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PRIMARY RESEARCH

Sustainability in automotive interior–comparison of volume and premium brand manufacturers

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Abstract

Sustainability is regarded as the keyword of the 21st century. The topic of resource conservation is now more relevant than ever. Above all, the automotive industry, which is the most important industry in terms of turnover and the growth engine for Germany, has to deal more intensively with sustainable development and the associated effects and challenges. Automotive manufacturers are under pressure to comply with both political guidelines and internal specifications and constantly changing individual customer wishes. For the automotive industry, electric motors, lightweight construction, and CO_2 emission reduction are key issues. Nevertheless, the car's interior cannot be ignored. After all, the interior is the part of a car most frequently seen by the driver and must therefore be practical, aesthetically pleasing, and at the same time weight saving. The use of natural fibers as alternative materials in the interior plays an important role and further steps towards greater sustainability. Consequently, the following research question arises: How do the three pillars of sustainability (economical, ecological, and social issues) influence automotive interior development at volume brand and premium brand manufacturers, and how do customers accept sustainable solutions? The contribution focuses on premium and volume brand manufacturers and identifies significant differences between both customer groups. Based on a literature review on sustainability in the automotive industry, previous efforts to increase sustainability in the automotive interior are highlighted. Subsequently, an empirical study is used to determine the expectations on the customer side regarding more sustainability in the automotive industry in general and in the interior sector in particular and to derive corresponding challenges and potentials for original equipment manufacturers and suppliers. The empirical study is based on an online survey with randomly selected persons via social media. The survey was conducted via Survey monkey. All persons with a minimum age of 18 years were considered. Almost 400 participants fulfilled the desired characteristics.

I. SUSTAINABILITY AS A MAJOR CHALLENGE FOR THE AUTOMOTIVE INDUSTRY

Sustainability is regarded as the keyword of the 21st century and its importance is not yet sufficiently widespread [1, 2]. The associated topic of resource conservation, which has been important since the 18th century, is now more relevant than ever. Above all, the automotive industry, which is the most important branch of industry in terms of turnover and the growth engine for Germany, has to deal more intensively with sustainable development and the corresponding effects and challenges. Automotive manufacturers are under pressure to comply with both political guidelines and internal specifications, as well as with constantly changing individual customer wishes [3, 4, 5]. For the automotive industry, topics such as electric motors and the corresponding optimization areas, lightweight construction and CO_2 emission reduction are key issues. Nevertheless, the car's interior cannot be ignored. After all, the interior is the part of a car most frequently seen by the driver and must therefore be practical, aesthetically pleasing and at the same time weight saving. The use of natural fibres as alternative materials in the interior plays an important role and is a further step towards greater sustainability [6, 7].

Consequently, the following research question arises: How do the three pillars of sustainability (economical, ecological and social issues) influence interior development at vol-

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ume and premium brand manufacturers and how do customers accept sustainable solutions? The article differentiates between volume (Skoda, FIAT, Renault etc.) and premium brand manufacturers (BMW, Audi, Daimler etc.) and identifies significant differences between both groups.
Based on a literature review on sustainability in the automotive industry, previous efforts to increase sustainability in the interior sector will be presented. Subsequently, an empirical study is used to determine the expectations on the customer side regarding more sustainability in the automotive industry in general and in the interior sector in particular and to derive corresponding challenges and potentials for Original Equipment Manufacturers (OEM).

II. SUSTAINABILITY IN THE AUTOMOTIVE INDUSTRY

Long-term success in the automotive industry is connected to consistent innovation strategies, strong branding, global efficiency in the value chain and qualified and motivated employees. Innovation management can be stated as the key long-term success factor – after all, no other industry invests more than the automotive industry in this area. Currently, the automotive industry is witnessing the greatest phase of upheaval in its history. Mega trends such as emission reduction, lightweight construction, automated driving, connectivity and mobility services have changed the landscape for good. In line with these trends, the supplier industry is also adapting and undergoing fundamental changes [8, 9, 6].
The topic of sustainability in the automotive industry is also gaining more momentum in the scientific community. Nunes and Bennett, for example, carry out a fundamental comparison of environmental initiatives of automobile manufacturers, conclude that these are often still very vague, and require further concretization. Another criticism is that the focus is primarily on the ecological dimension [10]. [11] develop a theoretical framework for analysing the influence of green and lean SCM practices on the sustainable development of automobile manufacturers. Ecological (e.g., CO_2 emissions), social (e.g., supplier screening) and economic (e.g., operating costs) aspects are considered as performance indicators [12]. [11] complement this with an analysis of a sustainable business model for the automotive industry that integrates all three dimensions of sustainability. This paper also shows that there has been a clear improvement in sustainability performance in the automotive supply chain over the last decade [11]. [13] emphasize that sustainability management in the automotive industry is only possible through a holistic process approach starting with the conception and continuing right up to the series production of the product. In addition to these rather conceptual contributions, several authors consider concrete materials about their sustainability potentials for the automotive industry [13]. [14], for example, the suitability of bio composites especially in the field of dashboards [14], whereas [15] focus primarily on the suitability of natural fibres [15]. Hetterich et al. consider the specific attitude of motorists towards sustainable materials in the interior sector. The focus here is on the willingness of customers to actually pay more for renewable raw materials [16].
Overall, the issue of sustainability in the automotive industry may well be gathering momentum and scientific focus, but the interior design sector in particular has been largely neglected. The article attempts to close this gap.

III. SUSTAINABILITY IN THE AUTOMOTIVE INTERIOR

The widespread innovation efforts in the field of electric mobility and autonomous driving also offer the potential to rethink and redesign the car's interior. The vehicle interior has to be transformed into an increasingly attractive living space. This can be achieved, for example, through attractive surfaces made of sustainable materials. The interior plays an increasingly important role in purchasing decisions. It arouses emotions, offers comfort, safety and functionality and radiates brand identity as a fusion [17].
The interior of a vehicle can be divided into six assemblies: the cockpit, the seats, the door and side trim, the headliner, the luggage compartment and the floor trim. Developments in this area are a balancing act between the pressure to innovate and the need to keep costs down [18].

A. Characteristics of Natural Fibre Materials

Already in 2005, more than 30,000 tons of natural fibres were used in the automotive industry in Europe [19]. In 2015, the figure was already 50,000 tons, of which ten to 20 percent were European hemp fibres. Hemp belongs to the category of baste fibres, which are most frequently used in automotive components. Hemp, kenaf and flax are suitable alternatives to glass fibres because they are less expensive, have a lower density, a high strength and are more environmentally friendly. The use of natural fibres can result in cost savings of ten to 30 percent compared to glass fibres. Due to its strength, it can be used as a reinforcement for vehicle interior parts such as door panels. In addition, kenaf, which is cultivated mainly in China and Thailand, has one of the best CO_2 absorption rates in the plant world [15, 19]. Another advantage is that the natural fiber-reinforced plastic does not splinter and can break without creating sharp

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edges. Its low weight and high load-bearing capacity are an advantage for lightweight construction and safety requirements and have a positive influence on crash management. Due to the positive cost performance ratio and the other advantages described, composite materials based on natural fibres have been used for several years for thermoplastics, thermosets and elastomers in automotive interiors. Well-known examples of this are doors made of flax or sisal fibres and polymeric binders such as polypropylene (thermoplastic) or polyurethane [17, 20].

When selecting alternative materials, care should be taken. For one, fibres from natural sources are not always more environmentally friendly than conventional fibres. Large amounts of water, pesticides, chemicals and energy are needed to prepare and dye the fabric during cotton degradation and processing. In addition, natural fibre reinforced plastics are neither as strong nor durable as metal or synthetic fibres, so they need to be replaced more frequently, resulting in increased energy consumption in the long term. Whereas natural fibres were previously concealed behind a thick film lamination, they are now becoming more and more visually perceptible and are increasingly finding their way into the premium interior as a design element. At the same time, suppliers and vehicle manufacturers are in equal demand to conduct even more intensive research in the field of natural fibre-reinforced plastics and to bring technologies to series maturity that make it possible to further increase the proportion of natural fibres in vehicle interiors [15].

B. Sustainability Measures in the Interior

The new hybrid materials and vehicle concepts pose a challenge for manufacturers and suppliers. The lightweight construction required for this should continue to offer the best surfaces in the interior since the appearance conveys a direct impression of quality. Therefore, corresponding solutions with bio-composite materials are of great importance, as, for example, the supplier DrAxlmaier shows with his Kenaf door trim for the BMW i3 electric vehicle. The component is made exclusively of natural fibre-reinforced polypropylene with functional elements [21, 22].

The use of natural fibre materials as a design element that underlines the sustainable character of a vehicle was not an option until now. They had not previously met the requirements of OEMs for a high-quality appearance and the technical process conditions of the manufacturers made it difficult to use the materials. After a long development period, the supplier DrAxlmaier and the manufacturer BMW have now joined forces to bring the innovation of visible natural fibres in the interior to series maturity. Requirements for design elements and weight reduction have been met and, at the same time, the materials are ecologically compatible. The "Fast Fibre Forming" developed by DrAxlmaier makes it possible to implement the "Visible Nature". Panels are made of kenaf fibres and coated with a wafer-thin transparent plastic film. The purity of the plant material used ensures a particularly high-quality surface appearance compared to other natural raw material sources such as hemp or flax [21].

In the BMW i3, the visible door beams and the instrument panel cover are also made of the fibres of the tropical mallow plant Kenaf. The reasons for the selection are that Kenaf has a high degree of fineness and purity of the fibres compared to flax and hemp, which is essential for a high-quality surface. This is an elementary prerequisite because the design philosophy of BMW i vehicles combines a consistent focus on sustainability, which becomes visible and tangible in the interior, with simultaneous fulfilment of the OEM's premium claim [23].

A further example is presented by Johnson Controls for the new BMW 3 Series with wood fibre components that not only relieve the burden on the environment, but also reduce weight by 20 percent compared to solutions previously used [24].

The use of renewable and natural raw materials as a sustainable alternative to plastics is in direct harmony with the needs of the young generation. Yanfeng Automotive Interiors, for example, deliberately presents the recyclable, artistically designed natural fibre middle parts of the door panel in a natural look. According to Han Hendriks, Chief Technology Officer at Yanfeng, there is currently a shift towards more personalisation and individualisation. Drivers want to be sustainable and at the same time be safe and in touch with the spirit of the times [25].

The supplier International Automotive Components (IAC) optimizes component designs for OEMs. A new product is the "Fibre Frame" technology. The natural fibre semi-finished product "EcoMatHot" replaces the classic material sheet steel in the mounting frame of the vehicle roof lining with panoramic or sliding roofs. The material consists of 70 percent renewable raw materials. A weight reduction of up to 50 percent is possible [26].

In the future, it is expected that the use of renewable raw materials and recycled materials will continue to gain in importance. Visible components made of renewable materials will be found more frequently in the interior of the cars of tomorrow. In this context, the natural materials must be designed haptically and optically so that they can no longer

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appear only in laminated or mixed form with plastics [24].

IV. EMPIRICAL STUDY ON CUSTOMER EXPECTATIONS REGARDING SUSTAINABILITY ASPECTS IN AUTOMOTIVE INTERIOR

An empirical large-volume study is conducted to investigate the expectations and potentials that customers see in sustainability elements, particularly in the interior sector. The empirical survey focuses both on customers of premium (e.g., BMW, Audi, Daimler etc.) and volume brands (e.g., VW, Opel, Skoda, Renault, Ford, Toyota etc.). The focus is on significant differences between both customer groups. Generally, sustainability measures are more widespread for premium brand manufacturers and corresponding customers have higher expectations with regard to design and equipment [27].

A. Structure of the Empirical Study

The empirical study is based on an online survey with randomly selected persons via social media. The selected persons are from the Heilbronn University of Applied Sciences, the University of Stuttgart and the company Valeo Schalter und Sensoren in Bietigheim-Bissingen. The survey was conducted via Survey monkey. All persons with a minimum age of 18 years were considered. A limitation to certain industries was not carried out. 395 participants fulfilled the desired characteristics – 141 premium brand customers and 254 volume brand customers. 70 percent of all participants are male and 30 percent female. The questionnaire consists of 23 questions, divided into three sections: "general sustainability", "specific sustainability in the automotive industry and the interior" and "future expectations".

B. Empirical Results

Most of the customers surveyed recognize the fundamental importance of sustainability. For both customer groups food is the area of life with the highest importance of sustainability (81 percent for premium brand customers and 72 percent for volume brand customers), followed by energy supply (66 percent for premium brand and 68 percent for volume brand customers) and habitation (63 percent for premium brand customers and 64 percent for volume brand customers). Mobility follows on rank four with 47 percent for premium brand customers and 52 percent for volume brand customers (see Figure 1). This shows that a fundamental need for sustainability exists, but sustainable mobility is only important for half of all included customers. There are no significant differences between premium and volume brand customers.

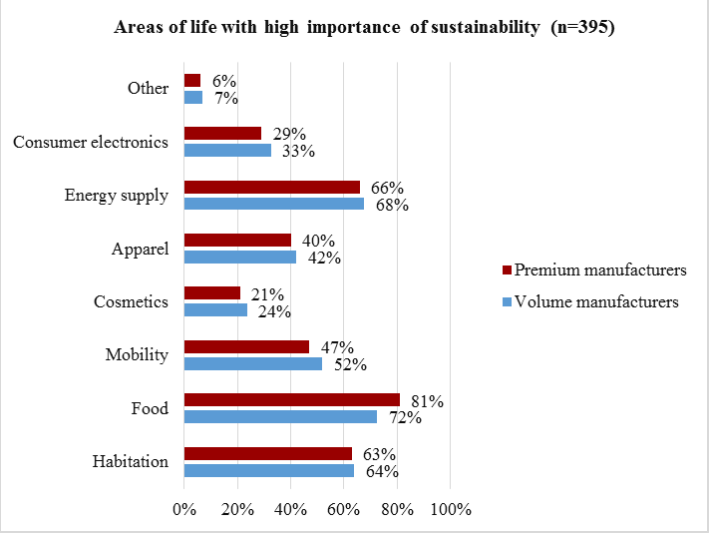

Fig. 1. Areas of life with high importance of sustainability

Looking at the factors decisive for buying a car, quality, price, performance and design are on the first ranks. Premium brand customers highlight design stronger compared to volume brand customers, which have a higher focus on the price. Sustainability plays a relevant or even very relevant role for only 39 percent of all volume brand customers and 34 percent of all premium brand customers. This is the lowest value for premium brand customers and the second lowest value for volume brand customers (see Figure 2). This shows that sustainability effects have only a limited influence on customers' purchasing decisions; the focus is still on traditional aspects as quality, performance, price and design.

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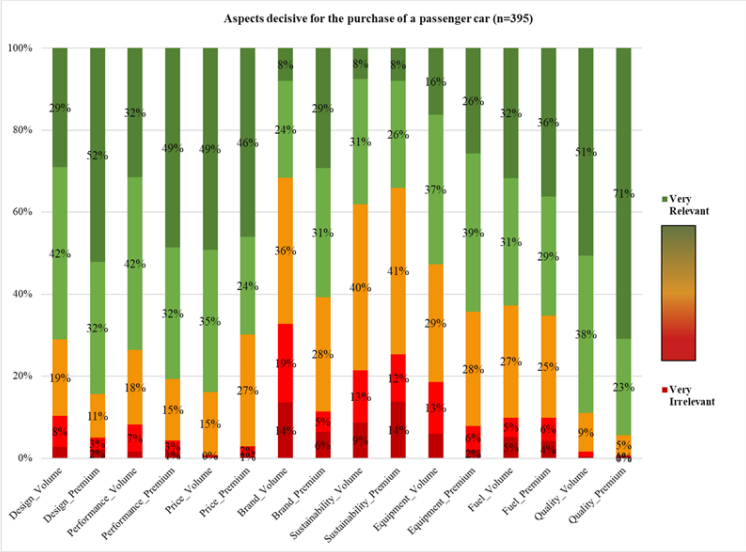

Fig. 2. Aspects decisive for the purchase of a passenger car

The acceptance to pay for additional costs for sustainable materials differs significantly between premium brand and volume brand customers. 63 percent of all volume brand customers would accept higher costs; the percentage for premium brand customers is only 47.5 percent. Therefore, the willingness to accept higher costs is more present for volume brand customers than for premium brand customers.

Analysing single modules of an automobile, interior and electronics (both 70 percent) receive the highest relevance for sustainability from the volume brand customer's point of view. Power unit follows on rank three with 66 percent. For premium brand customers interior is ranked only in the third place with 65 percent, dominated by power unit (76 percent) and electronics (72 percent) (see Figure 3). The result shows that interior is on the focus of both customer groups regarding sustainability and manufacturers should pay more attention to this topic. The following questions relate exclusively to the automotive interior.

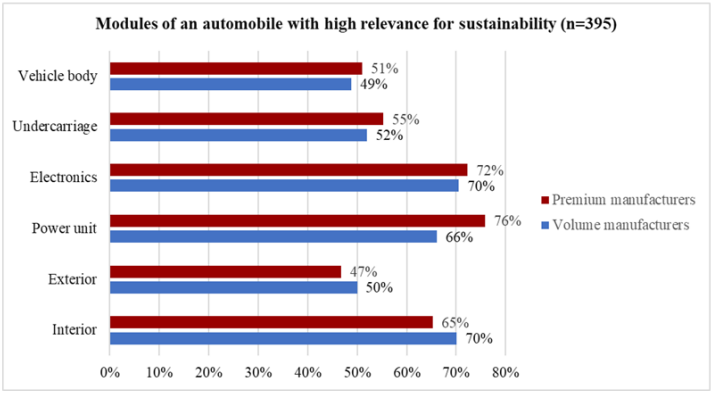

Fig. 3. Modules of an automobile with high relevance for sustainability

A majority of 74 percent of all premium and volume brand customers agree that the OEM should place more emphasis on the selection of sustainable and natural materials in the interior. Only six percent reject it, which represents a clear message to the OEM and emphasizes the message from Figure 3.

In order to control the customers' design perception of natural materials in the interior, a picture of an untreated door panel was shown to the participants (see Figure 4). The reaction to whether the test persons could imagine this in their automobile was very positive. 76 percent of all volume brand customers and 71 percent of all premium brand customers could imagine such a door, if properties as haptics, appearance and economy are retained. Only 15 percent (volume brand) resp. nine percent (premium brand) of the customers could not imagine such a door in an automobile.

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Fig. 4. Untreated door panel with natural materials

Looking at additional aspects, needed to be fulfilled by sustainable and natural materials in the interior, quality and safety (each 93 percent for volume brand customers and 92 percent resp. 88 percent for premium brand customers) receive the highest percentages based on the statuses "very important" or at least "important", followed by comfort (81 percent for volume brand customers and 83 percent for premium brand customers), smell (82 percent for volume brand customers and 81 percent for premium brand customers), optics (77 percent for volume brand customers and 81 percent for premium brand customers) and haptic (72 percent for volume brand customers and 79 percent for premium brand customers). The lowest percentage receive individuality for both customer groups with only 28 percent (volume brand customers) resp. 39 percent (premium brand customers) (see Figure 5). With the exception of individuality, there are no significant differences between both customer groups.

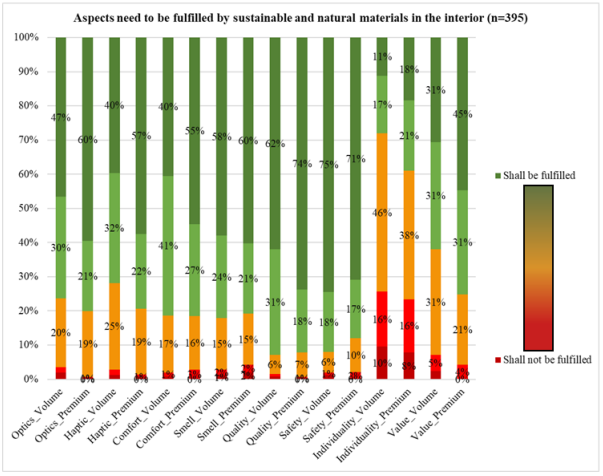

Fig. 5. Aspects need to be fulfilled by sustainable and natural materials in the interior

Looking at individual types of material, all customers would like to see more sustainable alternatives in the interior for plastics (70 percent for volume brand customers and 67 percent for premium brand customers), textiles (54 percent for volume brand customers and 52 percent for premium brand customers), leather (55 percent for volume brand customers and 45 percent for premium brand customers) and wood (45 percent for volume brand customers and 40 percent for premium brand customers) (see Figure 6). Especially for the first three materials, sustainable solutions are already available, as described in the previous chapter.

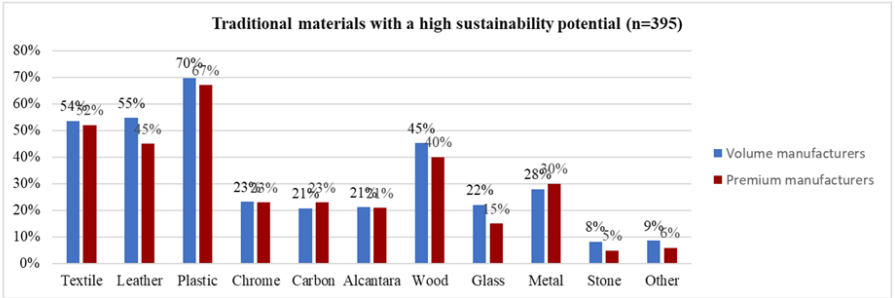

Fig. 6. Traditional materials with a high sustainability potential

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Regarding the variety of natural alternative materials, recycled materials (58 percent for volume brand customers and 52 percent for premium brand customers) and biometic plastics (51 percent for volume brand customers and 54 percent for premium brand customers) receive the highest percentages of customers evaluating it as relevant or even very relevant for the interior sector. Overall, all known alternative materials such as ligneous, hemp, kenaf or sisal are well accepted by customers and the percentages for irrelevance are minimal for all materials (see Figure 7).

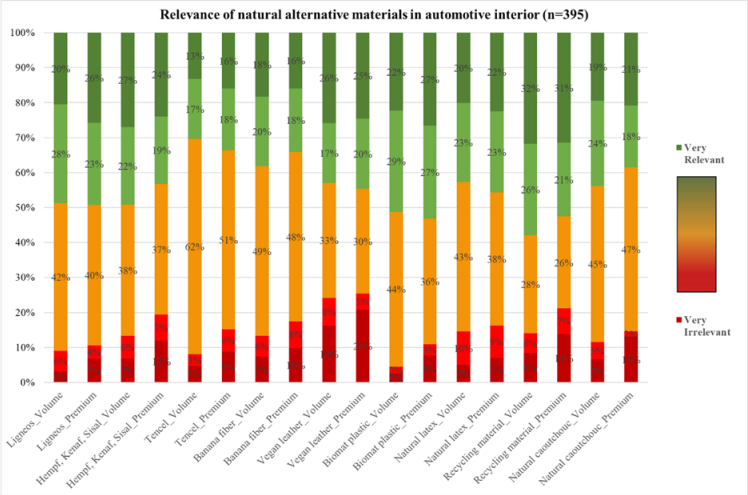

Fig. 7. Relevance of natural alternative materials in automotive interior

As an optional question, the participants were asked to decide which material they prefer for which interior component. The blue marked words are the materials with the highest customer percentage (see Figure 8 and 9). The results show that the materials selected by volume brand customers for the door panel, decorative elements, foot area, armrest and seat are already natural. Other natural materials such as recycled material or natural rubber also achieve a high level of approval for individual interior components, although they do not yet represent a majority opinion. For premium brand customers, natural materials are preferred for the centre console, door trim and decorative elements. The results show that the number of preferred natural materials is significantly higher for volume brand customers, indicating a higher sustainability awareness for this customer group.

Fig. 8. Interior components with corresponding materials – volume brand customer (n = 177)

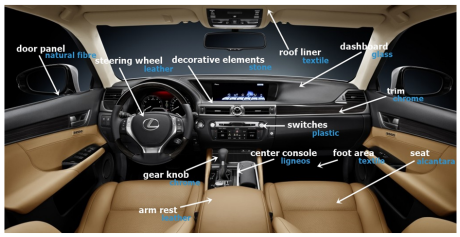

Fig. 9. Interior components with corresponding materials – premium brand customer (n = 141)

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The question whether natural materials should be more noticeable in interior design compared to conventional materials leads to mixed results. 35 percent of all volume brand customers and 34 percent of all premium brand customers highlight that natural materials should be noticeable, whereas 26 percent resp. again 34 percent disagree with this statement (see Figure 10). For volume brand customers neutral is the largest category with 40 percent, for premium brand customers the value is even quite high with 32 percent.

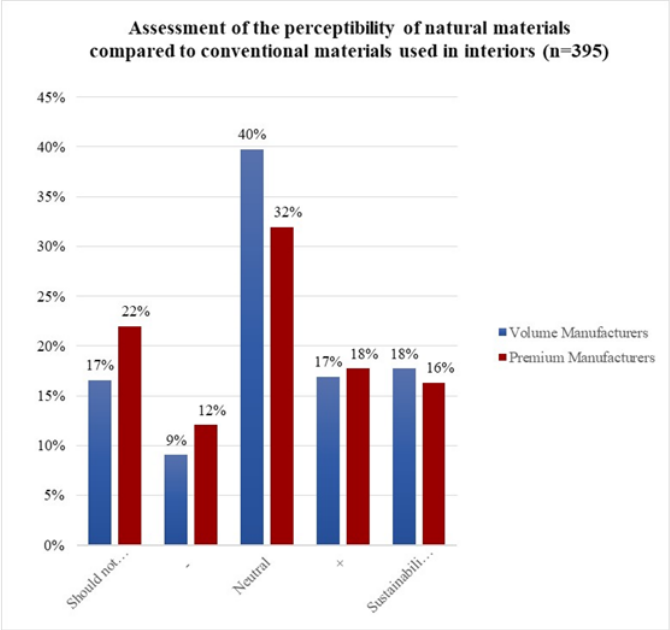

Fig. 10. Assessment of the perceptibility of natural materials in the interior

The final topic of the survey is the future relevance of sustainable materials in the interior. Nearly 74 percent of all volume brand customers and nearly 75 percent of all premium brand customers rate the future relevance as very high or at least high, thus prophesizing an increase in relevance in the coming years (see Figure 11).

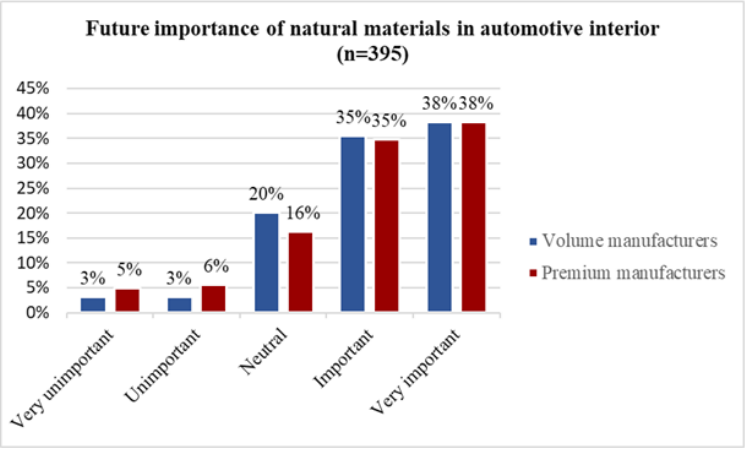

Fig. 11. Future importance of natural materials in automotive interior

Overall, it can be seen that the issue of sustainability is present in people's awareness. A tendency towards greater openness for new, more sustainable materials among customers of volume and premium brand automobiles is recognizable. The priority for customers is that sustainability is taken into account in manufacturing and production, but not to the detriment of appearance, feel, comfort or price. The differences between both customer groups are mostly

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not significant with the exception of the larger acceptance of higher costs for sustainable solutions by volume brand customers, the pronunciation of individuality by premium brand customers and the higher number of preferred natural materials for single interior elements by volume brand customers.

V. DISCUSSION OF THE RESULTS

There is an agreement in business practice that sustainability is one of the main key success factors. This can be confirmed largely by the empirical results. A majority of 63 percent of all volume brand customers are willing to pay a higher price for additional costs related to the use of natural and sustainable materials. The value for premium brand customers is little lower with 47.5 percent. All participants principally agree that sustainability should play an overall role in the automobile and should not be restricted to individual areas. Interior achieves the highest relevance together with power unit and electronics. On the other hand, customers highlight that all traditional criteria connected to automobiles – especially appearance, haptics, comfort, smell, quality, safety and value – must be fulfilled at the same time in a sustainable interior. At this point, a problem occurs for manufacturers. Natural materials fulfil certain properties, but others sometimes not. Consequently, manufacturers need to look more closely at this issue in order to satisfy the wishes of their customers. As seen in the empirical study, the majority of participants can imagine a door panel made of natural fibres and some natural materials are already the preferred materials for a few interior parts. The majority of customers also see an increase in the importance of sustainability for the interior in the future. It is therefore crucial for manufacturers to be innovative, show initiative, take advantage of emerging market opportunities and to act proactively. The focus should be on achieving first mover advantages, and it is crucial for OEMs to maintain their position as technology leaders. Therefore, it is imperative automotive companies concentrate on existing mega-trends – in particular sustainability [22, 27, 28].

VI. CONCLUSION

The automotive industry is a prime example of small steps bringing change and contributing to a more environmentally friendly world. Suppliers are working with manufacturers to find solutions for a more sustainable interior and the importance of implementing sustainability along the entire supply chain is well known to those involved. As a result, technological progress and the refinement of processes for the development of natural fibre products make it possible to replace products that currently pollute the environment more simply and cost-effectively with more environmentally friendly products, and at the same time to produce them in a more environmentally friendly way [15, 16].
Further research projects will analyse whether there are significant differences looking at the age of the customers, the gender or the specific automotive brand.

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