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Success Factors of Adopting Hydrogen Fuel Cars in Central Europe

An Analysis Regarding the Criteria of Purchasing Alternative Drivetrains

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Abstract – Current mobility is undergoing a transformation encompassing a multitude of elements, namely because of societal and governmental initiatives to make car-based personal transportation more sustainable and less resource-intensive. Drivetrain technology, the main component in automotive vehicles, however, alters fuel supply, infrastructure, supply chains, and even convenience aspects, which were previously taken for granted, causing new challenges. On the basis of the literature around the subject of effective customer acceptance of battery-powered cars and the technological aspects of hydrogen fuel cell vehicles, a questionnaire consisting of eleven questions was developed. Items cover overall ecological, economic, and convenience-related concerns to evaluate current consumer expectations and knowledge level about hydrogen transportation. Results reveal, that in hydrogen mobility needs to fulfil the criteria of price stable hydrogen, made possible by domestic and thereby resilient supply chains, actually allowing to provide an environmentally friendly individual transport in the first place. Additionally, existing benefits of current gen vehicles (combustion and battery electric vehicles), namely the aspect of safety and reduced noise emissions are well appreciated by consumers. These results outline what governmental institutions of all levels must prioritize in their adapted policymaking to further decarbonize transportation and openly promote hydrogen as an innovative fuel in Central Europe.

Keywords – Energy Efficiency, Car purchase reflections, pro-environmental behaviours

1 Introduction

The issue of climate change presents a tremendous hurdle for humanity, and strategies and concepts are seen as necessary to dramatically reduce the emitting greenhouse gases as a result of human activity. Since energy production, industry, agriculture, and transportation are among the most major sources of emissions, several governmental organizations throughout the globe are now enacting new legislation to minimize the emission of carbon dioxide equivalents (Lin & Huang, 2022; Herzer, 2022). This has encouraged research into alternate engine designs as well as cleaner and more efficient methods to use fossil fuels. There has been a rise in the manufacturing of BEVs for important markets over the last many years, and considerable efforts have been made to reduce the prices of both vehicles and batteries (Nykvist et al., 2019). Due to the relatively modest capacity of the batteries, however, battery electric vehicles (BEV) have a significantly decreased driving range, requiring drivers to organize time-consuming trips to charging stations. In response to these obstacles, the concept of promoting the use of hydrogen fuel cell (HFC) vehicles has recently gained traction (Bethoux, 2020), bolstered by the concept of expanding the use of so-called e-fuels, which would sustainably maintain the current level of mobility to a certain extent while drastically reducing emissions during vehicle operation.

This article's main aim is to evaluate German consumers' present expectations for prospective alternative drivetrains based on hydrogen-powered individual mobility in order to build a decision-based model for future research including both manufacturers and policymakers. The following objectives are developed.

First and foremost, it is essential to compile and organise prior information on the most important factors influencing consumer purchasing decisions. These forces will come from a variety of fields, namely from an ecologic, economic, or social origin. Second, a multifactor analysis evaluating the weight of each factor, synthesised from disciplines evaluated in the literature research, is built based on modern methodological concepts. In the third place, suggestions are made for more study on the legislative frameworks required to effectively implement hydrogen mobility as a zero-emission transportation innovation in the next decades.

This article combines the extensive insights of previous studies regarding the customer requirements for purchasing new vehicles and adopts key results into an analysis aimed at a diverse customer group to determine what factors are required to successfully promote the use of hydrogen fuel cell vehicles. The applied method encompasses a questionnaire, directed at individuals interested in purchasing a vehicle in the medium time frame, to elaborate their purchasing behaviour and thereby identify shortcomings or expectations of hydrogen mobility. Via a linear multiple regression model, the deciding factors leading to an increase or decrease of customer interest in hydrogen cars are elaborated upon. To meet the legal requirements of further decarbonization of the mobility sector, as well as to mitigate the ecological or health-related negative long-term repercussions on society, further steps are required for the successful policymaking of the nation states of Central Europe based on the results of the questionnaire. In addition, it encourages organizations, from OEMs to suppliers, to develop customer-centric strategic decision-making ideas in order to accomplish the harmonization of technical innovation and economic incentives towards a societally focused innovation strategy.

2 Literature Review and Hypothesis

To comprehend the driving force behind shifting client wants and desires, it is necessary to comprehend the primary goal and motivation of people and families to acquire a new car. Due to the enormous costs associated with acquiring and maintaining a vehicle, the acquisition of a new vehicle is seen as an extremely unusual financial event. While a cost-benefit analysis may seem reasonable, prior research indicates that the predicted positive connotations to image, embodied in status symbols, tend to have a substantial effect on customers' purchase decisions (Chng et al., 2019). As a consequence, customers of more expensive cars are less likely to contemplate switching brands, but purchasers of smaller and less expensive vehicles, who follow a pattern of reduced-price elasticity, analyse the available options on the automotive market much more extensively (Nayum et al., 2013). The evaluation of ecological aspects, on the other hand, may not reveal a significant element to influence the purchase behaviour of individual customers (Thornton et al., 2011).

Previous research (Lane & Banks, 2010; Orlov & Kallbekken, 2019; Peters et al., 2008) analysing the buying behaviour of consumers revealed a gap between the knowledge of policymakers and the understanding of customers themselves. Prioritizing factors such as size, price, and dependability, the majority of customers who are interested in acquiring a new vehicle concentrate on the vehicle segment first (Nayum et al., 2013), before considering other elements of economic or ecological backdrop. However, these aspects are overshadowed by the strong brand identity of customers, as luxury attributes may be more valued by customers than fuel efficiency (Givord et al., 2018; Noblet et al., 2006), thereby negating the majority of policymaking tools centered on rational and efficiency-based consumer decision models. Moreover, many consumers restrict their purchase research to situational and emotional considerations, which are often conveyed by brand loyalty, consequently overvaluing specific features such as prior good purchasing choices and missing rationed decision-making of alternatives (Nayum et al., 2013). To comply with increasingly stringent laws from national and international authorities alike, the demand to action is stronger than ever (Hammerl et al., 2022).

Customers interested in acquiring new automobiles do not base their decisions just on a single issue, but rather on a variety of interconnected aspects, including financial, ecological, and practical considerations.

First, the ecological consequences of hydrogen propulsion were chosen because, from both a consumer and a societal standpoint, customers consider the ecological impact of their buying behaviour when making decisions (Galarraga et al., 2020). Frequently accompanied by energy labels, based on national and supranational law, customers may base their decision on factors such as the amount of CO2 emissions (Wang et al., 2020; Zhang et al., 2020), range (Giansoldati et al., 2018), charging or refuelling time, and numerous other factors.

Due to the high material costs associated with the purchase of new automobiles, sporadic and frequently inexperienced buying is widespread. In addition to direct expenses and performance, image and branding are of equal

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significance to many clients. As these factors are unrelated to the general technical innovation of hydrogen mobility, except for higher purchasing costs (due to high investments and risk by the industry) and limited operational costs (primarily reduced tax incentives and stable fuel prices due to domestic production), most of them were not further considered for this questionnaire (Chng et al., 2019).

Moreover, the impacts of extrinsic factors such as temperature are notable. While Central Europe has a generally steady climate with mild winters, past research has shown that declining temperatures and elements like as winter tyres significantly reduce vehicle dependability and range (Jakobsson et al., 2022), necessitating changing consumption patterns. Similarly, the issue of possible fire risks associated with the chemical internal structure of lithium-ion battery packs present in typical BEVs during accidents (Cui et al., 2022), the potential identical dangers as well as new problems (Y. Wu, 2008) may also apply to HEVs. Even though hybrid technology, like the revolutionary adoption cycle of electric propulsion, is present in hydrogen mobility, many consumers resist from purchasing alternative drivetrain-powered vehicles. Lastly, the sense of sound plays a vital role, both for consumers who link a certain engine sound with an impression of quality and as a safety criterion, as quiet cars travelling at high speeds might pose several potential problems. While hydrogen fuel cell cars are quieter than their combustion engine rivals, they nonetheless produce a natural sound, most notably during intense acceleration, which is often anticipated by consumers (Münder & Carbon, 2022).

Refueling circumstances may further contribute to the probable sluggish adoption of hydrogen. While most consumers see supply security as a natural occurrence depending on a range of circumstances, customers themselves need many refuelling stations dispersed across Central Europe to be persuaded. To promote the use of hydrogen-powered automobiles, infrastructure is seen as crucial in addition to international collaboration, like the hydrogen trade system that many countries have deemed significant (Cronert & Minner, 2021; Han et al., 2022; Ku et al., 2022; Savari et al., 2022).

Originating from the idea of diversifying transportation in general, several institutions and organisations support integrated transportation. Typically, the term combined transport refers to the sequential use of at least two distinct modes of transport to carry an object. The goods remain inside the same transport unit for the length of the journey. The transport is conducted by rail networks, inland waterway routes, or ocean-going vessel for the majority of the total distance and by motor vehicle for the remainder, which is as short as possible; furthermore, when the modes of transport are changed, it is not the goods themselves that are transhipped, but rather the loaded loading units or loaded motor vehicles (Bundesamt für Güterverkehr, 2022; Gronalt et al., 2010; Kaffka, 2013). Like this idea, numerous prior studies have shown that there is no sensible method to combine a single powertrain, whether it be electric, hydrogen, hybrid, etc., that could efficiently accommodate all levels of mobility consumption, flexibility, and spontaneity (Wee et al., 2020; Q. Wu et al., 2010). Therefore, it is advocated that the powertrain should adapt to the client as opposed to imposing drastic modifications to the present mobility usage.

3 Methods

This study's objective is to analyse the factors responsible for persuading customers of all groups to change their long-term purchasing behaviour away from combustion engine-powered vehicles and toward the sustainable concept of hydrogen-powered electric cars, and then to combine simple arguments into the basis of future decision-making models.

Due to the very restricted post-prototype variety of options, clients will not be presented with the assessment of a direct model, but rather with the option of acquiring a hydrogen-fuel based vehicle if the demand for such mobility arises. Since the purchase of a vehicle is one of the most important choices a person can make stakeholders from all angles are placing a greater emphasis on developing ecological solutions for this industry.

The questionnaire was constructed further on the premise of uninterrupted growth in the automotive industry (Doğan & Erol, 2019), indicating that national and supranational institutions will pursue two main concepts: promoting the use of private mobility via alternative drivetrains with a strong emphasis on low-emissions and, thus, reduced environmental impact (Chng et al., 2019) and encouraging public transport infrastructure. While the efforts of businesses involved in the automobile industry, notably the OEMs and their extensive network of regional, national, and worldwide suppliers, continue to rise, the complexity of technical and strategic knowledge management is also expanding (Ton et al., 2022a). Consequently, the need for a customer-centric leadership approach has never been greater, necessitating ideas that offer both goods and services in response to rising worldwide supply chain needs (Donnellan & Kase, 2019).

As a result, a twelve-statement technique was adopted, in which the respondents are asked to assess twelve consumer purchase benefits, so-called items, of hydrogen fuel cell automobiles, based on previous literature depicted in the literature review. The questionnaire is constructed as follows.

Item1. Hydrogen burns without emitting CO2 and is classified as CO2-neutral.

Item2. In contrast to electricity, natural gas or petrol, the price of hydrogen is hardly subject to fluctuations and is currently cheaper than other fuels.

Item3. The price of hydrogen vehicles will be significantly more expensive than diesel/petrol vehicles, compared to electric cars.

Item4. The range of hydrogen vehicles is about the same as that of electric vehicles and is currently still significantly less than that of conventional consumers.

Item5. The refuelling time of hydrogen vehicles is extremely fast. Approx. 15 seconds are enough to fill the tank.

Item6. Hydrogen vehicles are resistant to temperature. In winter, the vehicles can be started without any problems.

Item7. Hydrogen vehicles have an increased risk of explosion in the event of an accident.

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Item8. There are currently only a few filling stations that offer hydrogen as a fuel.

Item9. Vehicles with hydrogen engines are noiseless. There is no concern about noise pollution.

Item10. Vehicles with fuel cells are more efficient and environmentally friendly due to the possibility of storing CO2 free electricity.

Item11. Different alternative drives fulfil different tasks. There should not be just one solution.

Item12. If hydrogen vehicles were available in Germany, I would buy a hydrogen vehicle.

All possible answers were evaluated on a bipolar, eleven-point scale ranging from 0 (strongly disagree) to 11 (strongly agree). This research aims to grasp the attitudes and perceptions of participants on a certain "latent" characteristic (phenomenon of interest as in purchasing a hydrogen vehicle). This 'latent' variable is represented by eleven 'manifested' items in the questionnaire, the final of which is a direct answer of purchase decision making (Joshi et al., 2015). These questions target a specific dimension of a phenomenon in a mutually exclusive manner; therefore, the respondent cannot submit a text-based answer and must instead supply a number between 0 and 11 to indicate his or her choice. The greater range of the point scale was selected on purpose to provide a more accurate depiction of contemporary consumer preferences.

Due of Germany's dominance in Europe, particularly Central Europe, in vehicle research and development, production, and marketing, the focus was narrowed to a single country. Although the manufacture of automobiles is shifting to neighbouring nations like the Czech Republic, Hungary, and Slovakia, the process of conceptualization and design remains firmly rooted in Germany. Even when working with partners in other countries, organisational and managerial considerations mean that Germany will continue to serve as the hub for project management and development, communication channels, and cross-functional teams. As a result, only German potential customers were able to respond, since the strategic decision-making essential to a successful invention is not now specifically focused on hydrogen transportation.

While BEVs and HEVs of all types do not share common technical parameters (Schonknecht et al., 2016) due to different usage scenarios of batteries, inverters, and similar components, they do share a futuristic design and offer fewer external design differences than traditional internal combustion engine vehicles.

Concerning the social context of the participants, age and educational background questions were regarded essential (Givord et al., 2018).

Using SoSciSurvey.com, the survey was designed to gather the data. Participants completed the survey between July 11 and August 4, 2022. There was no time restriction for submitting responses.

The necessary number of valid responses to achieve verifiable and reproducible results was calculated via G-power. Using a multiple regression model the relationship of a dependent variable to independent factors. Therefore, the option of an F test: Multiple Regression (R^2 deviation from zero), was applied.

The number of predictors is set to 11, based on the number of questions revolving around factors in the analysis. The effect size of 0.25 was selected with a mixture of the medium and large f^2 effect size index, based on Cohen, 1988, as it is seen as a compromise between economic models and personality psychology, i.e., customer-based decision-making models.

No hypothesis test offers 100% certainty. Since the test is based on probabilities, there is always the possibility of drawing a wrong conclusion. Two types of errors can occur in a hypothesis test: 1st kind error and 2nd kind error. The risks of these two types of error are inversely proportional to each other and are determined by the significance level and power of the test. An α of 0.05 was selected, resulting in a 1- β err probability of 0,95 indicating a 5% probability of choosing incorrectly when rejecting the null hypothesis.

These assumptions resulted in a suggested total sample size of 111 answers.

4 Results

The study included answers from 117 respondents; the descriptive statistics for the study's most important variables are shown in table 1.

Table 1: Overall descriptive data

Items	Categories	Percentage
Gender	Male	40.1
	Female	59.9
Age	<21	6
	21-30	77
	31-40	13
	41-50	7
	51-60	8
	>60	6
Education Background	Secondary school[1]	6
	High school	36
	Bachelor	46
	Master	19
	Ph.D.	5
	Other	5

Multicollinearity based on the variance inflation factor is barely measurable, demonstrated in table 2.

[1] Due to the difference between secondary school levels (namely Hauptschule and Realschule), the questionnaire included both parameters as possible answers. For simplification and differing school systems worldwide, the answers were combined in this instance.

Table 2: Test of multicollinearity based on the variance inflation factor (VIF)

Variable	VIF	1/VIF
Adv. 1	1.62	0.6165
Adv. 6	1.60	0.6237
Adv. 10	1.59	0.6287
Adv. 4	1.52	0.6575
Adv. 5	1.49	0.6714
Adv. 3	1.49	0.6728
Adv. 8	1.46	0.6836
Adv. 11	1.33	0.7505
Adv. 7	1.29	0.7772
Adv. 2	1.27	0.7889
Adv. 9	1.22	0.8176
Mean VIF	1.44	

One of the most crucial requirements of linear regression is that residuals at each level of the predictor variable have an equal variance distribution. In table 3 a Breusch-Pagan test is performed in order to evaluate the presence of heteroskedasticity.

Table 3: Results from the Breusch-Pagan test

H0: constant variance Variables: fitted values of Adv. 12	
Variables	**Values**
Chi^2	0.06
Prob > chi^2	0.8013

The testing of the possible purchase of hydrogen-powered cars against the eleven questions confirmed the following key findings, as shown in table 3 and 4, respectively.

Table 3: Statistical results regarding the hypotheses

Source	SS	df	MS	No. of obs	=	117
Model	204.03	11	18.54	F(11,105)	=	4.69
Residual	415.19	105	3.95	Probability > F	=	0.0000
				R-squared	=	0.3295
Total	619.23	116	5.33	Adj. R-squared	=	0.2593
				Root MSE	=	1.9885

To summarize:

- Advantage 2, the price stability of hydrogen as a result of (to some extent) plannable local production and potentially competitive pricing, is persuasive to buyers (P > t = 0.008).
- Advantage 10, claiming that HFC cars are more environmentally efficient when fuelled with the matching green energy and can store CO2 free power (P > t = 0.028).
- Advantages 7 and 9 were just on the cusp of statistical significance (P > t = 0.05), but their existence is remarkable enough to warrant discussion. The safety aspect (increased danger of explosion in the case of an accident, ADV. 7, P > t= 0.059) and their noise emissions (reduced or non-existent noise emission, ADV. 9, P > t= 0.079) might be regarded convenience aspects.

The entire model is judged significant (p0.01) and accounts for a substantial proportion of the variation in the dependent variable (R-squared=0.3295).

Table 4: Results of the linear regression model

Purch. HFC	Coef	Std. Error	T	P > t	95% Conf. interval	
Adv. 1[2]	-0.0702	0.1091	-0.64	0.521	-0.2866	0.1461
Adv. 2	0.2411	0.0890	2.71	0.008	0.0645	0.4177
Adv. 3	-0.0402	0.0951	-0.42	0.673	-0.2289	0.1484
Adv. 4	-0.0785	0.1038	-0.76	0.451	0.2845	0.1274
Adv. 5	0.0876	0.0758	1.16	0.250	-0.6263	0.2380
Adv. 6	0.1133	0.9834	1.15	0.252	-0.0816	0.0067
Adv. 7	-0.1814	0.0949	-1.91	0.059	-0.3697	0.0067
Adv. 8	-0.676	0.0945	-0.72	0.476	-0.2551	0.1198
Adv. 9	0.1283	0.0724	1.77	0.079	-0.0152	0.0272
Adv. 10	0.2697	0.1206	2.24	0.028	0.0304	0.2948
Adv. 11	0.1187	0.0888	1.34	0.184	-0.0573	0.2948
_cons	2.82	1.32	2.14	0.035	0.2030	5.43

[2] The advantages were directly translated from the questions Q1-Q11.

So far, the concept of innovation, the possibilities and sources of adopting hydrogen as a resource in private mobility, as well as the many future and present policymaking instruments of Central European state legislations have been examined. As push measures have already been (partially) implemented on a broader scale, it is essential to emphasise the need for future pull incentives in order to determine whether customers are really motivated to reconsider their current purchasing habits in favour of a hydrogen-powered vehicle. It was important to test a variety of hypotheses concerning critical aspects in order to discover which sectors really influence consumer behaviour on the Central European auto market.

This survey aimed to evaluate the opinions of current consumer groups on the purchase of a hydrogen-powered vehicle. The key hypothesis was on whether there are evident indicators that buyers expect when given with the opportunity to purchase a vehicle that is now just a concept, but important for attaining long-term emissions reductions in private travel. It is reasonable to conclude, based on the evidence, that the hypothesis is somewhat supported. The majority of consumers have not prioritised the zero-emission components of present hydrogen models, despite the fact that the reduced environmental impact is clear in terms of future advantages. According to current technologies for mass-producing hydrogen from emission-heavy coal, gas, or methane-derived resources, the majority of consumers seem to be considering the availability of alternate fuels for the future (ADV 1). Similarly, the higher price of innovation is not statistically significant, indicating that customers now regard cutting-edge technology as a company with a substantial research and development component (ADV 3). ADV 4, 5, and 8 focused on the oft-discussed range and refuelling challenges that are frequently encountered with other alternative engine designs. Surprisingly, while these characteristics tended toward increased importance, they did not meet the criteria for influencing the purchase decision. This might be attributed to the current state of hydrogen mobility in Central Europe, which is very concept-heavy and prototype-light, prohibiting significant considerations at this time. As with other battery-powered mobility concepts, winter weather with its colder temperatures and corresponding varied environment effects (increased energy for heating, tyre specifics, and all-wheel operation, etc.) may significantly reduce the range compared to the typical Central European mild weather in other seasons. Reaching equivalent relevance levels as ADV 5, it is expected that many customers lack genuine experiences with HFC cars in conjunction with Germany's mild winters, which have grown less mobility-limiting over the last few of years. Finally, the subject of alternative concepts, namely BEVs and HFCs, which provide different functions and so attract separate customer groups was explored. Despite not reaching statistical significance, it is important to note that prior research (Hiermann et al., 2019; Yang et al., 2016) indicates that the operating expenses of a mixed fleet can be significantly reduced across a wide range of pricing scenarios if the appropriate policy considerations are applied.

Furthermore, ADV 2 and 10 could be fully supported, indicating that many customers have a strong financial focus on the maintenance and thus longevity of their next vehicle purchase, while also valuing the emission-free ecological propulsion, focusing solely on the hydrogen-burning process during vehicle operation. ADV 7 and 9 were also studied, but failed to meet the stringent condition (P > t = 0.05) since they concentrated on qualities not present in diesel or gasoline-powered German automobiles, which dominate the market.

5 Discussion

Taking a longer view on the potential of hydrogen-based transportation is the first step in increasing the uptake of battery-powered electric automobiles in Central European culture. It is important to find out whether using hydrogen as a power source increases or lowers the likelihood of future sales of automobiles of all makes, models, and environmental impacts.

First, past literature states that the buying behaviour of automobile customers follows a hierarchical pattern of decision-making, in which buyers prioritise specific characteristics of future purchases, such as safety, range, and price. According to prior study (Chng et al., 2019; Lane & Banks, 2010; Nayum et al., 2013; Noblet et al., 2006; Peters et al., 2008), the automobile segment plays a distinct role in the decision-making process. Currently, there is a dearth of automobiles that use hydrogen as their primary fuel source, which has led to a lack of understanding about hydrogen propulsion amongst many consumers. Consequently, model-dependent concerns were purposely disregarded, and the attention was instead placed on the actual particulars of hydrogen as a replacement for BEVs. However, our research could verify, that customers demand changed as well in the last years, as customers do tend to focus the aspect of ecologic i.e., zero-emission individual transportation.

In addition, the importance of energy efficiency and, by extension, sustainable mobility, is frequently downplayed or replaced by the idea of reduced operational costs (Galarraga et al., 2020). Therefore, consumers prioritise practicality, reliability, and other factors beyond fuel efficiency when selecting a vehicle class. Policymaking that seeks to reduce emissions from private mobility, rather than focusing on intermodality-based concepts, should emphasise financial incentives oriented at smaller and overall energy efficiency.

Customers form conclusions based on a synthesis of their own experiences, the details of the situation at hand, and heuristic shortcuts rather than doing extensive study. Previous research has demonstrated that the outcomes of repeated activities in familiar environments tend to be favourable, notwithstanding the effect of one's beliefs or aims. Studies have shown that a customer's loyalty to a brand is best predicted by the frequency with which they have bought that brand in the past. According to this line of thinking, brand loyalty helps with decision-making in a way that is comparable to that of established routines (Nayum et al., 2013). However, the low market presence of automobiles in Central Europe, save for a few niche models compared to prior alternatives to the typical gasoline-based engines, meant that a clustering of income groups about future hydro-gen purchases of such respondents was not addressed (Givord et al., 2018).

Furthermore, many ODMs are still unsure about how to establish their future product-related strategy framework. Customers are often left in the dark about which technologies are still within the purview of automotive companies due to both internal unease and disarray resulting in neuroticism or even animosity due to a lack of adapted leadership (Ton et al, 2022b & Ton et al, 2022c) and external pressure through ever increasing legislative measures of both supranational and national legislative organs (Ton et al, 2021).

Finally, heteroskedasticity plays a significant role since rapid technological change introduces bias owing to worries about money, living conditions, employment expectations, etc. Research from moderate and high-income nations (Givord et al., 2018; Nayum et al., 2013) cautions against generalising findings from lower-income settings to higher-income ones when trying to understand consumers' purchasing decisions. In the diesel-powered, large size, and four-wheel drive segments, repeat buyers are more likely to stick with the same brand they've purchased in the past. Previous research on brand loyalty have indicated the significance of brand loyalty for future purchases of vehicles, and the results of this study support those conclusions.

Although the quantity of required replies for the questionnaire's precise, quantifiable, feasible, practical, and time-restricted framework was carefully studied, future study must expand on two specifics in particular. First, once a variety of automobile models with hydrogen-powered drivetrains are accessible to German consumers, a model-specific and categorical assessment of metrics such as size, range, fuel consumption, price, and other aspects must be quantified. Second, future questionnaires must evaluate socioeconomic factors such as housing situation, daily commute, use of the vehicle, number of users, family size, and driving behaviour in order to conduct an in-depth analysis of the feasibility of hydrogen fuel cell vehicles and derive region- or even county-specific policies.

6 Summary and Conclusion

The goal of this paper was to give an overview of the status-quo insights into the current purchasing decision-making of consumers regarding the purchase of automobiles with hydrogen drivetrains. As an introduction, the increasing importance of companies in the automotive sector as well as policymakers promoting sustainable mobility was briefly show-cased. Followed-up by some insights into the general concept of purchasing decision-making, most of the paper revolved around the question of which relevant items to include into a questionnaire directed at individuals seeking to purchase a car soon.

Based on extensive literature, subsequently an eleven items including questionnaire was formed, based on an eleven-point scale ranging from strongly disagreeing to strongly agreeing positions. The analysis was exclusively presented and promoted in Germany, due to the strong automotive focus as well as the only country in Central Europe which focuses their hydrogen manufacturing on green energy-based sources.

For further research, it is suggested to focus on the policymaking concept of hydrogen use, manufacturing, and promotion in neighbouring countries of Central Europe due to varying diversification of the energy mix as well different mobility demand and customer demands.

Overall, it can be safely stated, that customers focus on two main concepts when considering hydrogen fuel-based cars. Firstly, the expected price stability by domestic hydrogen manufacturing is deeply valued, due to the current high dependence of fossil fuels, that are subject to a variety of external effects, not in direct influence of consumers. Secondly, the ability to use individual mobility, that can be fuelled with a sustainable energy carrier is deemed as crucial, resulting in a necessity of bivariate consideration in future research.

7 Authors

Laszlo Hammerl is a Ph.D. student at the Magyar Agrár és Élettudományi Egyetem (MATE), formerly known as the Szent István University – Kaposvár Campus. His doctoral research focuses on the aspect of innovation in the German automotive industry and thereby evaluate, how hydrogen propulsion can become a meaningful alternative for customers in Central Europe.

Oliver Kremer is a Ph.D. student at MATE and has focused his studies so far towards crucial lack of skilled personnel in the Central European health sector and how its migration from Eastern Europe may improve the situation short term but potentially cause devastating effects in the long-term if not supported properly via adapted policymaking.

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