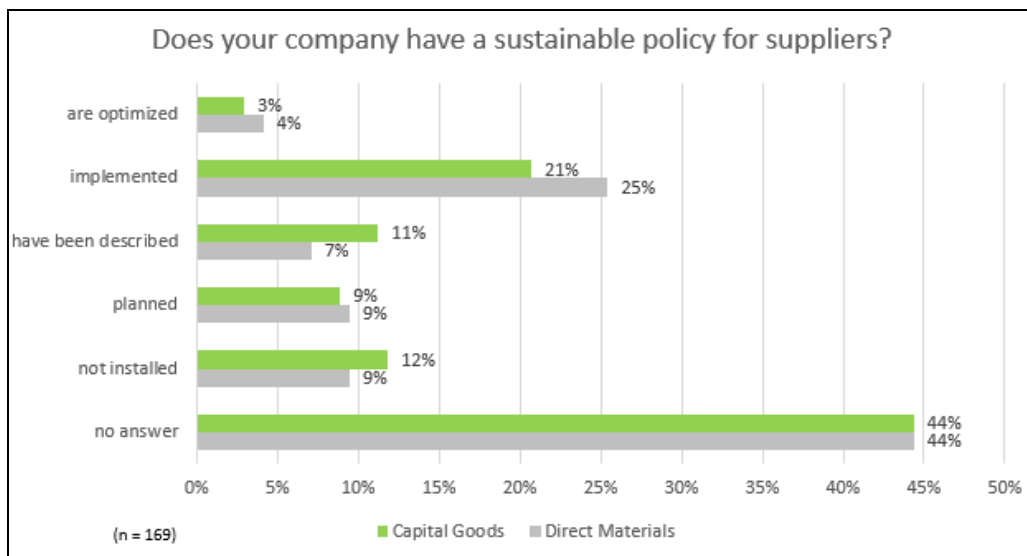
Figure 2. Does your company have a sustainable policy for suppliers?

Source: Own Survey 2022

In both categories (Capital Goods & Direct Materials), more than 50% of the companies still need to implement a sustainability policy for suppliers. Approximately 20 % of the companies are in the planning or description stage. About 25% of the participants have installed or optimised the approach.

The next question asks about the compliance policy that the companies have integrated. Figure 3 summarises the different categories and the responses.
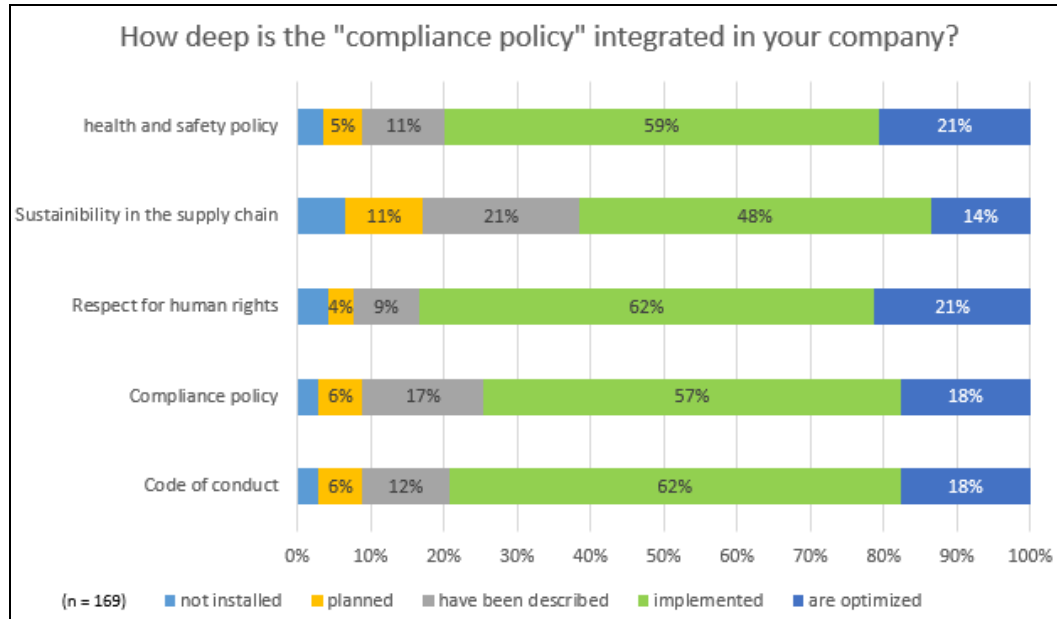
Figure 3. How deep is the "compliance policy" integrated in your company?

Source: Own Survey 2022

In all categories, the participants indicated that 60 - 80% have already implemented a compliance policy or are already in the process of optimising it. In particular, the category "Sustainability in the supply chain" was rated highly with 62% compared to Figure 6. The high degree of fulfilment shows that the requirements from the EU taxonomy (European Commission, 2023) have arrived in the supply chain and are being focussed on.

One element of Purchasing 4.0 describes the data and information created by digitising and connecting internal data and external data from the IoT. Internal data still has to be made "available" in some cases. The literature refers to this as Dark-Data, i.e. unused data and information in the company (unused knowledge). All information together creates transparency in the supply chain. One way to use the sustainability information is to combine them in a CBD.

Regarding value, the product-related CBD is focused on resource protection in the supply chain. For this reason, the companies were asked whether they work with CBD. The result of the survey is shown in Figure 4.
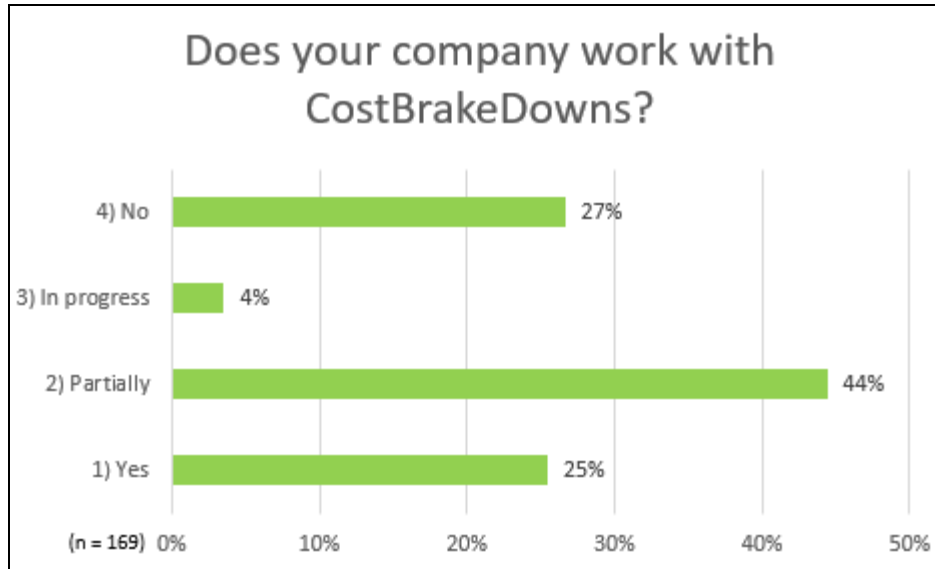
Figure 4. Does your company work with CostBrakeDowns?

Source: Own Survey 2022

It can be noted that 69% of the respondents are using CBD. A high level of agreement, which is now part of the rules for sourcing decisions in the automotive industry. The basis for the decision is the total cost of ownership, which is made transparent by cost analysis (Sanz, Semmler, Walther, 2007). The CBD represents a tool used to analyse all positions in the value creation in detail and standardised in its different areas, such as material, production process, tools or machines used or shipment cost. Based on the information in the CBD it is possible to compare the CBD from the supplier and find the best opportunity for saving all resources. That is one impact to have impact on sustainable purchasing. Use our global resources like material (reduce waste), optimal use of human power, transfer technology in "poor" countries and helps to the education of people. At this point, it is essential to note that the CBD has created transparency to highlight further opportunities for sustainable purchasing.

Digitalisation, in combination with the CBD tool, creates a high level of transparency in the value chain. The survey asked the participants how high the competitive advantages result from Purchasing 4.0. Figure 5 summarises the results. 66% of the respondents see a significant advantage here and rated > 6 on a scale of 1-10. The average of 6.1 confirmed that there is a significant advantage here. The experts in the interview rated the resulting advantage at 7.9, as shown in Table 6.
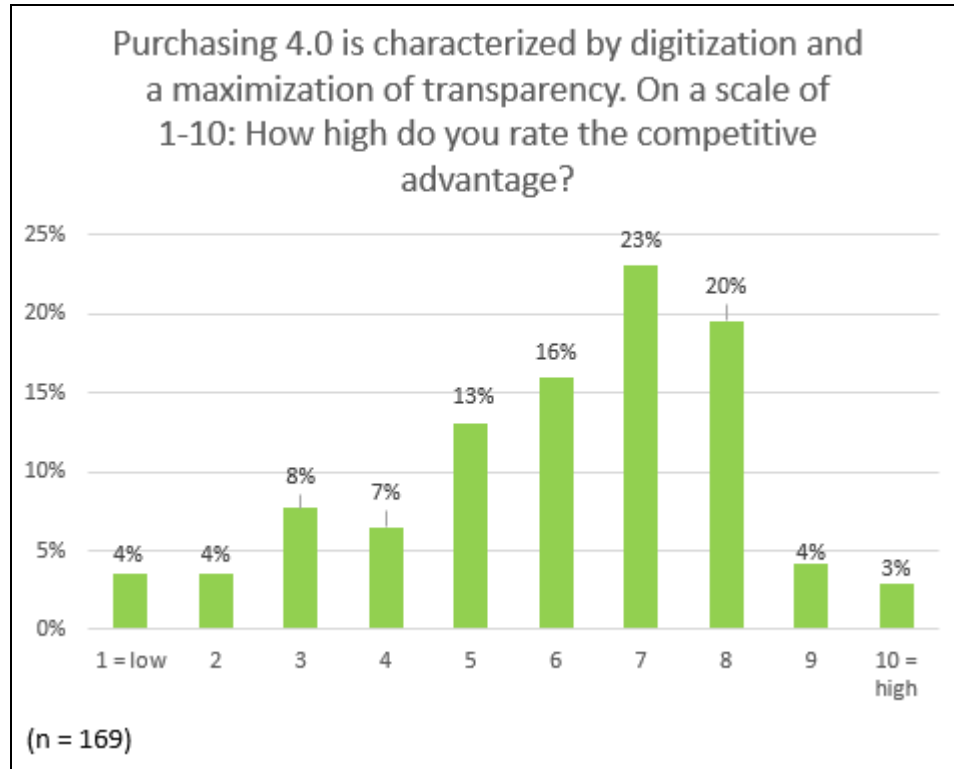
Figure 5. Benefits of Purchasing 4.0 by digitalisation

Source: Own Survey 2022

The extract of questions from the survey represents a derivation of the need for transparency. With transparency, the possibilities for interaction in the protection of resources are unlimited. In order to show further dependencies, questions were compared with each other.

Table 3 compares the question from Figure 3 based on the responses of the category "Sustainability in the supply chain" with the question from Figure 2 based on the response behaviour of the category "Direct Materials". H_0 and H_1 are assumed as follows:

H_0: There is NO dependency on integrating compliance policy and implementing a sustainability policy for suppliers.

H_1: There is a direct dependency on the integration of compliance policy and the implementation of a sustainability policy for suppliers

Table 3. Comparison Compliance - Sustainability vs. Direct Materials

Sustainability: How deep is the "compliance policy" integrated into your company? Vs. Direct Materials: Does your company have a sustainable policy for suppliers?	Reference	Result	Comment
	[df]	3	
	[α]	0,05	P – Value < α
	[p-value]	0,0001	H_1 is accepted
	[χ^2 - Cross Table]	44,340	7,814 critical value
	[H_0]	$\chi^2 > \chi^2_{1-\frac{\alpha}{2}}$	H_0 is rejected
	[r-value]	0,996	Positive Strong Correlation

Source: Own Table

It has been proven that there is a dependency between the compliance policy "sustainability in the supply chain" and the sustainable policy for suppliers' "direct materials". With an r-value rate of 0,996 the value has a positive strong correlation. If the company has a compliance policy in place, there is a sustainable policy for suppliers, too.

Table 4 compares the question from Figure 3 based on the responses of the category "Sustainability in the supply chain" with the question from Figure 2 based on the response behaviour of "Indirect Materials". H_0 and H_1 are assumed as follows:

H$_0$: There is NO dependency on integrating compliance policy and implementing a sustainability policy for suppliers.

H$_1$: There is a direct dependency on the integration of compliance policy and the implementation of a sustainability policy for suppliers

Table 4. Comparison Compliance – Sustainability vs Capital Goods

Sustainability: How deep is the "compliance policy" integrated into your company? Vs. Capital Goods: Does your company have a sustainable policy for suppliers?	Reference	Result	Comment
	[df]	4	
	[α]	0,05	P – Value < α
	[p-value]	0,0001	H_1 is accepted
	[χ^2 - Cross Table]	37,931	9,478 critical value
	[H_0]	$\chi^2 > \chi^2_{1-\frac{\alpha}{2}}$	H_0 is rejected
	[r-value]	0,994	Positive Strong Correlation

Source: Own Table

It has been proven that there is a dependency between the compliance policy "sustainability in the supply chain" and the existence of sustainable policy for suppliers "capital goods". With an r-value rate of 0,994 the value has a positive strong correlation. If there is a compliance policy in the company in place, there is a sustainable policy for suppliers, too.

Table 5 compares the question from Figure 4 with the question from Figure 5 based on estimating the competitive advantage generated by transparency through digitalisation. The Figure 7 responses were combined for the calculation so that all "Yes" and Partially responses were assumed true, and the other categories were scored as no. H_0 and H_1 are assumed as follows:

H_0: There is NO dependency between the use of CBD and a high competitive advantage through transparency created by digitisation

H_1: There is a significant dependency between the use of CBD and a high competitive advantage through transparency created by digitisation

Table 5. Cost Breake Down vs Purchasing 4.0 – Competitive Advantages

Does your company work with CostBrakeDowns? Vs. Purchasing 4.0 is characterised by digitisation and maximisation of transparency. On a scale of 1-10: How high do you rate the competitive advantage?	Reference	Result	Comment
	[df]	9	
	[α]	0,05	P – Value < α
	[p-value]	0,153	H_0 is accepted
	[χ^2 - Cross Table]	13,221	16,918 critical value
	[H_0]	$\chi^2 < \chi^2_{\frac{\alpha}{2}}$	H_1 is rejected
	[r-value]	0,847	Positive Strong Correlation

Source: Own Table

No dependency can be proven between the use of the CBD and the competitive advantages of digitisation in Purchasing 4.0. With the confirmation of the H_0 hypothesis, the questions are independent. Even if the r-value can be calculated as 0,847, these positive strong correlations are random.

The expert Interviews are used to have a much stronger confirmation of the survey questions. A part of the asked questions are used in this study. Table 6 compares the question of the survey with the answers of the experts in the automotive industry.

Table 6. Extract Expert Interview: Comparision Survey vs. Interviews

Question Survey: n = 169 Expert Interviews: n = 10		Questionnaire Survey [X̄]	Expert Interview [X̄]
Purchasing: How high is the level of digital transformation in your business? Scale 1 (low) – 5 (high)		3,7	2,7
Does your company work with CBDs?		70 %	90 %
How does transparency help to analyse optimisation potentials?	Better Position by Negotiations & Price Reduction	19 %	36 %
	Detail Discussions are possible	5 %	29 %
	High impact to use resources optimally	38 %	21 %
	Process Optimisation	24 %	14 %

Question Survey: n = 169 Expert Interviews: n = 10		Questionnaire Survey [X̄]	Expert Interview [X̄]
	No impact	14 %	x
Does your company have a sustainable policy for suppliers?		30 %	60 %
Purchasing 4.0 is characterised by digitalisation and the maximisation of transparency. On a scale of 1-10: How high do you rate the competitive advantage?		6,1	7,9
Do you see a competitive advantage through digitalisation in purchasing? Here: YES answers		62 %	100 %
What influence does purchasing have on sustainable procurement?	Nomination criteria	80 %	33 %
	High impact		24 %
	Company Strategy		14 %
	Supply Chain Act		10 %
	Transparency makes it possible		10 %
	Code of conduct		10 %

Source: Own Table

To summarise, the survey and the expert interviews provided empirical evidence that digitalisation creates transparency and directly impacts sustainable purchasing. The most significant impact is attributed to the nomination criterion, already being implemented in practice by the OEMs.

Conclusions

This study continued the indicated studies. On the one hand, it was proven that the level of digitalisation in purchasing has increased. The BME's pre-study from 2016 described the transfer of the 4.0 idea to purchasing and the need and the opportunities that arise (Frauenhofer Institute for Material Flow and Logistics IML, Bundesverband Materialwirtschaft und Logistik IML e.V., 2016). The BME studies from 2019 and 2020 have shown the continuation of digitalisation in purchasing by empirically proving the necessity of e-tools. The chronological development could be continued with the own study from March 2022. The readiness of digitisation in the business units of the companies was verified empirically (Figure 1). Pearson correlation analysis proved that companies with a compliance policy also have a sustainability policy for suppliers. Figure 5 provides empirical evidence that digitisation results in more transparency, which is a significant competitive advantage. However, it could not be demonstrated that CBD companies also see this as an instrument for creating competitive advantages through digitalisation.

With reference to Figure 5, it was empirically proven that digitisation significantly impacts transparency. The experts surveyed rate the impact even higher than the study indicates. Digitisation in purchasing is based on transferring the 4.0 idea to purchasing and is an element of Purchasing 4.0. Within the scope of intensive literature research in the context of the dissertation on Purchasing 4.0, the different purchasing levels could be identified and summarised in the core elements of Purchasing 4.0 in Figure 6.
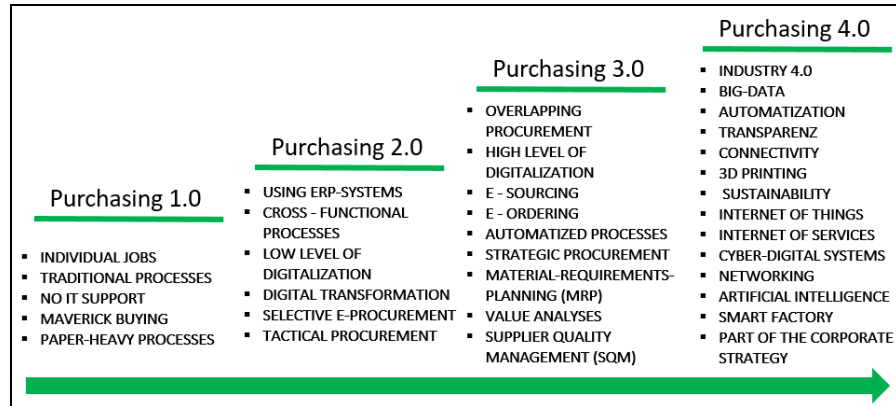
Figure 6. Levels of Purchasing

Source: Own Figure

By using the 4.0 idea in purchasing, Purchasing 4.0 can be identified with its elements. Significant parts still need to be researched, and a scientific definition is unavailable (Zafari, F., Teuteberg, F. 2018). This study focuses not on a detailed analysis of Purchasing 4.0, but on demonstrating the added value in connection with sustainable purchasing.

At the same time, digitalisation means that data is generated that must be made available. The demand to reduce emissions requires finding tools that create transparency and put the buyer in a position to reduce emissions. The transfer of the cost-related CBD represents an existing and proven tool. All items of a CBD can be transferred with CO_2 emission values so that CO_2 transparency instead of cost transparency is created. Figure 7 shows an example of a CO_2 CBD that can be used similarly as an essential factor in nominations criteria (see Table 6). The example used was generated with a test version of the company Calc4XL. The challenge is to receive the data for the CO_2 emissions generated during production for all positions in the CBD (along the value chain).

Databases are already available today that can be accessed. However, the data are still relatively general and need to be specified.

Figure 7. Example Product CO_2 CBD

Source: Calc4XL Testversion, April 2023

The example in Figure 7 was generated with a test version of the company Calc4XL. Next to the manufacturing price, the value of 0.2284 kgCO_2eq/1pcs can be calculated for this product. The challenge is to receive the data for the CO_2 emissions generated during production for all positions in the CBD (along the value chain). Databases are already available today that can be accessed. However, the data are still relatively general and need to be specified. Calc4XL refers to databases such as ProBas, DStatis, DEFRA, USEEIO, Climatepartner, Pe-Gabi, SimaPro-Pre, and Ecoinvent integrated today.

The association Catena-X Automotive Network (Catena-X) was founded to close the gaps in the databases. Founding members are automotive manufacturers and suppliers such as BMW AG, Deutsche Telekom AG, Robert Bosch GmbH, SAP SE, Siemens AG and ZF Friedrichshafen AG. The goal is to provide transparency in supply chains and to build up databases from which, among other things, CO_2 values can be derived and provide a basis for CO_2 reduction. Manufacturers worldwide along the supply chain should provide their information in the collaborative database to create a common standard for data and information flows along the automotive supply chain (Catena-X Automotive Network, 2023).

The result of this study is that Purchasing 4.0 will make a significant impact on sustainability through the element of digitalisation. The requirement for nomination as a decision criterion is the key to the most critical possible implications. Digitisation generates the data needed to create the necessary transparency. Using the company's data with data from the IoT represents a significant step forward in increasing transparency if the data is used in a systematic and standardised manner. In the future, data will be a crucial element of competitiveness.

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