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Book

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Personalized Total Cost of Ownership and Rational Car Choice: Evidence from Online Field Experiment

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Abstract

Purchasing a car is one of the decisions that may have a sizeable negative impact on an individual or family budget if all costs associated with owning a car are not properly considered. With car leasing being easily accessible, car buyers may underestimate all the costs beyond the leasing payments when choosing a car and select a vehicle above their own budget. This paper conducts an online field experiment in a specially designed bot in the Facebook Messenger application in Estonia, to investigate whether disclosing the complete personalized total cost of ownership (TCO) leads to a better calibrated choice of cars for a test drive. The study documents that introducing better information into real-life car choices does not have a positive effect on the correspondence between cost of car and individual budget. Quite the opposite, subjects deviate from their budget even more when a personalized TCO (for one month or five years) is disclosed, and in particular, subjects generally tend to choose cars above their budget. While previous studies on car buyer behaviour with different cost information have been carried out as lab experiments with hypothetical car buyers, our study contributes to the literature by conducting a field experiment with real car buyers, finding a substantial gap with the results obtained in the lab setting.

Keywords: Consumer behaviour; Online field experiment; Rational decision-making; Total cost of ownership

JEL codes: C93; D12; D91; P46

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1. INTRODUCTION

Bounded rationality, coined by Herbert Simon, states that people have limits to their cognitive ability to make an optimal decision (Kahneman, 2003; Simon, 1972). Bounded rationality concerns every purchasing decision; however, the pricier the good, the larger the share of the budget that could be spared is at stake. This paper focuses on car choice, as buying a car is one of those expensive decisions people make in their lives, which may have a negative effect on their family budget, as otherwise similar cars with similar functionalities can have different ownership costs.

The availability of a complete cost profile is a core requirement for an optimal car choice, according to bounded rationality theory. However, calculating costs associated with owning a car can be too difficult and time-consuming for an average car buyer without a mathematical background and a complete cost profile is not provided by car dealers. Consumers make decisions based on easily and publicly available information and on private information, which they need to gather or calculate themselves and which may be unavailable prior to making a decision. Therefore, car buyer decisions are often imperfectly calibrated with respect to their own financial constraints and may be strongly irrational (Codagnone et al., 2013; Nixon & Saphores, 2011; Greene, 2011; Turrentine & Kurani, 2007). The increasing propensity to use leasing financing tempts customers to focus only on the monthly leasing payment and not to consider the broader picture of operating costs.[3] Costs such as insurance, maintenance and fuel combined can be even larger than the leasing payment and may drastically differ between car producers and models. Making complete cost information proactively available and signalling it to the consumer may have a positive effect on the consumer's decision and nudge him or her towards a car choice that meets his or her individual financial constraints.

Signalling game equilibrium predicts that the better the information, the more calibrated decisions are made.[4] Therefore, in equilibrium consumer choice with better information is more rational, and with imperfect information, less rational (Kim, 1985; Stiglitz 2002). Previous research has provided mixed results on whether a more detailed cost profile turns buyers towards a more budget and environmentally friendly choice (Dumortier et al., 2015; Codagnone et al., 2013; Nixon & Saphores, 2011). Dumortier et al. (2015) have found using US data that, for example, providing 5-year fuel costs does not affect consumer decisions towards more fuel economic cars (hybrid, or electric) but stating the monthly Total Cost of Ownership (TCO) does. European studies on the other hand have found that the 5-year fuel cost does nudge consumers towards more fuel-friendly car choices and although consumers tend to think that fuel economy is important for decision-making, only a few actually make the calculations (Codagnone et al., 2013; Nixon & Saphores, 2011; Greene, 2011). However, most of the previous studies on this subject were carried out in a lab environment in hypothetical settings and did not use personalized Total Cost of Ownership (TCO) information (personalized fuel costs relative to customer's yearly mileage, maintenance, and actual insurance costs).

A noteworthy peculiarity of consumer behaviour in the car choice setting is that a car is an emotional choice. Besides the constructive processing used in decision-making, researchers have proved that emotions influence human decision-making as well, and should be taken into account in the relevant models (Modi & Jhulka, 2021; Sanfey et al., 2003). Therefore, emotions and the way consumers handle them during the decision-making process have consequences on

[3] In Estonia, 51% of new cars are bought with financing (see Rehemaa, 2019).

[4] Throughout the paper we refer to a car choice, which fulfils the individual budget constraint, as a well calibrated or rational one. We assume a simplistic individual profit function as a difference between the budget and car TCO over five years. Thus, choosing a car with a lower TCO increases the profit and implies a better calibrated (more rational) decision.

the outcome (Seo & Barrett, 2007). Heffner et al. (2006) have found that cars also have a symbolic value for the owner, and they signal who the owner is to other people. So, choosing a car may become overshadowed by its value as a status symbol regardless of the TCO. Furthermore, the wording used can play an important part in the decision-making: "fuel efficiency" and "cost per mile" may transmit different attributes to the decision-maker and he/she can go for the option which aligns with preferred attributes (Ungemach et al., 2018). In addition to car buying being emotional, the decision-making process may differ across age groups, family sizes, incomes, personalities and travel patterns (Choo & Mokhtarian, 2004; Sprei & Wickelgren, 2011).

This study conducts an online field experiment with actual car buyers to investigate the effect of better information about the costs associated with car usage, measured as personalized TCO, on the consumer's choice of cars selected for a test drive. Specifically, we exploit a two-by-two factorial design and provide the actual car buyers with either one-month or five-year information on either leasing payment only or complete TCO profile.[5] We investigate how the treatment effect varies across men and women, preferred car type (family vs. non-family car), and buyers planning to rely on their own funds or on leasing financing.

The application used for this study was a Facebook Messenger bot designed specifically to help car buyers choose the next car among all the possible new models offered on the Estonian car market. For each car, several exterior and interior pictures were presented together with the producer and model name, full purchasing price, option to view technical details and, depending on treatment, leasing and/or TCO information calculated for one month or five years. Relying on this information, the car buyer could express his/her choice whether he/she would buy this car or not and book it for a test drive.

The contribution of our study lies on the one hand, in conducting an online field experiment with actual car buyers, which makes it possible to compare our findings with evidence from laboratory experiments on hypothetical car choice. The majority of earlier studies were carried out as lab experiments or surveys with hypothetical car buyers (Dumortier et al., 2015; Codagnone et al., 2013; Nixon & Saphores, 2011). This research fills the gap by carrying out a field experiment and analysing real buyer choices. Running the experiment in the field, compared to the laboratory setting, ensures that participants are unaware of being part of an experiment, they reveal their actual preferences and decisions free of the experimental demand effect. Moreover, the specific question of interest can only be studied with actual car buyers. Members of the general population faced with hypothetical car choices provide a vague measure of actual preferences and they may be drastically different from real choices in a real environment with real consequences. Running the experiment online via a specially designed application fosters the cleanest data collection procedure, since the web application appears as a regular car choice calibration device.

A second contribution is that we observe the real-life decision-making process of car buyers under four different information settings relying on personalised TCO, rather than average TCO. This allows us to elicit the impact of car ownership cost information, which stems from the subject's individual driving patterns, on the goodness of car choice calibration. The subjects

[5] Total Cost of Ownership (henceforth, TCO) is regarded as a purchasing tool to understand the true cost of owning a product – a car in the given study (Ellram, 1995). TCO can be divided into consumer-oriented costs (cTCO) – everything from purchase price to all costs associated with using the product (Ellram et al., 1998), and society-oriented costs (sTCO), such as costs derived from air-pollution, traffic and noise (Danielis, 2019; Lebeau et al., 2013). This paper considers only consumer-oriented costs, hereinafter referred to as TCO.

are aware that TCO fuel cost is calculated based on their self-reported yearly mileage, while maintenance and actual insurance costs are car specific. The experimental design makes it possible to study several questions, which, to the best of our knowledge, have not been addressed in the previous literature, or at least have not been studied in the field experiment setting. The paper investigates the pure effect of leasing only vs. complete TCO information, and the effect of one-month vs. five-year cost calculations on customer's car choice calibration. These two research questions allow us to suggest the information profile that is most effective in nudging buyers towards a car choice that corresponds to their budget.

The results of the paper suggest that more information may not lead to a better calibrated car buying decision. Quite the opposite, information has an adverse effect on goodness of car choice calibration. We document that providing TCO information increases the average cost of the cars selected for a test drive and decreases the propensity to choose at least one car below a budget constraint. Whereas we document, if anything, a very weak effect of better information on propensity to choose cars below the budget constraint, suggesting that an adverse effect of information is most pronounced among subjects opting for cars beyond their budget.

Our findings suggest that complete cost information, which is in our case the five-year TCO profile, does not incentivise consumers to make a better calibrated car choice. There exist several behavioural explanations of consumer's bounded rationality persisting even when a complete information profile is disclosed; among others, consumer confirmation bias (Nickerson, 1998), consumer salience bias (Tversky et al., 1974; Bordalo et al., 2012, 2012a, 2012b), as well as binding effect of consumer TCO expectations and subjective reference point stemming from a currently owned car. However, the experimental design of the given study does not allow us to distinguish between the behavioural factors driving the adverse effect of disclosing a TCO on goodness of consumer car choice calibration. This question remains open for further investigation.

The rest of the paper is structured as follows. Section 2 describes the experimental design and the procedure of our online experiment. Section 3 presents the empirical strategy and data. Section 4 presents and discusses experimental results. Section 5 concludes.

2. EXPERIMENTAL PROCEDURE AND DESIGN

The experiment was conducted in a specially developed bot that works in Facebook Messenger (hereinafter, the application). Facebook Messenger or other chat platforms have been widely used in recent years in many areas, including education (Holotescu, 2016; Smutny & Schreiberova, 2020) and business (Muron, 2019) research. However, this is the first study to use a specially designed Facebook Messenger application to analyse consumer behaviour in general, and car buyers' decisions in particular. A major advantage of Facebook Messenger is that it limits user age (over 18 in this case) and allows subjects to easily exit the application and return at any time, which is not the case with a web page. The application appears as one of many contacts the subjects have in their Messenger contact list, making it possible to suspend and resume the car choice at the subject's convenience.

As a first step, each subject (car buyer) was asked to choose their preferred type(s) of car (sedan, minivan, hatchback, SUV etc), preferred gearbox (manual, automatic), engine (gasoline, diesel, hybrid, electric) and drivetrain (RWD, FWD, 4WD), in line with the study by Codagnone et al. (2013). The application filtered in only cars that matched the car buyer's criteria. The majority of new car models (total of 365 different cars) sold in Europe in April 2019 were represented in the application. If the subject skipped this part, the application made a random choice from 365 cars. The application also asked the subjects about their average monthly mileage to

calculate a personalized one-month and five-year fuel cost for each car and the buyer's budget in the form of maximum preferable monthly leasing payment or maximum car price, if the subject did not intend to use leasing financing.

Pictures and information about one new car was presented to the subjects at a time on their mobile phone screens (see Appendix A). The application automatically asked the buyer to signal whether she would consider buying the car or not. The signal for "no" was to swipe the car card left, and for "yes" to the right. The pictures showed the car's exterior and interior. Technical details and specific cost profile were provided for each car presented to the subject. The cost information varied across treatment groups. If during the interest signalling process a subject favoured more than ten cars, the application asked him/her to remove some of them so that only the top ten remained. Then it automatically provided specific guarantee terms (5 years or 100 000 km) for the ten selected cars.

The subject had to fulfil the following two criteria: (i) be at least 18 years old (age stated to Facebook), and (ii) select ten cars when using the application. All subjects were randomly assigned into four treatment groups, applying between-subject experimental design.[6] Table 1 visualises the 2x4 factorial design of the experiment.

Table 1. Treatment design

	Information amount	
	Only leasing cost	*Full TCO*
Time frame		
One-month period	Base	Treatment 1 (T1)
Five-year period	Treatment 2 (T2)	Treatment 3 (T3)

In all treatments, the subjects received identical visual and technical information about the selected cars, but the cost profile differed across the treatments. In the Base treatment (control group), subjects were presented with information on the leasing payment calculated for one month for each selected car. In T1, subjects received a full TCO profile calculated for one month. In T2, subjects were provided with leasing costs for five years, while in T3 they received a full TCO profile calculated for five years for each selected car. Our cross-treatment comparison focuses on three major differences. First, Base vs T1 and T2 vs T3 signals the pure effect of information amount on the car choice, keeping the time frame constant. Second, Base vs T2 and T1 vs T3 captures the pure effect of time frame on the car choice, keeping the information amount fixed. Lastly, Base vs T3 seizes the joint effect of the longer time frame and full TCO on car choice.

As this study investigates the choice of a car for a test drive based on available TCO information, only consumer-oriented TCO is taken into account and investigated. We include leasing payments, maintenance, insurance, and fuel/electricity in the TCO profile, as they are monetary operating costs. Some authors have also included vehicle tax, resale value and tyre costs in their TCO (Letmathe and Suares, 2017). This research does not, primarily because vehicle tax is not applicable in Estonia, resale value is extremely difficult to predict as it depends heavily on usage and maintenance habits, and tyre costs depend on the owner's preference (low-, medium- or high-quality tyres). Second, mental accounting (Thaler, 1985) suggests that people classify their spending and monthly car operating as one unified group. Resale value is seen more like one-time income rather than monthly depreciation cost from initial car price.

[6] The application was designed so that each subject was assigned to one treatment only and this assignment was fixed throughout a period of application use, even with multiple entries.

The TCO calculations were therefore based on the following model:

$$C_{TCO} = C_{IC} + C_{MC} + C_{EC} + C_{LC} \quad (1)$$

where, C_{IC} is comprehensive (casco) and mandatory third-party liability insurance costs (EUR). C_{MC} is five-year 15000 per annum mileage maintenance costs (EUR) stated by manufacturers and divided by 60 in one-month TCO. C_{EC} is the energy consumption (EUR) derived from the manufacturers stated New European Driving Cycle (NEDC) consumption of gasoline/diesel/ electricity averaged according to retail prices in March 2019 in Estonia and the individual subject's stated average yearly mileage. C_{LC} is the annuity leasing payment cost (EUR) on finance lease terms, which is calculated using formula (2) for a one-month period or multiplied by 60 in the case of a five-year TCO:

$$Pmt = \frac{PV - \frac{FV}{(1+i)^N}}{\left[\frac{1 - \frac{1}{(1+i)^N}}{i}\right]} \quad (2)$$

Where, PV stands for car retail price minus 10% first down payment; FV is PV minus 20% residual payment; i is interest rate 2% per annum; N represents 60-month period.

3. DATA AND EMPIRICAL STRATEGY

When using the application, subjects were linked to their respective, randomly assigned treatment group via their unique ID. Subjects were not aware that they were participating in an experiment or that there might be several data views available. These precautions ensure that the data is not affected by an experimental bias. Total sample size was 995, which divided between treatment groups as stated in Table 2. During the online experiment carried out from May 2019 to December 2020, a total of 556 observations matching selection criteria were collected in four treatment groups, with 428 observations having all data available. Table 2 presents the number of observations by treatment.

Table 2. Sample sizes in treatment groups

Treatment	Sample size – total	Sample size – all data
Base	160	142
Treatment 1 (T1)	179	164
Treatment 2 (T2)	109	46
Treatment 3 (T3)	108	76
Total	556	428

The following data was extracted from the application's database. Subject's unique ID, sex, treatment, number of family members (1, 2,…, 5 or >5), preferred car body type(s), engine type(s) and drivetrain, annual average mileage in km, intension to use leasing financing, if possible monthly net income, monthly existing loan payments, maximum new leasing payment (either calculated on previous data or stated by the subject), maximum car price, intension to buy new car in the next 6 months, subject's personal TCO for their top ten cars. For the full list, see Appendix B.

The main outcome of interest is the goodness of car choice calibration. Estimated subjects' budget was used as a benchmark for goodness of fit. We refer to cars with a TCO falling below

the budget constraint as a well calibrated choice, while those with a TCO above the budget constraint as badly calibrated. The budget constraint was estimated based on either (i) the subject's stated maximum leasing payment, or (ii) the subject's stated maximum car price, or (iii) the calculated maximum leasing payment, considering the subject's stated monthly net income and his/her existing monthly loan payments (the total per cent of loan payments, both existing and new, could be a maximum of 50% of the stated monthly net income).

Three empirical measures are used to assess the goodness of fit. The first empirical measure is a *goodness of fit ratio*, which is based on the ten selected cars and computed as:

$$GF = \frac{\overline{TCO}}{BC} \tag{3}$$

where $\overline{TCO} = {\sum_{x=1}^{10} TCO_x}/{10}$ is the average total cost of ownership for the ten selected cars and BC stands for the budget constraint. The goodness of fit ratio GF tells how much the average cost of the selected cars deviates from the budget constraint. $GF \in (0,1]$ implies that $\overline{TCO} \leq BC$; in other words, the choice fulfils the budget constraint. $GF > 1$ implies that the $\overline{TCO} > BC$; in other words, the choice is above the budget constraint.

The second empirical measure identifies that at least one of the ten selected cars fulfils the budget constraint:

$$I\left(TCO^{min} < BC\right) = I\{1 \; if \; TCO^{min} \leq BC; 0 \; if \; TCO^{min} > BC\}, \tag{4}$$

where $TCO^{min} = \min\{TCO_1, TCO_2, \dots, TCO_{10}\}$ is the lowest TCO out of the ten selected cars.

The third measure captures that all ten selected cars are below the budget constraint and is computed as:

$$I(TCO^{max} < BC) = I\{1 \; if \; TCO^{max} \leq BC; 0 \; if \; TCO^{max} > BC\}, \tag{5}$$

where $TCO^{max} = \max\{TCO_1, TCO_2, \dots, TCO_{10}\}$ is the highest TCO out of ten selected cars.

Empirical analysis comprises three parts. The first part focuses on a regression analysis of the goodness of fit ratio, computed following formula (3). A usual linear regression analysis is applied with the logarithm for the goodness of fit ratio as a dependent variable. The full regression specification is as follows:

$$\begin{aligned} lnGF_i = \alpha + \beta_1 \cdot T1_i + \beta_2 \cdot T2_i + \beta_3 \cdot T3_i + \beta_4 \cdot Male_i + \beta_5 \cdot FC_i + \beta_6 \cdot \\ Leasing_i + \beta_7 \cdot Next6months_i + \beta_8 \cdot Year_i + \varepsilon_i, \end{aligned} \tag{6}$$

where subscript i stands for an individual subject; $lnGF_i$ is the logarithm for the goodness of fit ratio; $T1_i, T2_i, T3_i$ are binary treatment variables; $Male_i$ is a male indicator variable; FC_i is a family car indicator variable; $Leasing_i$ is an indicator of whether the subject is considering lease financing; $Next6months_i$ indicates whether the subject plans to buy a car in the next six months; $Year_i$ indicates the year when the data for a given subject was collected; $\beta_1, \dots, \beta_8$ are the corresponding coefficients; ε_i is an individual error term. A regression analysis with a stepwise inclusion of controls is then performed.

The second and third parts of the analysis focus on the subjects choosing all cars or at least one car below the budget constraint, defined in equations (4) and (5). The dependent variable is binary; therefore, we apply a probit regression of similar specifications as the regression (6):

$$Pr(x_i = 1|C_i') = \alpha + \beta_1 \cdot T1_i + \beta_2 \cdot T2_i + \beta_3 \cdot T3_i + \beta_4 \cdot Male_i + \beta_5 \cdot FC_i + \beta_6 \cdot Leasing_i + \beta_7 \cdot Next6months_i + \beta_8 \cdot Year_i + \varepsilon_i, \quad (7)$$

$$Pr(y_i = 1|C_i') = \alpha + \beta_1 \cdot T1_i + \beta_2 \cdot T2_i + \beta_3 \cdot T3_i + \beta_4 \cdot Male_i + \beta_5 \cdot FC_i + \beta_6 \cdot Leasing_i + \beta_7 \cdot Next6months_i + \beta_8 \cdot Year_i + \varepsilon_i, \quad (8)$$

where x_i is the realization of random variable X_i taking value 1 if ${TCO^{min}}_i \leq BC_i$ and 0 otherwise; y is the realization of random variable Y_i taking value 1 if ${TCO^{max}}_i \leq BC_i$ and 0 otherwise; ${C_i}'$ is the vector of the control variables listed on the right-hand side of equations (6) and (7) for individual i. Models (6), (7) and (8) control for year, as the experiment was conducted in years 2019 and 2020, covering the COVID-19 pandemic outbreak, which likely reflected on car buyers behaviour.

4. RESULTS AND DISCUSSION

4.1. Descriptive Analysis

We start by analysing three car choice calibration measures across treatments and across several major characteristics of car buyers. Appendix 3 presents summary statistics of the major controls across four treatments. Table 3 presents overall cross-treatment differences in car choice calibration. The descriptive results reveal that subjects in treatments where only leasing cost was revealed (Base, T2) adhere to a budget constraint more than in treatments with full TCO disclosure (T1, T3). In line with this observation, the propensity to choose at least one car and all cars below a budget constraint is higher in the Base (18% and 82% respectively) and T2 treatments (28% and 74% respectively).

Table 3. Goodness of fit across treatments based on ten selected cars

	Base	**T1**	**T2**	**T3**
Average goodness of fit ratio	1.04	1.20	0.96	1.22
	(0.307)	(0.361)	(0.361)	(0.283)
Share of subjects with all cars below BC	0.18	0.12	0.28	0.08
	(0.382)	(0.328)	(0.455)	(0.271)
Share of subjects with at least one car below BC	0.82	0.63	0.76	0.68
	(0.388)	(0.483)	(0.431)	(0.468)
N	142	164	46	76

Note: Mean coefficients; standard errors in parentheses.

Table 4 reveals that goodness of choice varies across men and women with a consistent pattern. Women tend to choose more budget friendly cars in the Base and T2 treatments, which are the treatments with only leasing cost displayed, while men make better calibrated choices in T1 and T3 treatments, which are the ones disclosing a full TCO. This observation suggests that an adverse effect of TCO profile on goodness of car choice calibration is stronger among women. Furthermore, our results provide suggestive evidence that disclosing a five-year leasing cost reduces the average TCO of the chosen cars substantially among women (average cost of ten selected cars is 31% lower than the budget among women and 1% lower among men in T2). However, the share of female subjects in treatment groups Base and T2 are too small (9 and 5 respectfully) to make unambiguous conclusions.

Table 4. Goodness of fit across treatments and gender

	Males				Females			
	Base	**T1**	**T2**	**T3**	**Base**	**T1**	**T2**	**T3**
Average goodness of fit ratio	1.05 (0.301)	1.18 (0.332)	0.99 (0.344)	1.22 (0.290)	0.88 (0.370)	1.34 (0.506)	0.69 (0.424)	1.27 (0.227)
Share of subjects with all cars below BC	0.17 (0.373)	0.12 (0.325)	0.22 (0.419)	0.09 (0.286)	0.33 (0.500)	0.14 (0.359)	0.80 (0.447)	0.00 (0)
Share of subjects with at least one car below BC	0.80 (0.398)	0.67 (0.471)	0.76 (0.435)	0.69 (0.465)	1.00 (0)	0.38 (0.498)	0.80 (0.447)	0.62 (0.518)
N	133	143	41	68	9	21	5	8

Note: Mean coefficients; standard errors in parentheses.

Table 5 presents goodness of fit across treatments and car designation, distinguishing between family and non-family cars. Subjects in T2 and T3 treatments, in which five-year cost information is provided, who plan to buy non-family car models better meet their budget constraints. However, the propensity to choose all cars below a budget constraint is marginally higher among family car buyers (29% and 13% vs. 27% and 7% in T2 and T3 respectively). However, while among non-family car buyers providing five-year costs substantially improves goodness of fit, in the case of leasing cost disclosure (12% lower vs. 4% higher than a budget) and marginally in the case of full TCO (20% vs. 22% higher than a budget), for family car buyers the effect of the longer time frame is the opposite, as the goodness of fit ratio deteriorates substantially for the TCO cost profile (33% vs. 20% higher than a budget), while no effect is recorded for leasing cost. In line with this result, the share of subjects among non-family car buyers who choose at least one car below a budget constraint drops substantially when a better cost profile is disclosed, falling from 80% in the Base treatment to 57% in T1, 58% in T2 and 33% in T3. For non-family car buyers, the difference is not as pronounced, decreasing from 83% in the Base to 65% in T1 and 77% in T3, while increasing to 95% in T2.

Table 5. Goodness of fit across treatments and car designation

	Family car				Non-family car			
	Base	**T1**	**T2**	**T3**	**Base**	**T1**	**T2**	**T3**
Average goodness of fit ratio	1.03 (0.296)	1.20 (0.320)	1.04 (0.420)	1.33 (0.301)	1.04 (0.315)	1.20 (0.386)	0.88 (0.269)	1.20 (0.274)
Share of subjects with all cars below BC	0.16 (0.370)	0.05 (0.215)	0.29 (0.464)	0.13 (0.352)	0.18 (0.390)	0.17 (0.376)	0.27 (0.456)	0.07 (0.250)
Share of subjects with at least one car below BC	0.80 (0.404)	0.57 (0.499)	0.58 (0.504)	0.33 (0.488)	0.83 (0.381)	0.67 (0.471)	0.95 (0.213)	0.77 (0.424)
N	50	63	24	15	92	101	22	61

Note: Mean coefficients; standard errors in parentheses.

Table 6. Goodness of fit across treatments and intention to use leasing

	Leasing				No leasing			
	Base	**T1**	**T2**	**T3**	**Base**	**T1**	**T2**	**T3**
Average goodness of fit ratio	1.08 (0.322)	1.28 (0.341)	1.06 (0.406)	1.26 (0.267)	0.88 (0.168)	0.83 (0.155)	0.80 (0.193)	0.86 (0.169)
Share of subjects with all cars below BC	0.18 (0.386)	0.07 (0.251)	0.25 (0.441)	0.06 (0.235)	0.16 (0.374)	0.37 (0.490)	0.33 (0.485)	0.29 (0.488)
	0.70	0.47	0.61	0.57	0.97	1.00	1.00	1.00

	Leasing				No leasing			
	Base	**T1**	**T2**	**T3**	**Base**	**T1**	**T2**	**T3**
Share of subjects with at least one car below BC	(0.459)	(0.501)	(0.497)	(0.499)	(0.180)	(0)	(0)	(0)
N	111	134	28	69	31	30	18	7

Note: Mean coefficients; standard errors in parentheses.

Table 6 summarises goodness of fit for subjects who plan and do not plan to use leasing. Subjects who do not plan to use lease financing make better choices regarding their budget constraints in all treatments, compared to subjects who rely on leasing. Notably, their average goodness of fit measures indicate that in all four treatments the subjects who do not plan to use leasing choose cars below their stated or calculated budget constraint. This may show that when buying a car with their own savings instead of using financing, people tend to take cost information into account more carefully and adjust their decision accordingly. In lease financing, a small monthly payment may deviate people's attention away from the full price of the car and running costs, resulting in choosing a car outside their budget.

The results presented in Tables 5 and 6 are interrelated, as family car buyers plan to use leasing more often than non-family car buyers (85% vs 77%, $p = 0.057$, χ^2 test). The latter may be related to, on average, the higher price and TCO of family cars due to more seating places, engine size, better safety features, etc.

4.2. Regression Analysis

The descriptive results presented in the previous subsection reveal the adverse effect of better information on rationality of car choice. We proceed with a regression analysis, aiming to derive a causal effect of the amount and quality of information on car choice calibration. Table 7 provides regression results for the goodness of fit ratio, following specification (6) with a stepwise inclusion of controls. Model (i) controls only for treatment and year when the data was collected; model (ii) adds gender; model (iii) adds car designation (family, non-family); model (iv) includes whether the subject plans to use lease financing; model (v) controls additionally for whether the subject plans to buy a car within the next six months.

Table 7. Goodness of fit estimates – OLS regression

Specification	**(i)**	**(ii)**	**(iii)**	**(iv)**	**(v)**
Treatment 1 (T1)	0.14***	0.15***	0.15***	0.14***	0.14***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Treatment 2 (T2)	-0.10*	-0.10	-0.10*	-0.05	-0.05
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Treatment 3 (T3)	0.18***	0.18***	0.19***	0.15***	0.15***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Year 2020	-0.01	-0.00	0.00	0.04	0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Male		0.06	0.06	0.07	0.07
		(0.06)	(0.06)	(0.05)	(0.05)
Family car			0.04	0.01	0.01
			(0.04)	(0.03)	(0.04)
Leasing				0.29***	0.29***
				(0.04)	(0.04)

Specification	**(i)**	**(ii)**	**(iii)**	**(iv)**	**(v)**
Next 6 months					-0.01
					(0.03)
Constant	-0.01	-0.07	-0.09	-0.34***	-0.34***
	(0.04)	(0.07)	(0.07)	(0.08)	(0.08)
N	428	428	428	428	428

Note: Standard errors in parentheses. Ordinary least squares regressions. Dependent variable is a logarithm of the goodness of fit ratio (a ratio between average TCO of the selected cars and budget constraint). * p < 0.10, ** p < 0.05, *** p < 0.01

The regression analysis provides further support for the earlier descriptive evidence that introducing better cost information does not have a positive effect on choice calibration. On the contrary, T2 and T3 worsen the choice compared to the Base treatment. Namely, providing full TCO information for one month (T1) reduces the goodness of fit index by 14% ($p<0.01$) in full model specification (v), compared to only leasing payment for one month (Base). Disclosing full TCO for five years (T3) decreases goodness of fit by 15% ($p<0.01$), compared to the Base treatment. Therefore, at least in the case of new cars, revealing only leasing costs leads to better calibrated choices with respect to the budget constraint. Disclosing a full TCO profile, either for one month or five years, induces car buyers to opt for cars with operational costs far above their budget. Notably, when only leasing cost is disclosed, time frame (one month vs. five years) has no effect on choice calibration. Among other controls, leasing has a strong positive association with a goodness of fit and improves it by a substantial 29% ($p<0.01$). This result goes in line with the estimates reported in Table 6.

Next, we investigate the propensity of subjects to choose all cars below the budget constraint, following specification (7). Table 8 employs probit regressions and presents marginal effects. Controls are included stepwise with the same order as in Table 7. The results reveal no significantly different propensity to choose all cars below budget in T2 and T3, compared to the Base treatment. However, subjects in T4 reveal persistently lower, albeit statistically weak, probability of choosing all cars below the budget constraint (47 pp, $p<0.1$) in the full model (v). Interestingly, while disclosing full TCO substantially increases average TCO of the chosen cars, the propensity to choose all cars below a budget constraint remains, if anything, weakly affected by the cost information. These two observations suggest that subjects who adhere to a budget constraint and choose only affordable vehicles do so irrespectively of cost information provided, whereas those who tend to choose cars above the budget have an adverse response to better cost information and deviate from the budget constraint even further than when complete TCO for a five-year period is disclosed.

In line with the results in Table 7, subjects relying on lease financing have 53 pp ($p<0.01$) lower probability of choosing all cars below a budget constraint. Additionally, men are 43 pp ($p<0.1$) less likely to choose all cars below a budget constraint, even when controlling for a full set of characteristics.

Table 8. Likelihood of choosing all cars below the budget constraint – probit regression

Specification:	**(i)**	**(ii)**	**(iii)**	**(iv)**	**(v)**
Treatment 1 (T1)	-0.23	-0.26	-0.26	-0.28	-0.28
	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)
Treatment 2 (T2)	0.35	0.33	0.37	0.27	0.26
	(0.23)	(0.23)	(0.24)	(0.24)	(0.24)
Treatment 3 (T3)	-0.48**	-0.49**	-0.52**	-0.47*	-0.47*
	(0.24)	(0.24)	(0.24)	(0.25)	(0.25)
Year 2020	0.09	0.08	0.06	-0.02	-0.02
	(0.19)	(0.19)	(0.19)	(0.20)	(0.20)
Male		-0.36	-0.41*	-0.43*	-0.43*
		(0.23)	(0.24)	(0.24)	(0.24)
Family car			-0.24	-0.16	-0.15
			(0.17)	(0.17)	(0.17)
Leasing				-0.52***	-0.53***
				(0.18)	(0.18)
Next 6 months					0.04
					(0.16)
Constant	-1.00***	-0.66**	-0.52*	-0.06	-0.09
	(0.20)	(0.30)	(0.31)	(0.35)	(0.37)
N	428	428	428	428	428

Note: Standard errors in parentheses. Probit regression, marginal effects are reported. Dependent variable is choosing all cars below a budget constraint. * p < 0.10, ** p < 0.05, *** p < 0.01

Lastly, we investigate the propensity of subjects to choose at least one car below a budget constraint. Table 9 documents the probit regression results following specification (8) and marginal effects. The results suggest that providing full TCO for one month (T1) and five years (T3) reduces the probability of choosing at least one car below a budget constraint by 54 pp (*p<0.01*) and 48 pp (*p<0.05*) respectively in the full model (v), compared to the Base treatment. Cross-treatment differences are consistent with the estimates in Table 7. With economically and statistically significant effects of full TCO provision (both one month and five years) on propensity to choose at least one car fulfilling the budget, our result that better cost information has an adverse effect on subjects tending to choose cars above the budget gains further credibility. The latter substantially reduces their likelihood to choose at least one vehicle below the budget when equipped with complete TCO information, instead of leasing cost only. Moreover, subjects who are planning to buy a family car are 43 pp (*p<0.01*) less likely to choose at least one car below a budget constraint. Notably, men reveal no systematically lower propensity to choose at least one car below the budget. The coefficient for leasing is omitted in the model as all subjects in T1, T2 and T3 who use no leasing, choose at least one car below a budget constraint.

Table 9. Likelihood of choosing at least one car below the budget constraint – probit regression

Specification:	**(i)**	**(ii)**	**(iii)**	**(iv)**	**(v)**
Treatment 1 (T1)	-0.56***	-0.54***	-0.53***	-0.53***	-0.54***
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Treatment 2 (T2)	-0.20	-0.19	-0.09	-0.09	-0.09
	(0.24)	(0.24)	(0.24)	(0.24)	(0.24)
Treatment 3 (T3)	-0.42**	-0.41**	-0.48**	-0.48**	-0.48**
	(0.19)	(0.19)	(0.20)	(0.20)	(0.20)
Year 2020	0.08	0.10	0.07	0.07	0.07
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Male		0.29	0.23	0.23	0.23
		(0.21)	(0.21)	(0.21)	(0.21)
Family car			-0.44***	-0.44***	-0.43***
			(0.14)	(0.14)	(0.15)
Next 6 months					0.00
					(0.14)
Constant	0.84***	0.56**	0.80***	0.80***	0.80***
	(0.17)	(0.27)	(0.29)	(0.29)	(0.30)
N	428	428	428	428	428

Note: Standard errors in parentheses. Probit regression, marginal effects are reported. Dependent variable is choosing at least one car below a budget constraint. Leasing control is excluded from analysis as all subjects who do not plan to rely on leasing financing choose at least one car below a budget constraint in T1, T2 and T3. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3. Discussion of the Results

Our findings suggest an adverse effect of better cost information profile on car buyer choice calibration, resulting in the subjects deviating from their budget even further when a complete TCO profile is disclosed. This result contradicts rationality considerations and points towards major behavioural biases distorting the subjects' decisions. Although our experiment does not allow us to distinguish between different potential drivers of the adverse information effect, we discuss some of them in this subsection.

The results may indicate stronger than expected confirmation and/or salience bias in the consumers' decisions. The car buyer may interpret the cost information in a way that supports his/her personal car preference (Nickerson, 1998). As people nowadays gather most of their information from the internet prior to visiting a showroom, very often the initial purchasing decision has already been made in the consumer's mind. Buyers visit dealerships to take a test drive and affirm their decision. When the decision has been made, people tend to seek only extra information to confirm the correctness of their choice and disregard the opposite data. Therefore, it may be that consumers disregard future ownership costs if the TCO information is presented too late in the decision-making flow.

Consumer salience interrelates with a confirmation bias and implies that people tend to focus on information that is more prominent and may ignore less prominent information (Tversky et al., 1974; Bordalo et al., 2012, 2012a, 2012b). Salience may distort the rationality of a consumer's decision via two mechanisms, as they tend to disregard any information that (i) undermines their initial decision; (ii) appears less pleasing. Price, monthly leasing payment,

low mileage or any other feature that stands out or has been made to stand out deliberately among other car characteristics, may incline the consumer's choice towards salient attribute(s). Bordalo et al. (2012) showed in their model that especially in the case of expensive, high-quality goods, the salience of each good's attributes increases by showing irrelevant alternatives – the decoy and compromise effects – which are known violations of the independence of irrelevant alternatives. As a result, consumers intentionally focus on a preferable information set, even if it offers poor information, which yields an irrational decision.

Salience bias has been explicitly studied in the behaviour of lottery buyers, as they tend to overweight information that draws their attention and to underweight information that does not (Bordalo, 2012). The same effect was documented in online shopping, where charging higher shipping costs and lower initial product price leads to increased overall sales and vice versa (Hossain and Morgan 2006). In the case of a car choice, the relative importance of preferred car attributes is even stronger than in the case of other products, as a car is a durable and expensive good. Codagnone et al., (2013) suggest that in case of purchasing a car most consumers first choose a class of vehicle, and environmental concerns come only after ten other main attributes. While, for a general consumer, a less fuel consuming car may be attractive as an idea (Commission, 2017), but if it does not fit their family of five, has not the preferred body type or has a higher retail price, the long-term saving concerns and environmental-friendliness of the car (lower TCO) do not make much difference (Allcott, 2011).

Confirmation and salience biases stipulate that car buyers, when faced with a complete TCO profile, may interpret it in a way that favours their preferred car, for instance, due to a smaller margin of TCO compared to leasing only. The latter may be particularly valid for expensive, highly technological cars with a high purchase price and relatively low running costs due to fuel efficiency (cars with electric or hybrid engines), exceptional durability, safety features and extensive manufacturer's guarantee. While leasing cost profile gives very limited information on the actual cost of owning a car, TCO includes an explicit set of cost components, allowing the buyer to focus on the most favourable ones and ground his/her decision on selected cost entries, as these, in his/her opinion, speak in favour of the preferred car. As more expensive cars may be more efficient and durable, certain TCO components may appear very pleasing for the buyer who is tempted to buy a given car, even if it the costs are beyond his/her budget. Therefore, while bounded rationality theory would predict better choice under richer information, salience and confirmation bias suggest that TCO may give more space for a biased consumer to find an argument in favour of his or her preferred car, even if he/she can hardly afford it.

Consumer expectations about the cost of owning a car may explain the adverse effect of TCO on the rationality of a car choice, particularly, if the expected TCO exceeds the actual TCO (displayed by the application). The subject's initial expectation of the TCO for the selected cars may be higher than the actual cost (provided by the application). Costs for fuel, insurance and maintenance incorporated and disclosed in a TCO profile, may appear lower than expected by the subject. Therefore, when provided with the actual TCO, the subjects may find more expensive cars with a higher TCO cheaper than expected. As a result, when faced with leasing cost only, the subject would opt for cheaper cars fulfilling their budget constraint, as they may expect more expensive vehicles (i.e. those with a higher leasing cost) to have an excessive TCO, but when the actual TCO turns out to be low relative to the leasing cost, the subjects switch their choice to the more expensive cars. The latter may be particularly vivid in the case of expensive cars, characterised by high leasing payments, but low running costs due to fuel efficiency, exclusive durability and extensive producer's maintenance support. If the actual TCO of more expensive car appears lower than initially expected, a buyer may choose this option over a cheaper car.

The reference point is another factor which may distort consumer rationality. Individual TCO expectations depend largely on previous car ownership experience. According to the Estonian Transportation Agency, the average age of an Estonian car is 14 years.[7] Older cars have generally lower fuel efficiency and higher maintenance costs. Most people know at least approximately how much they spend per month on their current car. When presented with the full TCO for a new car they might choose the more expensive one as the fuel and maintenance costs are lower compared to their current car.

Consumers with different financial constraints or different costs associated with their current cars; that is, different reference points, tend to react to the information differently. Following the prospect theory, the relative weight of TCO information on car choice decision may vary depending on the relative wealth of the consumer and/or his/her budget for a car, as well as on his/her risk and loss aversion (Kahneman and Tversky, 1979; Tversky and Kahneman, 1974; Thaler, 1985 and 1999). Buyers with a larger budget may be less sensitive to TCO information than those with a more constrained budget, as according to prospect theory, consumers perceive the outcomes of their decisions in terms of the value function (Kahneman & Tversky, 1979). Similarly, buyers with cars requiring high maintenance costs may find the TCO of a new car lower than the TCO of their current car, and therefore more expensive cars may appear affordable due to higher efficiency and durability and, as a result, lower maintenance costs. The current car may serve as a benchmark of TCO and with new cars being more efficient, a more expensive car may offer a substantial TCO reduction, albeit at a higher purchase price, compared to the currently owned older car. However, future research is needed to study these mechanisms in detail.

[7] Retrieved on 1 May 2021 from https://www.mnt.ee/et/ametist/statistika/soidukite-statistika.

4. Conclusions

This paper investigates methods for nudging consumers towards better calibration of car choice by revealing the car's personalized Total Cost of Ownership (TCO) prior to the test drive decision. An online field experiment was conducted using a specially designed Facebook Messenger application, where subjects were allocated into four treatment groups depending on quality of cost information accompanying the choice of cars for a test drive. More specifically, we varied the amount of cost information (only leasing payment or full TCO) and the time frame (one month or five years) over which costs are calculated. Our analysis focuses on cross-treatment differences in subjects' average TCO for the cars selected for a test drive and their propensity to choose all or at least one car below their budget constraint.

The results suggest that disclosing a full personalised TCO in a real-life car buying process does not nudge consumers towards better choice calibration in terms of family budget. Quite the opposite, TCO information is associated with choosing more expensive cars. Especially men and those who plan to use lease financing, are more likely to choose cars outside their budget constraint. Consumers who plan to use their own savings for a potential car purchase tend to make more budget-friendly decisions. Females made better decisions in treatment groups where leasing only, but not full TCO, was revealed. Importantly, we document that the adverse effect of a better cost profile is particularly strong among subjects who opt for cars above their budget, as the results reveal, if anything, a very weak effect of TCO on the propensity to choose all cars below the budget constraint, but an economically and statistically strong effect on the average TCO of the selected cars and a propensity to choose at least one car below budget.

Although the logical conclusion would be that better information leads to better decisions, this research proves the opposite in the case of choosing a car. One explanation for these surprising results may be that buying a car involves more than anticipated emotional factors and social status. Otherwise, having no car at all or buying a cheap used car should be a logical choice. Another reason is that the new cars that this study relied on, have become a lot more fuel efficient in recent years. Revealing a full TCO may have created a positive surprise for the subjects when they compared the monthly expenditure on fuel of the new car to their current car. This may have led to the conscious or subconscious decision to choose more expensive cars than initially planned. However, further research is needed to analyse the exact mechanism deteriorating goodness of car choice when a complete TCO profile is disclosed.

This research reveals that there might be a major difference between the results of lab experiments and real-life decision-making. The majority of previous research focusing on the effect of TCO on choosing more environmentally and budget friendly cars was carried out in lab settings (Codagnone et al., 2013; Dumortier et al., 2015; Greene, 2011). People in a lab environment might feel pressured to make more "socially acceptable" decisions – in the current case choosing a more environmentally and budget friendly car. Moreover, the hypothetical car choice designed in earlier lab experiments tells very little about the real-life behaviour of car buyers. Our online field experiment proves that the individual decision-making process is more complex and deviates from the rational choice much more in the field experiment, when people do not sense they are being observed, compared to the artificial lab environment. This research shows that more field experiments are needed to come to a definitive decision about whether revealing better and more transparent cost information might nudge consumers towards more economically rational choices.

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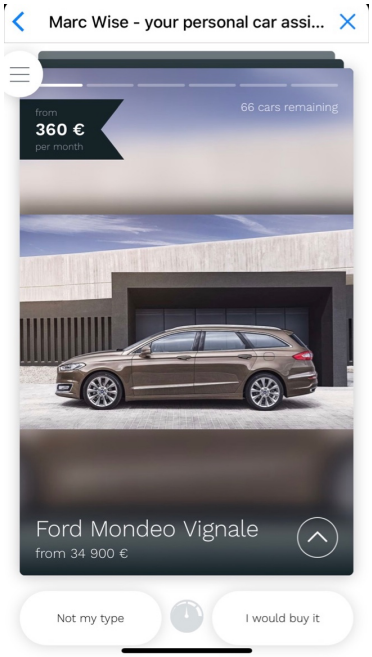
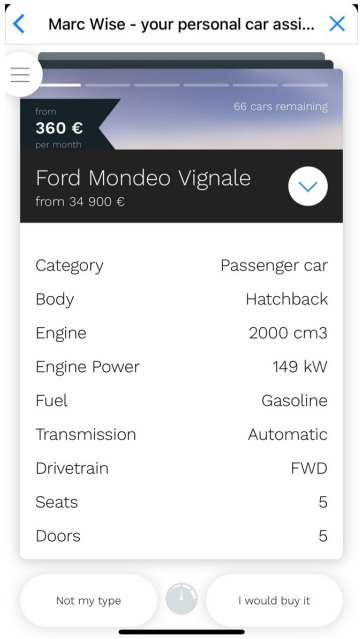
Appendices

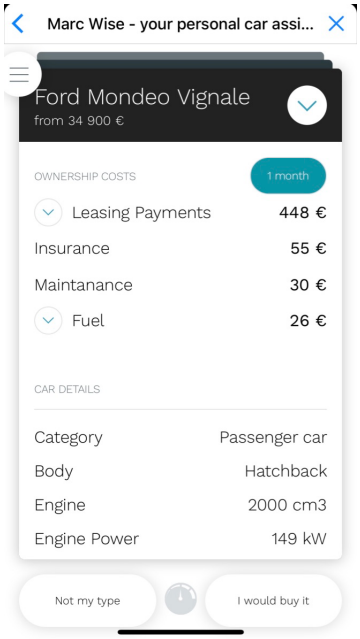
Appendix A: Application Visuals across Treatment Groups



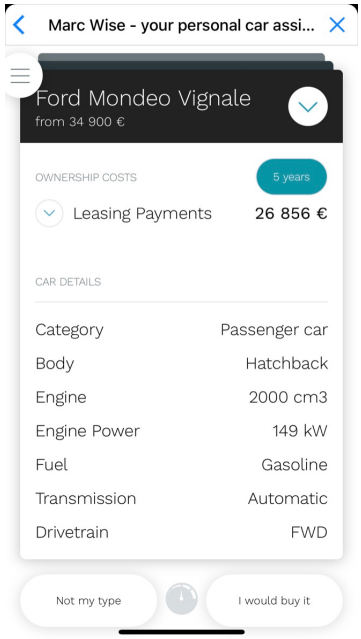
(i) All treatments: Only leasing payment visible on car card. Details open on click on the arrow.



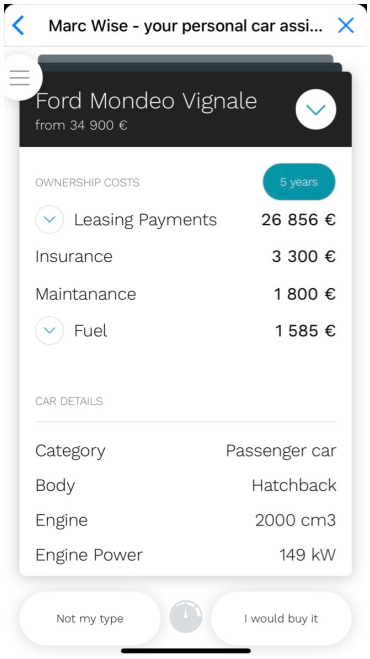
(ii) Base treatment: one-month leasing only cost



(iii) Treatment 1: one-month full TCO



(iv) Treatment 2: five-year leasing only costs



(v) Treatment 3: five-year full TCO

Appendix B: Data structure

Variable	Value (unit)
Treatment	Base, T1, T2, T3
Sex	Female, Male
Created	Date
Family car?	True/False
No of family members	2, 3, 4, 5, >5
Leasing needed	True/False
Five-year budget constraint	Self-calculated (EUR)
Maximum monthly leasing payment	0-1000 (EUR)
Calculate leasing	True/False
Maximum car price	0-100000 (EUR)
Monthly net income	0-10000 (EUR)
Monthly existing loan payments	0-5000 (EUR)
Number of dependents	0, 1, 2, 3, >3
Calculated maximum payment	Self-calculated (EUR)
Intent to buy new car in the next 6 months	True/False

Appendix C: Descriptive estimates by treatment

	(1) Base	(2) T1	(3) T2	(4) T3
Male	0.94	0.87	0.89	0.89
	(0.245)	(0.335)	(0.315)	(0.309)
Family car	0.35	0.38	0.52	0.20
	(0.479)	(0.488)	(0.505)	(0.401)
Leasing	0.78	0.82	0.61	0.91
	(0.415)	(0.388)	(0.493)	(0.291)
Plans to buy a car in the next 6 months	0.49	0.61	0.59	0.64
	(0.502)	(0.489)	(0.498)	(0.482)
TCO min	25266.01	27732.68	29549.28	38027.29
	(6336.6)	(6763.6)	(7810.6)	(7884.6)
TCO max	50291.94	55219.07	58213.41	67681.36
	(21046.7)	(21233.1)	(33332.3)	(29163.9)
TCO average	37495.48	38847.90	40544.85	51042.21
	(13227.2)	(10471.9)	(13857.6)	(13363.0)
Estimated budget	41769.86	37525.61	52433.04	47000.26
	(27886.3)	(25762.1)	(41089.5)	(31812.4)
N	142	164	46	76

Note: Mean coefficients are reported; standard errors in parentheses.

KOKKUVÕTE

Isikustatud autoomamise kogutulu ja vastutustundlik autovalik: eksperimentaalne tõestus

Auto ostmine on üks neist otsustest, millel võib olla märkimisväärne negatiivne mõju inimese või pere eelarvele. Seda eriti juhul kui kõiki auto omamisega seotud kulusid ei arvestata nõuetekohaselt. Kuna autoliising on hõlpsasti kättesaadav, võivad autoostjad auto valimisel kõiki muid kulusid peale liisingumakse alahinnata ja valida sõiduki üle oma eelarve. Selles artiklis viiakse läbi veebipõhine eksperiment Facebook Messengeri rakenduses spetsiaalselt loodud robotis, et uurida, kas täieliku isikustatud autoomamise kogukulu (TCO) avalikustamine viib tarbija paremini kalibreeritud otsuseni. Uuringutulemused näitavad, et parema teabe lisamine reaalses autovalikus ei avalda positiivset mõju autokulude ja individuaalse eelarve vastavusele. Vastupidi, subjektid kalduvad eelarvest veelgi rohkem kõrvale, kui neile avalikustatakse isikustatud TCO (üks kuu või viis aastat). Eriti need subjektid, kes tavaliselt eelistavad kallimaid autosid. Mehed ja need, kes plaanivad kasutada liisingfinantseerimist, valivad oma eelarvepiiranguid ületavaid autosid suurema tõenäosusega. Seevastu tarbijad, kes kavatsevad auto ostmiseks kasutada oma sääste, teevad pigem eelarvesõbralikumaid otsuseid. Naised tegid paremaid otsuseid gruppides, kellele kuvati ainult liisingukulu, mitte täielikku TCO. Kui varasemad uuringud autoostjate käitumise kohta koos erineva kuluinformatsiooniga viidi läbi laborikatsetustena hüpoteetiliste autoostjatega, aitab meie uuring kirjandusele kaasa, tehes väliseksperimendi tegelike autoostjatega, leides olulise lahknevuse laboris saadud tulemustega.