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Avoidance rather than change: What influence does the price shock for mineral oils have on the mobility behaviour of users of motorised private transport in Germany?

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Abstract

One of the most significant challenges facing the world today is rapid climate change and the negative effects it is having on our environment. The transport sector is responsible for high CO₂ emissions, and will have to make fundamental contributions to climate goal targets in the medium to long-term future. In the past, far-reaching measures have been tested regarding how to encourage people to switch from their own cars or motorised private transport (MPT) to the more emission-friendly local public transport (PT). Previous projects have only been able to convince people to switch temporarily through subsidised public transport. Detached from the ecological aspects, the turmoil in the global economy at the end of February 2022 resulted in a price shock in mineral oil prices, which shifted the primary focus of mobility behaviour from ecological to economic concerns. The logistic regression analysis of a quantitative survey (n = 611) in Germany confirms that a large number of journeys taken via private car were saved due to the increased price. However, despite high mineral oil prices, travelling by private car remains the primary means of transport for many people. Switching to public transport is particularly noticeable among women. This is due, among other things, to their lower incomes. Contrary to results of prior studies, the present analysis shows that participants from large cities have saved fewer trips by private car compared to people living in rural areas, even though large cities generally have a denser infrastructure with a more comprehensive range of mobility options. Travel time and reliability are the main factors in our respondents' choice of transport mode and are more compatible in large cities with denser public transport than in rural areas. The avoided car journeys are predominantly in the leisure sector and have not been substituted by other means of transport.

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1. Introduction

Human-made climate change and the development of sustainable environmental strategies are two of the most urgent and fundamental challenges of the 21st century, in which the transport sector will play a central role (Dubios et al. 2019). In Germany, exceedances of EU-wide pollutant limits have led to court-ordered driving bans in the affected cities. The transport sector, as one of the primary foundations of the German economy, has one of the highest greenhouse gas emissions in the German economic cycle (Climate Protection in figures 2020). According to the Federal Environment Agency, the ambitious climate targets for 2021 have not been met (Climate Protection Act 2021). Due to this fact, further intensified efforts are inevitable, with the aim of strongly minimising greenhouse gases (Energy and Mobility 2021).

The German population views climate change as a major threat. In the past, however, there have been no major trends in behavioural change in the choices vis-a-vis means of transportation. Though a multitude of measures to improve public transport offerings and a heavily subsidised public transport price were supposed to bring about a change in MPT* to public transport, only a small group of people could be convinced to change. It is difficult to convince many car drivers to switch to an attractive public transport service with a stable gasoline price. Buying a car is also a long-term decision that cannot be revised in an economically sensible way over the short term (Al-Busaidi et al. 2019). Travel habits, on the other hand, are usually long-term patterns from mobility experiences and can only be reconsidered through effective arguments.

The drastic increase in petroleum prices since Russian troops invaded Ukraine at the end of February 2022 has had a major impact on the global economy and has brought an array of economic challenges to the forefront, at least for the time being. Gasoline prices have risen steadily in recent months, albeit at a moderate pace. The war has caused prices to jump by over 64% to record levels in a very short time (Onour et al. 2022). This drastic increase in the price of mineral oil is a central factor in the use of transportation in Germany where the private car is the primary means of transport (Ruhroft 2019). This is why a majority of Germans are directly affected by the price increase at the petrol station. Scientific studies on price elasticity have therefore tended to be theoretical in nature in the past, typically based on hypothetical questions (Caldara et al. 2019). The current crisis thus offers the opportunity to empirically explore the influence of price on mobility behaviour in real-life circumstances.

From our quantitative online survey, we were able to draw upon 611 complete data sets from across Germany for the analysis. Using logistic regression, we were able to infer significant predictors of mobility behaviour, as well as willingness to avoid MPT journeys due to current economic developments. The primary aim of our research is to show whether this large and rapid price increase might lead people to be more aware of mobility and to avoid MPT journeys, or whether changes in the choice of means of transport can be observed whatsoever.

2. Literature Review

The present study refers to the impact of increased oil prices on economic performance, people's insecurity due to high inflation and the resulting inferences on mobility behaviour.

After the 1974 oil crisis, research in energy economics focused on modelling supply shocks and quantifying their impact on the world economy (Onour & Abdo 2022). The impact of the oil price shocks of the 1970s has been well documented in the literature and has prompted a review of the cyclical component of GDP since the mid-1990s and early 2000s based upon these factors (Balke et al. 2010). According to a study by Hamilton (2009a, 2009b), the impact of oil price shocks on economic activity depends upon the underlying cause of these shocks. Accordingly,

* According to the report on the results of mobility in Germany, the term "motorised individual transport" in our study refers mainly to car drivers and their passengers, but also to motorised two-wheelers such as motorbikes, mopeds or mopeds. The participants were informed accordingly when the question was posed.

unlike prior oil price shocks that were triggered by supply disruptions, the oil price increase of 2007-2008 was mainly due to strong demand in the face of declining global production (Hamilton 2009a, 2009b). Kilian (2009) finds that oil price increases triggered by supply-side shocks have a small and merely temporary effect on the real oil price (and thus on economic activity). Carstensen et al. (2013) note that the 2008 oil price increase, following initial declines, was subsequently more than offset by the increase in global demand for the country's export goods. The results of a recent study from Onour et al. (2022) on the change in the price of mineral oil since the Russian invasion of Ukraine show that a significant increase in the price of oil is to be expected. Due to the economic interdependence of individual companies, an increase in the price of an essential commodity like mineral oil leads to an increase in product costs across all sectors (Roquel et al. 2018). Ultimately, these cost increases will be passed on to consumers if no significant measures are taken to cap them. The additional economic burdens therefore particularly affect the manufacturing industry and the population at large.

There is a broad consensus in the literature that, unlike previous oil price shocks, the rise in oil prices over the last two decades has driven aggregate demand shocks, and the role of supply-side shocks on economic activity has been limited (Hamilton 2009a; Kilian 2009; Balke et al. 2010; Hai-lemariam et al. 2019). Oil price shocks trigger negative responses of economic uncertainty; however, these responses are significantly affected by external shocks (Tunc et al. 2022).

Since the 1970s, the price of a litre of gasoline has increased more than fivefold in total. The effects of the second oil crisis beginning in 1979 led to a significant price increase, which declined slightly from 1986 onwards (Federal Statistical Office 2022). The dynamic reactions of the variables were significantly influenced by two major recent historical events: the COVID-19 crisis (2020) and the global economic impact of the war in Ukraine (2022) (Tunc et al. 2022).

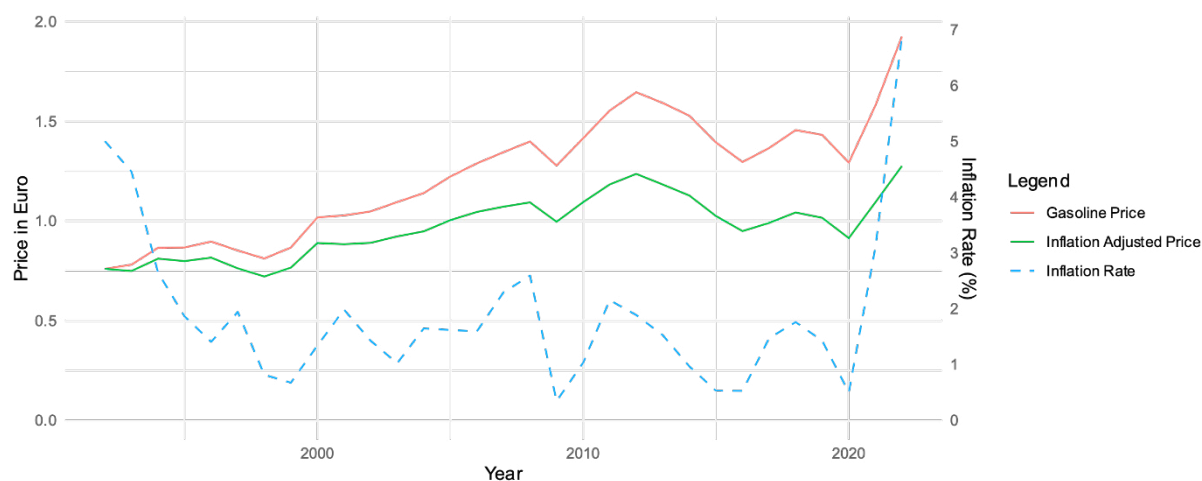


Fig. 1: Development of gasoline price, inflation rate and inflation adjusted price. Own representation adopted at Statista (Federal Statistical Office 2022).

The macroeconomic price development in Germany in February 2022 is an extreme economic burden for people and companies alike, due to a drastic increase in the price of services and goods with an inflation of 5.1% (previous month January 2022: 0.9%) (Consumer Price Index 2022). In line with theories of investment under uncertainty, studies show that increased uncertainty delays firms' hiring and investment decisions (including Bernanke 1983; Bloom 2009; Elder and Serletis 2010; Bloom et al. 2018) and households' consumption decisions (Bloom 2016). These negative effects on consumption, investment and hiring decisions affect output by weakening both aggregate demand and aggregate supply (Visco 2017).

It is evident that negative influences from economic uncertainty on aggregate economic activity are transmitted via various variables such as industrial production (Baker et al. 2016; Jurado et al. 2015; Hailemariam et al. 2019),

investment (Bernanke 1983; Bloom 2016). Unemployment rate (Caggiano et al. 2017; Baker et al. 2016) and gross domestic product (Bloom, 2009; Baker and Bloom 2013; Cheng 2017). Moreover, Degiannakis et al. (2018) have evidence that the interaction between uncertainty shocks and macroeconomic variables is not constant over time, but rather is influenced by prevailing economic conditions.

Such economic uncertainty is noticeable across all price indices. For the present study, the focus is on commodity price developments, which have a large impact on the prices of other goods (Roquel et al. 2018). The COVID-19 pandemic with its consequences for supply chains and global trade, rising prices for CO2 emissions and the war in Ukraine have all had – and continue to have – an impact on the level of producer and consumer prices. The price of gasoline has tended to rise in recent decades, but mostly in a moderate way. However, due to the global economic difficulties that have prevailed since February 2022, there has been a drastic price shock, with prices rising to €2.30 per litre of gasoline at times.

The increased cost of living is difficult to bear for many people in Germany, while salaries remain static. This circumstance forces higher-level support from politics as well as individually optimised economic management. Against this backdrop of dwindling financial leeway in the face of rising expenses, the value of cars must be reassessed.

In the past, there have been many modelling attempts worldwide to steer a modal shift by increasing the attractiveness of local transport (Grzelec & Jagiello 2020). The design of the models as well as the results and consequences vary greatly; the central measure of most projects is a price reduction or free use of public transport (de Witte et al. 2006, 2008, 2013; Koblowski 2020). Buying a car represents a significant investment in a long-term mobility option. Decision-making depends on certain factors such as financial resources and their use. Gasoline prices and the cost of other goods in the market influence the purchase (Al-Busaidi 2019).

From a socio-ecological perspective, the aim is to convince people to make a nationwide switch to more emission-friendly public transport options. Nevertheless, the car is particularly popular in Germany and represents the primary means of transport for the population, despite large-scale investment in public transport projects (Nobis & Kuhnimhof 2018). The price as a significant factor for consumption decisions and has not yet been able to bring about lasting changes in people's behaviour. For example, studies have shown that cheap or free public transport is not attractive enough for people to switch if gasoline prices remain stagnant (Koblowski et al. 2019).

For this reason, the question of what influence the current price shock may have on the mobility behaviour of consumers is relevant and understudied, both from a theoretical and a practical point of view. For this reason, an online survey was conducted on previous mobility behaviour and its change due to the current overlapping crises impacting Germany.

3. Data and methods

3.1. Research design

The basis for this study was the drastic increase in the price of mineral oil after a decade of relative stability. Since prior studies on the influence of the price have mainly been theoretical, the aim of the present study was to determine empirically, based on the current situation, whether the mobility behaviour of MPT drivers has changed due to the price shock of mineral oil and whether they have made fewer MPT trips in total.

Based upon the knowledge of whether there is a general willingness to avoid MPT journeys, we inquired about alternatives to foregoing the journey or MPT journey or making the journey via public transport, which had not yet raised prices at that time. We were also interested in whether the price shock might have led to changes in transport preference, generally. To this end, we asked participants to rank the means of transport car, public transport and bicycle before and after the price shock according to their personal frequency of use. Moreover, participants were asked to rate their choice of transport mode with regard to travel time, reliability, price, environmental friendliness and health on a Likert scale.

We subsequently collected key factors socio-demographic data, as well as variables that have also been asked in prior studies (de Witte 2006, 2008, 2013; Macharis 2006; Akyelken 2013; Turdalieya & Edling 2018). These variables included gender, income, household size, car availability in the household, education, age, cars in the household, ownership of an electric car and experience with public transport, as well as residential situation. The residential situation aspect included access to and attractiveness of public transport, the working context, travel time by car or public transport to work and the frequency of car trips to work per week.

3.2. Approach and participants

The quantitative online survey was conducted with the help of the Unify survey platform over the period of March - April 2022 with a Germany-wide user sample. This meant that the effects since the price shock of February 24, 2022 could already be perceived by participants and could be determined promptly in survey results. A total of 1,330 people took part in the survey. At the beginning, it was asked whether the participant used a private car. If this question was answered in the negative, then the questionnaire was closed. A total of 611 records were completed in full by people whose primary means of transportation is the private car. The most important characteristics of the participant sample are listed in Table 1 below.

Table 1

Demographics of survey participants, whose main mode of transport is the private car (n = 611)

Characteristic	Number	Percent
<i>Survey participants by age:</i>		
Gen. Z (1995-2009)	75	12.3%
Gen. Y (1980-1994)	358	58.6%
Gen. X (1965-1979)	105	17.2%
Gen. Baby Boomer (1950-1964)	73	11.9%
<i>Gender:</i>		
Women:	279	45.7%
Men:	329	53.8%
Diverse:	3	0.5%
<i>Place of residence:</i>		
< 5,000	145	23.7%
5,001 – 20,000	108	17.7%
20,001 – 100,000	157	25.7%
> 100,000	201	32.9%

3.3. Data analysis

Before data analysis began, the survey data was cleaned and processed. In the evaluation, only those questionnaires were considered that were fully filled out and whose primary means of transport has been private car in the past.

In the data analysis, we were interested in both the mobility situation and the effect of price on mobility behaviour. A major focus was on the effect of the current price situation on the avoidance of journeys by personal car. As the journey to work is a very important and a frequently repeated route in everyday life, we looked at mobility behaviour specifically in the context of work and analysed influencing factors, such as working on-site in a company and home office as a future form of work, as well as the potential consequences for mobility resulting from changes in the mode of work.

Descriptive statistical methods (Döring & Bortz 2016) were used for the evaluation in order to analyse and present

the mobility situation of the full sample. Furthermore, methods of inductive statistics were used to determine correlations between the relevant variables (Eid et al. 2017). Statistical calculations were carried out in the data analysis software SPSS 27.

4. Results and discussion

4.1. Mode of transport preference

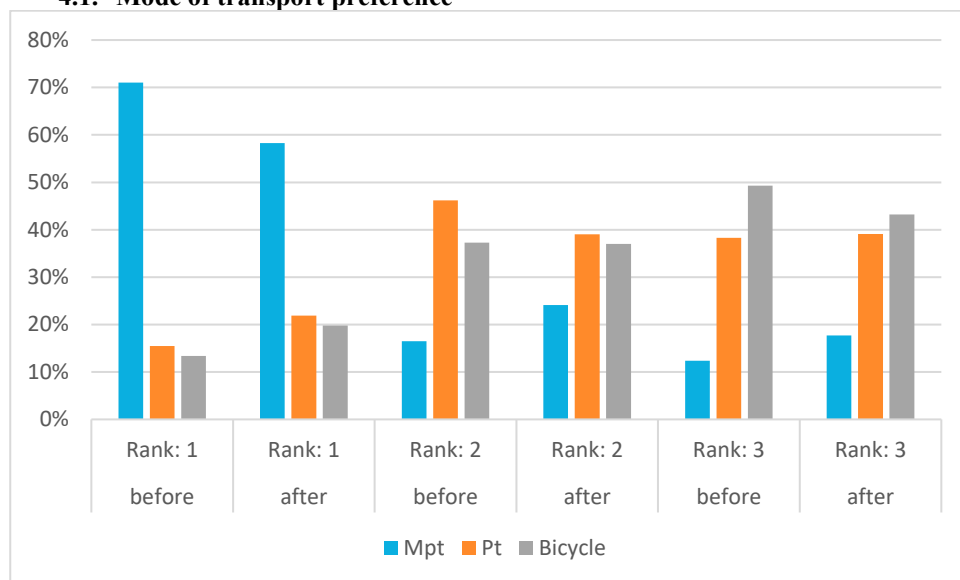


Fig. 2: Ranking of preferred mode of transportation (before and after price increase). Own representation.

An important question is whether the price increase in mineral oil has an influence on participants' preferred mode of transportation. Figure 2 shows the ranking of preference for car, public transport and bicycle before and after the price increase. The graph shows that the car has become less attractive than both public transport and cycling due to the price increase. However, despite the drastic price increase, the car remains the most preferred mode of transport among participants, with public transport and cycling coming in second and third, respectively. It also shows that the gap in second place between public transport and cycling has narrowed due to the price increase. One explanation for this is that consumers also fear a price increase for public transport, which does not affect cycling to the same extent.

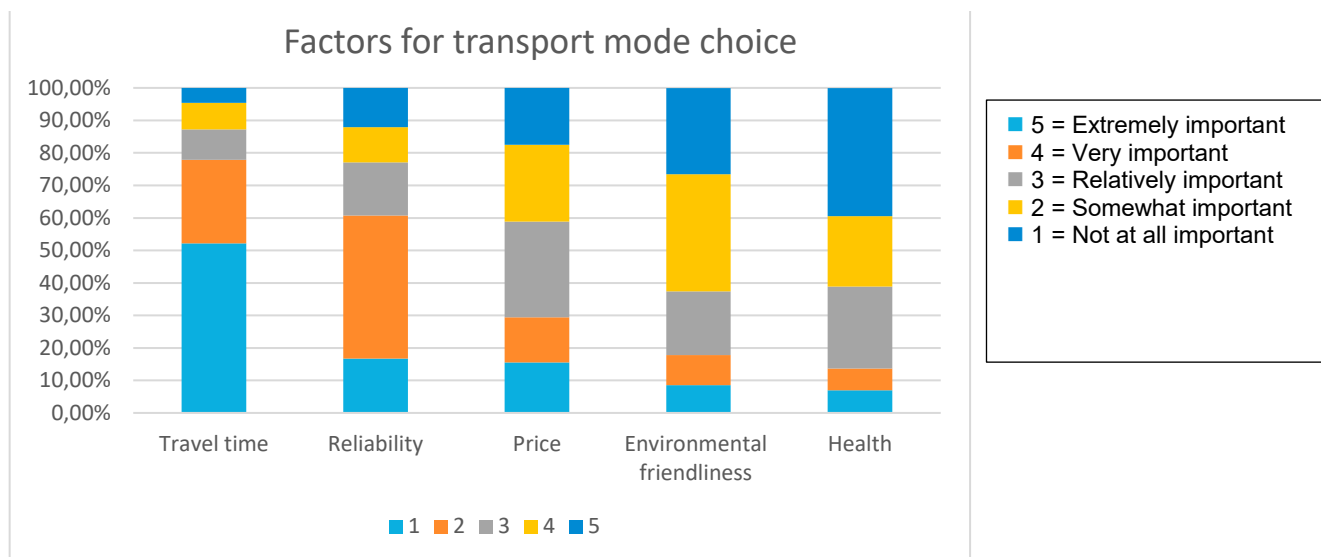


Fig. 3: Factors of transport mode choice (Own representation)

We also asked about the factors that play a role in transport mode choice (see Figure 3). The results show that travel time (mean=4.12) and reliability (mean=3.43) are the dominant factors that inform transport mode choice, followed by price (mean=2.90), environmental friendliness (mean=2.39) and health (mean=2.21).

4.2. Impact on personal use of private transport

Our survey shows a very differentiated picture with regard to how the mineral oil price increase affects MPT use. In terms of avoiding MPT trips, of the 611 participants, 55 (9%) said they had avoided one trip, 108 (17.7%) two trips, 74 (12.1%) three trips, 26 (4.3%) four trips and 66 (10.8%) more than four trips. Thus, a total of 329 participants (53.9%) stated that they have saved MPT trips since the price shock. The remaining 282 participants (46.1%) stated that the use of their own car has been unchanged despite the price shock.

Table 2

Cross-tabulation: willingness to change public transport versus avoidance of private car trips

		Willingness to change to pt		Total
		Yes	No	
Car trips avoided	Yes	169 (70.7%)	159 (43.0%)	328 (53.9%)
	No	70 (29.3%)	213 (57.0%)	283 (46.1%)
Total		239	372	611

Regarding alternative modes of transport, 239 participants (39.1%) stated that they would consider switching to public transport, while 372 participants (60.9%) stated that they could not imagine doing so. The cross-tabulation in Table 2 below shows that the willingness to switch has an influence on the avoidance of MPT trips: 70.7% (169 of 239) of those willing to switch state that they have in fact avoided MPT trips. Among those not willing to switch, only 43% (160 out of 372) have avoided MPT trips.

Table 3

Cross-tabulation: Travel avoidance vs. avoidance of MPT trips

		Willingness to forego travel		Total
		Yes	No	
Car trips avoided	Yes	227 (71.7%)	101 (34.8%)	328 (53.9%)
	No	89 (28.3%)	194 (65.2%)	283 (46.1%)
Total		316	295	611

316 of the 611 respondents stated that they would consider not travelling at all. At 51.6%, the willingness to forego travel completely is higher than the willingness to switch to public transport (39.1%). The cross-tabulation in Table 3 shows that willingness to completely forego travel has an influence on the avoidance of MPT trips: 71.7% (227 out of 316) of those willing to forego state that they have actually avoided MPT trips in recent months. Among those not willing to forego, only 34.8% (101 out of 295) have avoided MPT trips.

Overall, the analysis shows that participants for whom public transport is a possible alternative react more sensitively to gasoline price increases. They forego trips or switch to public transportation options. The study also shows that, despite a higher mineral oil price, public transport is an alternative for just 39.1% of respondents (239 out of 611). The switch to public transport in our study is thus not predominantly dependent on the price of mineral oil. These findings are in line with observations on mobility behaviour from previous studies (e.g., Cats et al. 2017; Kębłowski et al. 2019). Here, no area-wide switch to public transport could be recorded, even due to low-cost public transport. For the groups of people who do not see an alternative in public transport, the only option is to save MPT journeys by not travelling. As journeys to work are usually enforced by employers, it can be assumed that car journeys in their free time are cancelled without replacement or made by alternative means of cycling or walking.

4.3. Logistic regression analysis

In the previous section, we have shown that 53.9% of the participants avoided MPT trips due to the price increase in February 2022. In various previous studies (e.g. De Witte 2013, Hahn et al. 2023, Hahn et al. 2024)), the avoidance of MPT trips was identified as a significant indicator for a sustainable contribution to climate protection. For this reason, we used logistic regression to investigate which exact variables have an influence on whether someone saves trips or maintains their previous mobility behaviour despite higher mineral oil prices.

In addition to the dependent variable "avoidance of MPT trips", we derived the independent variables relevant to our study from previous studies and structured the questionnaire accordingly. Firstly, we collected essential socio-demographic and extensive information on forms of mobility and their mobility practices. These include the variables gender (Akyelken 2013), age (Turdalieya & Edling 2018), education (de Witte (2006, 2008, 2013), income (Hamidi & Zhao 2020), household size (Hamidi & Zhao 2020), inhabitants (Macharis 2006), mobility (car, e-cars, public transport, working context) and mobility practices (Hahn et al. 2023, Hahn et al. 2024).

The evaluation of the omnibus test of the model coefficients provides results regarding the likelihood ratio test in the form of the Chi-square value and the associated significance level (p-value). The result of the model summary outputs the values of $-2\log$ likelihood as well as the coefficient of determination according to Cox & Shell, and the modified pseudo- R^2 according to Nagelkerkes as a measure of quality. This value shows how well the variance of the dependent variable MPT trip avoidance can be explained by the independent variables (Backhaus et al. 2018). In order to be able to classify the significance of the coefficient of determination, we calculated the effect size according to Cohen (1988), using the formula: $f^{\lambda} = R^2 / 1 - R^2$.

The output table below contains relevant information on the model, the independent variables, the estimated regression coefficient, the expected standard error, as well as the Wald test, the Exp (B) and the confidence interval (CI) of 95%. The results of the described analysis are listed in Table 4 below and the interpretation of the significant

p-value are articulated after that.

Table 4

Results of logistic regression analysis for the dependent variable of car avoidance

Model	Variable	B	S.E.	Wald	Sig.	Exp(B)	95% C.I. for Exp(B)	
							Lower	Upper
Gender	Female	.559	.202	7.663	**	1.749	1.177	2.598
Age	Age	.002	.009	.031		1.002	.983	1.020
Education	Grammar school	.153	.559	.075		1.166	.390	3.485
	Completed vocational training	-.137	.407	.113		.872	.393	1.937
	University graduation	.307	.572	.288		1.359	.443	4.168
	Bachelor study	-.311	.445	.489		.733	.306	1.752
	Diploma study	.172	.488	.124		1.187	.456	3.088
	Master study	-.266	.471	.320		.766	.304	1.928
	Doctorate	.277	.633	.191		1.319	.381	4.559
Income	1,001-2,000	-.476	.600	.627		.621	.192	2.016
	2,001-3,000	-.150	.563	.071		.861	.285	2.595
	3,001-4,000	-.361	.564	.410		.697	.231	2.105
	4,001-5,000	-.741	.581	1.628		.477	.153	1.487
	> 5,000	-1.007	.564	3.185	*	.365	.121	1.104
Household size	2 persons	.224	.320	.489		1.251	.668	2.344
	3 persons	.297	.361	.677		1.346	.663	2.732
	4 persons	.043	.385	.012		1.044	.491	2.220
	> 4 persons	-.213	.567	.141		.808	.266	2.457
Inhabitants	5,001 - 20.000	-.564	.308	3.344		.569	.311	1.041
	20,001 - 100.000	-.231	.287	.646		.794	.452	1.394
	> 100,000	-.643	.296	4.715	*	.526	.294	.939
Car	Car anytime available	-.862	.504	2.920		.422	.157	1.135
	2 cars in household	1.253	1.24	1.005		3.500	.302	40.510
	3 cars in household	1.585	1.27	1.549		4.880	.402	59.236
	4 cars in household	1.569	1.31	1.428		4.804	.366	63.011
	> 4 cars in household	2.222	1.49	2.216		9.222	.495	171.786
E-cars	2 E-cars in household	-.280	.321	.760		.756	.403	1.418
	> 2 E-cars in household	-1.056	1.31	.643		.348	.026	4.602
Public transport	Access to public transport	-.038	.125	.095		.962	.754	1.229
	Public transport	-.064	.130	.244		.938	.727	1.210

	experience							
	Attractiveness of public transport	.109	.130	.713		1.116	.865	1.438
Working context	Duration of car journey to work	-.001	.009	.029		.999	.982	1.015
	Duration of public transport journey to work	-.004	.004	.807		.996	.988	1.004
	1 car trip to work per week	-.132	.340	.149		.877	.450	1.708
	2 car trips to work per week	.413	.334	1.528		1.511	.785	2.907
	3 car trips to work per week	.231	.359	.414		1.260	.624	2.545
	4 car trips to work per week	.510	.456	1.255		1.666	.682	4.069
	> 4 car trips to work per week	-.671	.319	4.412	*	.511	.273	.956
Mobility practices	Use car several times a week	.493	.260	3.590		1.638	.983	2.727
	Use car several times a month	1.092	.333	10.765	***	2.980	1.552	5.722
	Use car rarely	.872	.384	5.157	*	2.392	1.127	5.078
	Use car never	.387	.662	.342		1.473	.403	5.390
	Use public transport several times a week	-1.089	.500	4.744	*	.337	.126	.897
	Use public transport several times a month	-1.329	.509	6.817	**	.265	.098	.718
	Use public transport rarely	-1.450	.511	8.062	**	.235	.086	.638
	Use public transport never	-1.662	.565	8.635	**	.190	.063	.575
	Bicycle several times a week	-.102	.348	.086		.903	.457	1.786
	Bicycle several times a month	-.720	.356	4.079	*	.487	.242	.979
	Bicycle rarely	-.678	.367	3.413		.507	.247	1.042
	Bicycle never	-.755	.387	3.802	*	.470	.220	1.004

*p<.05, **p<.01, ***p<.001

Model 1: $X^2(12) = 45.389$, $p < .001$, $R^2 = .268$

The logistic regression model shows that it can in fact make a significant contribution to the explanation of variance: ($X^2(12) = 45.389$, $p < .001$, $R^2 = .268$, $f^2 = .37$). Accordingly, 26.8% of the variance of the dependent variable can be explained by the model. According to the calculations of Cohen (1988), this value constitutes a strong effect. The model thus shows significant results. Accordingly, the independent variables of gender, income, place of residence, frequency of MPT to work, as well as MPT, public transport and bicycle have a significant influence on the avoidance of MPT trips. In the following section, we will discuss these factors in greater detail.

4.4. Significant variables

4.4.1. Household income

The results of the logistic regression show a significant relationship between income above 5,000€/ month and avoidance of MPT trips. When the household income is above 5,000€/ month, then the odds are 1:0.365 in relation to an income below 1,000€/ month. The probability of avoiding MPT thus decreases by 64.5%.

Our participants show a very differentiated income level. 26.4% have a household income of more than 5,000€ net per month. In contrast, 14.2% earn an income of less than 2,000€ and 5.1% have an income of less than 1,000€ each month. In the intermediate income classes, 22.4% earn between 2,001 and 3,000€, while another 20.8% have between 3,001€ and 4,000€ and 16.2% between 4,001€ and 5,000€ at their disposal.

The cross-tabulation (Table 5) shows how income is related to avoided MPT trips. It specifically shows that 351 participants (57.4%) have an income of less than 4,000€. These participants saved more MPT trips than they made. For the 260 participants (42.6%) with an income of more than 4,000€, their willingness to forego reverses and fewer MPT trips are avoided than are made. With increasing income, willingness to save MPT trips decreases. By comparison, of the 31 respondents who earn less than 1,000€, 24 people (77.4%) avoided MPT trips. And by contrast, this willingness to avoid MPT trips decreases to 46.6% (75 of 161 people) in the highest income class who earn an income of more than 5,000€.

Table 5

Cross tabulation: Household income versus avoidance of MPT trips

		Household income						Total
		< 1,000	1,001 – 2,000	2,001 – 3,000	3,001 – 4,000	4,001 – 5,000	> 5,001	
Car trips avoided	Yes	24 (77.4%)	33 (58.9%)	74 (54%)	75 (59.1%)	47 (47.5%)	75 (46.6%)	328 (53.7%)
	No	7 (23.6%)	23 (41.1%)	63 (46%)	52 (40.9%)	52 (52.5%)	86 (53.4%)	283 (46.3%)
	Total	31	56	137	127	99	161	611

All in all, Table 5 shows that willingness to avoid private car journeys steadily decreases with rising incomes. Several reasons are probably responsible for this correlation. First, a higher income makes it easier to absorb price increases without having to make other sacrifices. Secondly, it seems that primarily leisure trips are saved, and it can be assumed that people with high incomes tend to work full time and thus have less leisure time. Thirdly, travel time represents a value to individuals (Stevens et al. 2019), which tends to be ranked higher for high income individuals. To this end, willingness to switch to transport modes with a higher travel time, such as public transport, is lower for people with particularly high incomes. This is in line with the findings of prior studies (Cornut & Madre 2017), which shows that high income earners have enough financial resources and neednot avoid private car journeys for economic reasons.

4.4.2. Gender

It can be seen that women have a significantly higher willingness to avoid MPT trips or to shift to public transport.[†] When changing the gender expression from male to female, the likelihood of avoiding a trip increases by 1.749. Thus, the probability of avoiding a trip increases by 74.9%. Gender is therefore considered a significant factor in avoiding private transport trips.

[†] Due to the lower number of 0.5%, the regression was carried out without the category diverse.

Table 6

Cross-tabulation: Gender versus avoidance of MPT trips

		Gender			Total
		female	male	divers	
Car trips avoided	Yes	172 (61.6%)	156 (47.4%)	0 (0%)	328 (53.9%)
	No	107 (38.4%)	173 (52.6%)	3 (100%)	283 (46.1%)
	Total	279	329	3	611

This significant result is also reflected in the women's actual avoidance of MPT journeys. 172 (61.6%) of women respondents stated that they had avoided MPT journeys since February 2022. The picture for men is quite contrary. The cross-tabulation in Table 6 shows that, on the contrary, 156 (47.4%) of the men avoided MPT trips. Of the three respondents with non-binary genders, none had avoided MPT journeys.

Overall, it should be noted that women show a significantly higher willingness to abstain than men. This tendency is in line with previous studies, including the results of the qualitative study on understanding attitudes towards public transport and private car (Beirão & Cabral 2007). In this study, a major focus of the increased willingness to switch resides in the costs and the financial possibilities.

Therefore, we investigated whether income has a moderating effect and might mediate the influence of gender on willingness to forego. We found that women, in particular, in our study belong to the two lowest income classes up to 2,000€. Of the 31 respondents with a household income below 1,000€, there are 23 women and only 8 men. In the two highest income categories – income between 4,001 - 5,000€ (33 women/66 men) and income above 5,000€ (64 female/95 male) – it is clear that in our sample men generally have higher incomes. As income has a significant influence on willingness to save trips, income can be seen as having a moderating effect with, among other things, a low willingness to save on the part of men.

All in all, it can be said that women have a significantly higher willingness to forego MPT journeys and that this finding can be attributed, among other things, to their lower income.

4.4.3. Place of residence

Place of residence as an influential component of access is a decisive factor in the choice of means of transport to use the private car or alternative forms of mobility, such as public transportation systems. Especially in rural regions, total travel time to one's workplace plays a significant role. In our study, a significant result was found among inhabitants of cities of more than 100,000 people. Accordingly, there is a negative correlation between the avoided MPT journeys and the inhabitants from cities of more than 100,000 inhabitants. If the number of inhabitants changes from less than 5,000 to more than 100,000 people, then the probability of avoiding MPT trips drops by 47.4%.

Table 7

Cross tabulation: Place of residence versus avoidance of MPT trips

		Place of residence				Total
		< 5,000	5,001 – 20,000	20,001 – 100,000	> 100,000	
Car trips avoided	Yes	79 (54.5%)	55 (50.9%)	94 (59.9%)	100 (49.8%)	328 (53.7%)
	No	66 (45.5%)	53 (49.1%)	63 (40.1%)	101 (50.2%)	283 (46.3%)
Total		145	108	157	201	611

The place of residence for our study participants shows a healthy balance between rural and urban life. 145 participants (23.7%) live in areas with fewer than 5,000 inhabitants, while 108 participants (17.7%) live in small towns with between 5,001 and 20,000 inhabitants. 157 people (25.7%) live in medium-sized cities with between 20,001 and 100,000 inhabitants, while the largest share of our study with 201 participants (32.9%) live in cities of over 100,000 people.

The cross-tabulation in Table 7 shows that place of residence has an influence on the avoidance of private car trips: 54.5% (79 out of 145) of rural participants who live in places of fewer than 5,000 inhabitants state that they have actually avoided private car trips. By contrast, 46.8% (100 out of 201) of the participants living in urban areas have avoided using their private cars.

This finding – that people living in larger cities have saved fewer MPT trips compared to people living in rural areas – is surprising. In their 2011 study, Bergstad et al. were able to show that households from larger cities use cars significantly more often than households from rural areas. Furthermore, there are more mobility options in cities as an alternative to private cars and often shorter distances must be covered like, for instance, commuting to work in a nearby neighbourhood (Kinigadner et al. 2016). For these reasons, avoiding car journeys and switching to other modes of transport seems more obvious in urban areas than in rural regions.

One explanation for this is that people living in urban areas often have to travel longer distances. It can therefore be assumed that each MPT trip is considered more consciously, as gasoline costs per trip are higher and the gasoline cost factor often accounts for a significantly higher proportion of the cost of living in rural regions. Another potential reason is the extent of the COVID-19 pandemic, as the desire for a home office was reiterated often in our survey. Especially for people with further distances to work, home office has become a useful option during the COVID-19 pandemic (Ipsen et al. 2021). This tendency to shift work to home has now been reinforced by the increased gasoline prices from an economic point of view. However, further empirical studies are needed to explain this surprising relationship between place of residence and the avoidance of car trips.

4.4.4. MPT-trips to work

There is a significant correlation between avoiding MPT trips and the number of trips to work. In situations where no trips to work are necessary, 89 respondents avoid MPT trips. When the number of MPT trips to work increases to more than four MPT trips to work, the probability of avoiding MPT trips drops by 48.9%.

Table 8

Cross-tabulation: MPT trips to work versus avoidance of MPT trips

		MPT trips to work						Total
		0	1	2	3	4	>4	
Car trips avoided	Yes	89 (61.4%)	43 (55.8%)	69 (68.3%)	45 (58.4%)	23 (62.2%)	59 (33.9%)	328 (53.7%)
	No	56 (38.6%)	34 (44.2%)	32 (31.7%)	32 (41.6%)	14 (37.8%)	115 (66.1%)	283 (46.3%)
Total		145	77	101	77	37	174	611

In terms of the number of trips to work, our sample is quite heterogeneous. 145 (23.7%) of respondents do not travel to work once a week, while 174 (28.5%) participants travel to work every day (the median is between 1-2 trips per week). At the time of the survey, the home office requirement, which was briefly enforced by the federal government, had been lifted, but many companies still maintain the option of working from home (Kolarova et al. 2021). Therefore, the group that does not commute to work every day is composed of unemployed, part-time, as well as full-time employees who increasingly work in a home office.

With regard to the avoided MPT trips since the price increase, Cross-table 8 shows that participants who do not regularly travel to their places of work are higher than the non-avoided MPT trips. It is striking that for the MPT journeys to work between 0 and 4, the percentage of those who avoid MPT journeys is about the same (mean= 61.5%).

The value is only significantly lower for participants who had to travel to work on a daily basis is significantly lower, which was the case for 59 (33.9%) of 174 participants. This shows the high dependence on the car, which is seen as a reliable and individual means of transport with a fast journey time (Mattioli et al. 2020). Due to the high rates of on-site presence at the workplace, these participants are dependent upon their cars and an avoidance of MPT journeys, (e.g., through home office days or substitution by public transport) is not possible or not sufficiently attractive.

4.4.5. Mobility Practices

In the sub-area of mobility practices, significant results are shown for the three different main modes of transport: private transport, public transport and cycling.

MPT.

For MPT as the main means of transport, a reduction from daily MPT use to MPT use several times a month increases the chance of avoiding a MPT trip by 198%; with less frequent MPT use, the probability is 139.2% compared to daily MPT use.

Table 9

Cross tabulation: Main mode of transport MPT versus avoidance of MPT trips

		Main mode of transport MPT					Total
		(almost) daily	several times a week	several times a month	less often	never	
Car trips avoided	Yes	55 (32.7%)	144 (57.6%)	81 (70.4%)	41 (64.1%)	7 (50%)	328 (53.7%)
	No	113 (67.3%)	106 (42.4%)	34 (29.6%)	23 (35.9%)	7 (50%)	283 (46.3%)
Total		168	250	115	64	14	611

Daily use (27.5%) and several times a week (40.9%) are by far the most frequent characteristics for the people in our sample. This circumstance is understandable, as MPT use was a prerequisite for participating in our survey. The percentage avoiding MPT trips is quite low at 32.7% among those who use the car on a daily basis. The percentage rises steadily and peaks at 70.4% among those who use the car only several times a month. The percentage drops again for those who use it even less frequently or never at all.

The results can be interpreted as follows: for participants who use the private car frequently, it is therefore difficult to avoid private car journeys because the private car cannot be adequately compensated. Those who rarely or no longer use the car due to the crisis probably also rarely used the car in prior times. For these reasons, there is hardly any potential for this group of people to further reduce their MPT journeys.

Thus far, we have only looked at car usage. In the following section, we want to look at the mobility behaviour of multi-modalists, referring to those people who use different modes of transport in their everyday lives (Schuppen, 2014).

Public Transport

Daily public transport use shows negative significant correlations compared to all other expressions. In our sample, 45 participants (7.4%) travel daily with MPT, 149 participants (24.4%) travel several times a week, 133 participants (21.8%) travel several times a month, 193 (31.6%) travel less frequently, and 91 participants (14.9%) never travel. For our study, we directly excluded people who do not use MPT. The basis for the survey is thus only among those who drive cars with some regularity. For this reason, it is understandable that the use of public transport is significantly lower than the use of the car as a primary means of transport.

Table 10

Cross tabulation: Primary means of transport public transport versus avoidance of MPT trips

		Main mode public transport					Total
		(almost) daily	several times a week	several times a month	less often	never	
Car trips avoided	Yes	38 (84.4%)	93 (62.4%)	68 (51.1%)	93 (48.2%)	36 (39.6%)	328 (53.7%)
	No	7 (15.6%)	56 (37.6%)	65 (48.9%)	100 (51.8%)	55 (60.4%)	283 (46.3%)
Total		45	149	133	193	91	611

As is evident in Table 10, the percentage of people who avoid using public transport is constantly decreasing. While the percentage remains at 84.4% for the group that uses public transport on a daily basis, it drops to 39.6% for the group that never uses public transport. In general, the less often public transport is used, the more the probability of avoiding private car trips decreases. Put another way, the more public transport is integrated into users' mobility practices, the easier it is for them to avoid using private cars, more generally.

Bicycle.

As regards cycling, we see a similar trend like that of public transport, albeit in a less pronounced way. In the survey, 76 participants (12.4%) reported using a bicycle every day. 172 participants (28.2%) bicycle several times a week, 142 participants (23.2%) use it several times a month, 128 participants (20.9%) use it less often and 43 participants (15.2%) never use it.

Table 11

Cross tabulation: Main mode of transport bicycle versus avoidance of MPT trips

		Main mode of transport bicycle					Total
		(almost) daily	several times a week	several times a month	less often	never	
Car trips avoided	Yes	50 (65.8%)	109 (63.4%)	68 (47.9%)	58 (45.3%)	43 (46.2%)	328 (53.7%)
	No	26 (34.2%)	63 (36.6%)	74 (52.1%)	70 (54.7%)	50 (53.8%)	283 (46.3%)
Total		76	172	142	128	93	611

Much like the use of public transport, the percentage of people who avoid using private transport is also steadily decreasing here (see Table 10). In the group of daily bicycle users, however, the percentage of those who avoid MPT trips is only 65.8% (compared to 84.4% in the group of daily public transport users). By contrast, the percentage drops more slowly to 46.2% for the group of people that never use the bicycle (compared to 39.6% for the group of public transport abstainers). Overall, it can be concluded that the use of a bicycle as an alternative mode of transport has an influence on the avoidance of MPT trips. However, this influence is relatively smaller than for the equivalent public transportation group.

5. Limitation

Our survey is targeted exclusively at MPT drivers. Of the total of 1,330 calls to our survey, 611 participants were able to meet this requirement and completed the questionnaire in full.

People's mobility behaviour consists of patterns that have often developed over the long term, and the purchase of a car also ensures that a long-term transport mode decision has been made. Our survey took place between March - April 2022, meaning it was administered shortly after the drastic price increase at the end of February 2022. It is thus not possible to determine with certainty whether the financial pressure on private car drivers was already sufficiently strong to force them to rethink their travel behaviours. The financial impact is often only noticeable after a few weeks or months following the price shock.

At the time of the survey, it was also not clear whether the severe economic consequences of the war would be short-term or long-term, or whether the price increases for gasoline and energy would likewise lead to price increases for public transport over the medium to long term. After the conclusion of our survey, inflation increased even further and optimised purchasing decisions became more necessary for individuals with scarce financial resources. The decision to either buy petrol or buy groceries takes on a completely different quality with inflation well above 5%. Furthermore, the costs of gas and electricity, in particular, have risen sharply, which in turn are not absorbed by corresponding salary adjustments in the short term and also have an impact on the financial resources vis-a-vis mobility.

It should also be noted that in our study, the bicycle is the least frequently used primary means of transportation of the three possible options, compared to private and public transport. This reflects the underdeveloped cycling culture in Germany, where the bicycle often serves as a supplementary form of mobility or as a feeder for the first and last metres of a full journey. It is thus an open question as to whether the results on the role of the bicycle can be transferred to other countries, such as the Netherlands, where bicycle culture is more pronounced.

In the further course of time following our survey, political decision-makers put together financial relief packages for the German population. In the realm of mobility, MPT drivers were considered, as was public transport more broadly. Drivers of private cars received a temporary gasoline rebate in the form of a subsidised gasoline price of less than 2€ per litre. In return, public transportation could be used nationwide for €9 per month. In the current political debate, different forms of low-cost public transport are being discussed.

In our study, we focussed on the three main modes of transport: car, public transport and bicycle. In view of the fact that ecological factors are becoming increasingly important and traffic in city centres is generally being greatly reduced, the option “walk” should be included in further research. Further research approaches lie in the classification of journeys and the identification of supporting measures (e.g. home office).

The economic situation continues to be quite unstable and it is difficult to estimate which measures may relieve the burden on German people and drive the transport sector forward. Against this backdrop, the price development and the changed framework conditions should be re-examined in future studies in order to derive targeted implications.

6. Conclusion

The price of mineral oil has remained at a high but relatively constant level in recent decades. For this reason, the question of what influence the current price shock may have on the mobility behaviour of consumers is relevant from both a theoretical and a practical point of view.

Our study provides relevant findings on the type and extent of the mobility elasticity of MPT users. In terms of extent, the overall result of our survey shows that just under 54% have saved on MPT trips since the price shock occurred, while the mobility behaviour of just under 46% of MPT drivers remains unchanged. It further shows that the primary means of transportation of the MPT drivers has remained the MPT, although the dominance of the MPT has been reduced to a certain degree. This suggests that the mobility behaviour of people with higher incomes is more robust to price-induced changes. This raises critical questions about how price-controlled incentives for sustainable mobility might be designed in a more socially just way. As a mode of transport that is independent of the price of mineral oil, the bicycle has seen the greatest growth as a result of the changed situation. An improvement in the cycling culture is likely due to the ongoing measures to clean up the air, especially, in large cities and the expansion of the cycling infrastructure.

With regard to the nature of mobility elasticity, we find that trips to work limit the possibility to avoid trips. Our study indicates that the leisure sector has a higher elasticity, as these trips can be avoided or more easily adapted to other modes of transport (e.g., by choosing destinations that are easily accessible by public transport). Our study also shows that the mobility elasticity of multi-modalists is greater. As they have already integrated other means of transportation (like public transport or cycling) into their everyday lives, it is easier for them to switch to such alternatives in times of crisis. With regard to the influence of urban versus rural areas on mobility elasticity, it is surprising that urban participants from large cities have saved fewer MPT journeys compared to people living in rural areas, despite the fact that large cities generally have a dense infrastructure with a more comprehensive range of mobility options. There are various explanations for this finding, but further research is needed to investigate this observation in greater detail.

Overall, our study confirms the notion that switching away from the car is not solely related to the price of petroleum. At the moment, there does not exist a general willingness to switch to public transport. The key aspects of travel time and reliability must be perceived by people as a genuinely comparable option to private transport. In the view of many of the study’s participants, public transport does not meet these primary concerns regarding the choice of a preferred means of transport, especially in rural regions; it is imperative that these issues be included in further planning among policymakers.

Beyond global economic unrest, climate change is the greatest challenge facing the world in coming decades. However, ecological countermeasures to mitigate climate change have been pushed into the background, at least temporarily, due to the tense economic situation. However, they must not continue to be disregarded, among other things, due to the threat of global warming. The price shock in the price of mineral oil alone is not sufficiently decisive to initiate a reconsideration and a willingness to switch to more emission-friendly public transport. In short, those who with limited financial resources will continue to use private transport.

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