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The role of fuel cost information in new car sales

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ABSTRACT

Transitioning to more sustainable transport behaviours is key to achieving national and international climate change objectives. Households can contribute to the new low carbon economy by switching to more energy efficient vehicles. In addition to societal and environmental benefits, such a change should lead to private benefits for households through lower energy expenses, while avoiding the perceived costs that could accompany a modal change in personal transportation (switching away from cars). This paper uses a discrete choice experiment (stated preference) to explore the effects of using alternative fuel cost labels on the demand for more efficient cars. Results show that reframing from fuel consumption (litres) to monthly fuel costs increases the willingness to pay for higher levels of fuel efficiency. More generally, these results highlight that informational interventions can be improved by framing information in a metric that is more salient and familiar to consumers.

1. Introduction

The transport sector as a whole is a major contributor to global greenhouse gas emissions. In the EU28 in 2016, 20% of total emissions are attributable to road transportation, of which cars make up the largest share (61%) (European Environment Agency, 2018a). Furthermore, the decline in European road transport emissions has been relatively slow – between 2005 and 2016, road transport emissions decreased by just 3%, compared to 20% for total non-transport emissions. While the average carbon intensity (CO_2/km) of new cars in the EU has declined by 16% since 2010 (European Environment Agency, 2018b), the share of low-carbon electric vehicles is currently just 1.1% (European Environment Agency, 2017). Government interventions to encourage households to switch to lower emission vehicles are therefore critical, both from the perspective of reducing the environmental externalities of private mobility, but also for the potential to increase household welfare through reduced energy costs.

1.1. Information failures

Information is very important for consumer decision-making, and gaps resulting from lack of information may explain apparently non-rational decisions. Possible information failures affecting car purchases include asymmetric and imperfect information, rational inattention, hidden costs, and transaction costs. It is widely agreed that imperfect information can lead consumers towards making non-optimal choices (Allcott and Sweeney, 2015, Labandeira et al., 2012, Phillips, 2012). Car buyers, assuming they are cost/emission-minimisers, need accurate fuel consumption/emission information in order to justify investing in more fuel efficient

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vehicles. Hidden and transaction costs represent another example of informational failures (Ramos et al., 2015), Huang et al. (2018). Transaction costs, such as search costs associated with gathering and assimilating information pertaining to a product, the cost of specification and tendering, bargaining and negotiation costs, could create deviations from optimal outcomes (Sorrell, 2004). In the context of new car sales, search and assimilation costs may arise if consumers are not able to easily convert the information they are presented with into a format that they understand, for example if they need to consult fuel prices and undertake subsequent calculations to understand the financial impact of fuel consumption estimates.

The provision of energy information and the resulting assumed behavioural change is conditional on households being attentive to energy costs. For example, a survey by Turrentine and Kurani (2007) shows that US car owners do not systematically track their fuel costs or the price of petrol. Allcott (2011) also finds that 40% of car buyers did not calculate future fuel costs when investing in their last vehicle, and 35% "thought" about fuel costs but did not make any calculations. This inattention may, however, be rational if obtaining the information is costly in time and effort (Sallee, 2014), and that the degree of inattention it is influenced by individual characteristics such as mileage (Leard, 2018).

1.2. Energy efficiency labels

Internationally, the provision of energy efficiency labels is a widely used and a core policy to overcome information failure and increase investments in energy saving technologies such as cars, appliances and buildings. A large body of literature exists, both within the transport sector and beyond, which has examined the impact of such labels on consumer decision-making.

1.2.1. Energy labels for new cars

There are several factors which justify the provision of energy labels within the motor sector. Energy labels provide information that it would otherwise be difficult and time-consuming for consumers to obtain, particularly before a purchase is made. Sammer and Wüstenhagen (2006) also mention information asymmetry between buyers and sellers as a primary reason, i.e. the fact that credence characteristics cannot be checked before or after purchase, and that labels are one credible way to provide this information to consumers.

As with household appliances and residential/commercial property markets in the EU, legislation requires that new vehicle sales are accompanied by labels which provide information on the estimated energy consumption of the vehicle and the environmental impacts arising from it. With regard to the effectiveness of such labelling schemes on consumer choices there is some evidence that consumers are willing to pay more for vehicles labelled as being more efficient. In the Spanish car market, vehicles labelled either 'A' or 'B' are found to attract a premium of around 6% above vehicles with lower ranking but otherwise similar characteristics (Galarraga et al., 2014), while in Switzerland, an A-rated car attracts a 5–11% price premium above a B-rated vehicle, in addition to the effect of fuel economy *per se* (Alberini et al., 2014). From a sustainability perspective, research from Maine in the United States suggests that environmental attributes may be significant in purchase decisions when examining vehicles with similar specifications, but do not appear to be considered for class-level (i.e. SUV, small car etc.) car purchasing decisions (Lundquist et al., 2006).

Haq and Weiss (2016) argue for "(i) uniform labels that mirror […] the design of the EU energy label, (ii) data and classification metrics that accurately reflect the fuel consumption and CO_2 emissions […] and (iii) a labelling scale that allows differentiation between efficient hybrid and plug-in hybrid vehicles."

1.2.2. Fuel cost labelling for new cars

Providing fuel consumption information in monetary terms might increase the demand for more fuel efficient vehicles. This policy has been implemented in a number of countries – in Canada, new car labels provide the buyer with an annual fuel cost estimate. The US EPA redesigned the fuel economy labels in 2013 to include annual and five-year fuel costs (relative to the average new vehicle for the latter). Panassié (2018) finds that the new EPA labels do affect purchase decisions, with more small cars sold and fewer SUVs. Focus group and survey results have shown that consumers appreciate inclusion of running costs on car labels (Boardman et al., 2000). In addition, results from a combined laboratory and online experiment showed that "labels focusing on fuel economy or running costs are better understood" and more effectively support pro-environmental behaviour than labels that state only information on CO_2 emissions (Codagnone et al., 2016). Research on emissions arising from transport activities has shown that there exists a preference for methods of contextualising carbon dioxide information to make it more relatable to individuals (Brazil et al., 2013, Waygood and Avineri, 2018), and it has noted that there is a need to provide consumers with what may be considered "useful" information (Waygood and Avineri, 2016) rather than the traditional approach of highlighting emissions in terms of mass of carbon dioxide produced.

1.2.3. Energy labelling in other sectors

While this study concentrates on labelling in car sales, similar issues of communicating energy use and related costs also occurs in other sectors. For household appliances, a number of studies have assessed the role of reframing energy information into monetary units, and the inclusion of running cost estimates into appliance labels has been tested in a number of in-store and online pilots, mostly with positive (efficiency) effects. In a Swiss study, Stadelmann and Schubert (2018) found that both standard and monetary labels increased the proportion of energy-efficient appliances sold online. However, they also observed a volume effect, in that labels increased the average size of freezers sold. In their pilot study providing energy cost information for fridge-freezers and tumble dryers in Norway, Kallbekken et al. (2013) found a significant effect with regard to tumble dryers, although this effect was observed in combination with additional staff training and also appeared to decline over time. A similar study in Ireland examined ten-year energy costs for tumble dryers but did not find a statistically significant effect (Carroll et al., 2016). Similarly, research by (Heinzle, 2012) utilised a discrete choice experiment and found that consumers are willing to pay a higher premium for televisions, when monetary costs are displayed in a ten-year format, but a lower price when displayed in a one-year format (compared to non-monetary EE information). For lightbulbs, Min et al. (2014) found that the provision of annual energy costs increases the willingness to pay for lower energy consumption and longer life (similar effects are observed in Blasch et al. (2017). Andor et al. (2017) find that adding annual operating cost information to EU labels (fridges) increases the probability of choosing higher energy efficiency levels.

Within the property sector, there is a large body of research which has explored sales and rental premiums associated with energy efficiency. These studies, most of which are based on hedonic regressions, explore property value once an energy efficiency labelling system (non-monetary) is in place (we are not aware of studies which have explored the effects of monetary information on the valuation of energy efficiency). There is strong evidence that households value energy efficiency (rental or sales premiums) in a labelled environment (Brounen and Kok, 2011, Fuerst et al., 2015, 2016, Jensen et al., 2016, Chegut et al., 2016, Cajias and Piazolo, 2013). Similar findings are evident for the business sector (Eichholtz et al., 2010, Fuerst and McAllister, 2011b, 2011a, Wiley et al., 2010, Eichholtz et al., 2013, Das and Wiley, 2014, Robinson and McAllister, 2015, Chegut et al., 2014, Bonde and Song, 2013, Newell et al., 2014, Fuerst et al., 2013, Kok and Jennen, 2012).

1.3. Theoretical investment framework

The purchase of more fuel efficient vehicles can be considered to be an investment in energy efficiency by consumers. In their model of investment in energy efficiency, Allcott and Greenstone (2012) state that an individual (in this case a new car buyer) chooses between an efficient good (denoted by 1), with energy intensity e_1, and an energy inefficient good (denoted by 0), with energy intensity e_0, where ($e_0 > e_1$). Energy intensity can be thought of as the energy used by one unit of energy services, for example the litres of fuel per kilometre of driving. This model states that the individual will select the more efficient good if:

$$\frac{\gamma p m_i (e_0 - e_1)}{(1 + r)} - \sigma > I \tag{1}$$

where: p is the price of a unit of energy (fuel costs per litre), m_i *is* the agent-specific quantity of energy services (the amount they will drive) and r is the risk-adjusted discount rate between the two periods.[1] σ and I are the unobserved net opportunity/utility cost and incremental investment costs of the more efficient good, respectively. The individual will choose the energy-efficient good if the willingness to pay (WTP) (equal to the discounted energy cost savings net of any unobserved costs) exceeds the incremental investment cost (right-hand-side). To allow for the energy efficient gap or ‘investment inefficiencies’, Allcott and Greenstone (2012) scale energy savings by parameter γ ($0 < \gamma < 1$).

There are a number of potential information gaps for car buyers highlighted in Eq. (1). For example, to form an accurate fuel cost forecast, buyers must be aware (and have unbiased expectations) of fuel prices, their use (annual mileage, for example) and the difference in fuel efficiency between different models. While vehicle consumption ratings and fuel prices are easily and costlessly acquired, household lack of knowledge in relation to past fuel expenditures (Turrentine and Kurani, 2007) may indicate that they do not perform fuel cost comparisons (Allcott, 2011). Given these findings, it is also possible that buyers have biased (or missing) expectation in relation to their annual mileage. Furthermore, even without any information gaps, some buyers may have difficulty converting this information into an accurate fuel cost forecast. In this regard, a hypothetical test in the US (Allcott, 2011) shows that such calculations are generally biased (but not necessarily in the direction which would explain an undervaluation of improved efficiency). In Germany, Heinzle (2012) also finds large errors in electricity cost calculation for televisions. From an environmental perspective, the issue is whether informational gaps or calculation errors are manifesting in a higher energy efficiency gap (γ) and reducing the demand for more fuel efficient vehicles. Specifically within the transport sector, it has been argued that imperfect information, in conjunction with individuals' limited computational abilities, may lead decisions that deviate from rational behaviour, and therefore that measures such as information reframing should be considered (Garcia-Sierra et al., 2015).

1.4. Car sales in Norway

Our experiment focuses on the new car market in Norway. The Norwegian tax regime already provides strong incentives to purchase environmentally friendly cars. For example, electric vehicles are exempt from VAT and other car-related taxes, which typically add up to around 40% of the full price of a new car. With respect to the choice experiment, which focuses solely on internal combustion engine vehicles, the most relevant tax component is the CO_2 tax as CO_2 emissions are perfectly correlated with fuel consumption for gasoline and diesel cars.

The CO_2 tax on new cars imposes a strongly increasing marginal cost, starting at zero for vehicles emitting less than 70 g CO_2/km, and rising to around 350 euro per gram for emissions in excess of 195 g CO_2/km. As a result of these strong incentives, the average (NEDC rated) CO_2 emissions of new cars sold in Norway in 2017 were only 82 g/km, in large part due to a 20.9% market share for zero emission vehicles, and 31.3% for hybrids (of these 59% were plug-in-hybrids) (OFV AS, 2017a).

Incentives to purchase low-emissions and fuel efficient cars also play a major role via use-related charges (Bauer, 2018). In 2017,

[1] While the factors in Eq. (1) are estimated under uncertainty and should include expectation operators, we have maintained the original specification of Allcott and Greenstone (2012) who use this to describe the investment decision and inefficiency more generally.

when the survey was conducted, the road use charge was NOK 5.19/l for petrol and NOK 3.80/l for diesel, the CO_2-tax was NOK 1.04/l for petrol and NOK 1.20/l for diesel, and VAT 25% of the sales price. In total these taxes make up around 60% of the cost of petrol and somewhat less for diesel (depending on the market price). Fuel costs make up a significant share of total operating costs for new cars. For a typical new car, costing NOK 400,000, driven 15,000 km per year, and with a fuel consumption of 0.59 L/10 km, the estimated fuel costs are 13.222, compared to total operating costs (excluding depreciation and the alternative cost of capital) of 45.566 (OFV AS, 2017b).

Data from the International Energy Agency highlights the uniqueness of the Norwegian car market, specifically in terms of progress in transitioning to low emissions transport, reporting a market share of 39.2% for electric vehicles for the country in the year 2017. This compares with 6.3% for neighboring Sweden, 2.2% for China, 1.7% for both France and Germany, and 1.2% for the United States (IEA, 2018).

1.5. Paper outline

This paper seeks to further the literature by examining how the reframing information on fuel efficiency can impact upon consumer decisions within the new car market. While significant work has been undertaken examining the role of fuel prices and efficiency in car sales, this research focuses primarily on how such information is framed, rather than the specific role of fuel efficiency estimates. This paper is organised as follows: A methodology section outlining both the modelling methods used and the data collection process, a results section providing the results of mixed logit models, a discussion section providing interpretation of results, and a conclusions section outlining the relevance of the findings for research and policy.

2. Methods

This research set out to examine the role that the reframing of fuel cost information can play in terms of highlighting the fuel efficiency of new vehicles. Specifically, this study involved the distribution of a split sample (control/treatment) discrete choice experiment to a representative sample of the Norwegian car buying population, via an online survey undertaken in late 2017. This survey was distributed to over 1000 individuals representing a cross section of the Norwegian population in all regions of the country. The discrete choice experiment was the first section of a wider survey examining the role of fuel consumption information in Norwegian vehicle purchases (results reported in Orlov and Kallbekken, *under review*).

2.1. Discrete choice experiment

In a Discrete Choice Experiment (DCE), respondents are presented a series of *choice sets*, consisting two or more alternatives, and asked to choose their preferred alternative in each set. This approach was initially developed by Louviere and Hensher (1982) and Louviere and Woodworth (1983). Analysis of DCE results is based on the Random Utility Model (RUM) (Luce, 1959, McFadden, 1973). The model represents a respondent *i*'s preferences by a utility function U_i containing a deterministic element (V) and a stochastic element (e):

$$U_{ij} = V_{ij}(X_{ij}) + e_{ij} = \boldsymbol{b}\boldsymbol{X}_{ij} + e_{ij} \tag{2}$$

V *is* typically specified as a linear function of the attribute vector ($\boldsymbol{X}$) of the j different alternatives in the choice set. In our experiment, the vector contains the following attributes: price, fuel efficiency, safety rating, and luggage space. $\boldsymbol{b}$ is a vector of coefficients, that is, marginal utilities, corresponding to the attribute vector. e represents unobservable influences on the respondents choice. Respondents are assumed to choose the utility-maximizing alternative, but because of the stochastic component e, the analysis becomes probabilistic.

This study employs the mixed logit model presented by Train (2003), which removes three limitations of standard logit models as it allows for random taste variations, unrestricted substitution patterns, and correlation in unobserved factors over time. This is achieved by letting the coefficient vector $\boldsymbol{b}_i$ vary across respondents, by splitting it into a vector of population mean values ($\boldsymbol{\beta}$) and a vector of individual deviations from the mean values ($\boldsymbol{\eta}_i$)

$$U_{ijt} = \boldsymbol{b}_i\boldsymbol{X}_{ijt} + e_{ijt} = \boldsymbol{\beta}\boldsymbol{X}_{ijt} + \boldsymbol{\eta}_i\boldsymbol{X}_{ijt} + e_{ijt} \tag{3}$$

$\boldsymbol{\beta}$ is a vector of fixed coefficients, which is estimated by the econometric model. The subscript t indexes choice sets and signals that the model incorporates dependencies across multiple choice sets faced by respondent i. $\boldsymbol{\eta}_i$ is a vector of the unobserved and stochastic deviations from the vector of mean coefficients ($\boldsymbol{\beta}$) for respondent i.

After the model has been estimated, the monetary value of a marginal change in any single attribute can be found by the ratio given in Eq. (4) where β_p is the estimated average coefficient for the price term and β_c is the estimated average coefficient for any other attribute under consideration. These ratios show the WTP for a change in any of the attributes, and are often known as implicit prices:

$$\mathrm{WTP}_c = \frac{-\beta_c}{\beta_p} \tag{4}$$

For example, in the current study, the WTP for fuel efficiency improvements is the marginal utility of fuel efficiency divided by the

Table 1
Attribute levels.

Price (NOK thousand)	Fuel efficiency (litres/100 km)	Safety score (% of max Euro NCAP)	Luggage space (litres)
500	8	90	700
450	7	80	600
400	6	70	500
350	5		400
	4		

marginal (dis)utility of price. Estimates derived in this way are consistent with utility maximisation and demand theory, at least as long as a status quo option is in the choice set (Bateman et al., 2002), included in this study as an option to choose neither car presented.

2.2. Advantages of stated preference methods

Stated preference (SP) methods are a long-established means of eliciting preferences and willingness-to-pay valuations for various product attributes. SP methods do not rely on in field observations like relevaled preference (RP) methods, but they do have a number of distinct advantages that are desirable to both analysts and policy makers.

SP methods can be used to examine non market goods, which either may not be present within a specific market, or are currently under development. For example, within the transport space, this enables analysts to examine individuals demand for potential transport solutions such as the construction of a new metro or the implementation of a congestion charge. In addition, SP methods enable analysts to vary attribute levels that may be correlated in a real-world setting, such as ticket price and journey length in a public transport context. From a resource perspective, SP methods enable analysts to collect larger, and - importantly - more statistically representative samples, than would be possible with an RP approach. Based on these considerations an SP approach, specifically a DCE, was considered to be the most appropriate means of data collection in order to meet the goals of this study.

2.3. Experimental design and attributes

Prior to the distribution of the survey, a series of focus groups identified safety rating and luggage space as the most important attributes to include in the experiment, in addition to the research parameters of interest: purchase price and energy efficiency. Attribute levels (the vectors X) were selected to reflect those currently present in the Norwegian automobile market, see Table 1. A fractional factorial design, utilising the JMP software package, generated 32 unique choice pairs. To prevent respondent fatigue, these pairs were split across four survey blocks, so that each respondent faced only eight choices. These eight choices were presented in either the control or treatment format, with each respondent only receiving choices in a single format to avoid any framing contamination effects. Therefore, there were eight versions of the survey in total, four control and four treatment blocks, as illustrated in Fig. 1.

2.4. Label design

The labels shown to respondents were designed to contain all the necessary information regarding the four attributes under examination (price, fuel efficiency, safety score, and luggage space) required to make a choice. They only differed with respect to the inclusion of monetary contextualising information for fuel efficiency in the treatment version. In the control version of the experiment, the attributes were displayed in a simplified version of how they are currently displayed on new cars in Norway with the additional prominence of fuel efficiency reflecting current labelling approaches. In the treatment version, the energy consumption variable was augmented with a monthly fuel cost estimate, displayed in terms of Norwegian Kroner (NOK).[2] This did not introduce another attribute, rather it reframed and contextualised existing information. Both the treatment and control images also contained a graphic with the vehicle's environmental rating (A-G), as mandated under current EU and Norwegian legislation. The rating is based on CO_2-emssions, which is proportional to fuel consumption when fuel type is constant. In this study, all vehicles considered used gasoline. Fig. 2 illustrates one of choice cards presented to the respondents with two choice pair (one in the control group format and one in the treatment group format). Each responded only viewed choices in control or treatment versions, and were required to undertake eight such choice as part of the DCE. In addition to the choices described by the four attributes, respondents had the option to select "neither" if they would not purchase either option.

3. Results and discussion

A mixed logit model was estimated to assess the role of the information treatment, and to estimate any change in consumers' WTP for reduced fuel consumption.

[2] When the experiment was conducted, 1 Norwegian Krone was equivalent to 0.1 Euros and 0.13 US Dollars.

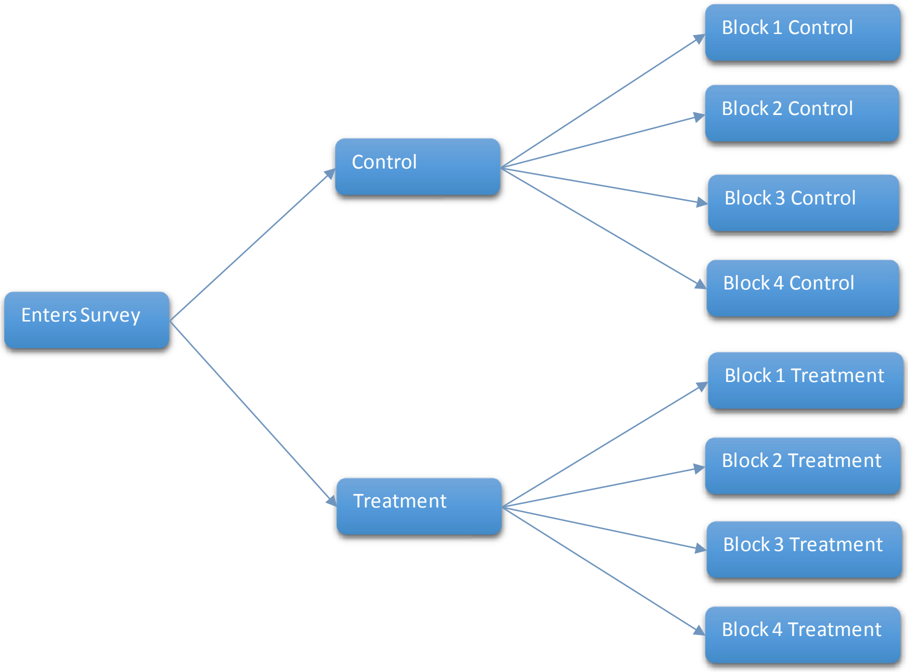

Fig. 1. Respondent assignment.

3.1. Sample

In terms of the population under examination, the sample was designed to represent the adult Norwegian population who have at some point purchased a new car, or were planning to do so within the next 12 months. The survey response rate was 30%. In terms of education and employment status, 52.3% have a bachelor's degree or higher, 55.4% are employed, 24.6% retired, and 7.3% are students. Compared to the general population of Norway, this makes our sample older, more likely to be retired, more highly educated and less likely to live alone. All of this is, however, broadly consistent with how the population of (new) car buyers might be expected to differ from the general population. Table 2 outlines the properties of the control and treatment samples respectively, and highlights their similarities, in terms of respondents' age and gender. In addition, respondents were asked to state their level of environmental concern on a 1–5 scale (1 implying "not concerned at all" and 5 implying "very concerned"), with results indicating no significant differences between the samples, ensuring that environmental attitudes are not driving any difference observed in the responses.

3.2. Mixed logit modelling results

Table 3 presents results from the mixed logit model (estimated in NLOGIT version 6). Fuel efficiency is modelled using two methods – in Model 1, as five dummy variables (five fuel consumption categories measured in litres per 100 km); in Model 2, as a continuous variable (in litres/100 km). For both models, fuel efficiency is interacted with the treatment dummy (fuel cost labelling). All attributes and interactions are assumed to be normally distributed, except price (log-normal). For the alternative specific constant for the 'neither' option we also assume a normal distribution (this is equivalent to estimating an error components model).

All non-efficiency attributes are found to be statistically significant (at the 1% level) and of the expected sign. In both models, utility is increasing in luggage space and safety, and decreasing in price. In the control group (non-interacted coefficients), higher fuel efficiency leads to very large and significant increases in utility. For Model 1 (dummy coding), the marginal effect appears to be relatively stable across the efficiency range, although the utility increase is highest at the lower end (between 8L/100 km) and 7L/100 km). In this model, the interaction term is significant for the two most efficient cars only (5L/100 km and 4L/100 km), which implies that fuel cost information has increased the utility associated with the most fuel efficient cars. In Model 2, the effects of the continuous efficiency attribute can be considered an average effect across the full efficiency range (note that higher consumption implies lower efficiency, and therefore a negative coefficient). As with Model 1, the non-interacted efficiency attribute is very large and significant, again implying that fuel efficiency is highly valued by Norwegian car buyers. This high marginal utility of fuel efficiency is further increased by treatment (interaction term significant).

Table 4 presents these results as WTP estimates. Buyers will pay about 55,000 NOK more for each ten percentage point improvement in safety (Model 1). For luggage space increases up to 600L, each 100L raises WTP by about 40,000 NOK, but then drops off for the largest car (Model 1). Fuel efficiency is an extremely important attribute – in the control group (Model 1), buyers will pay

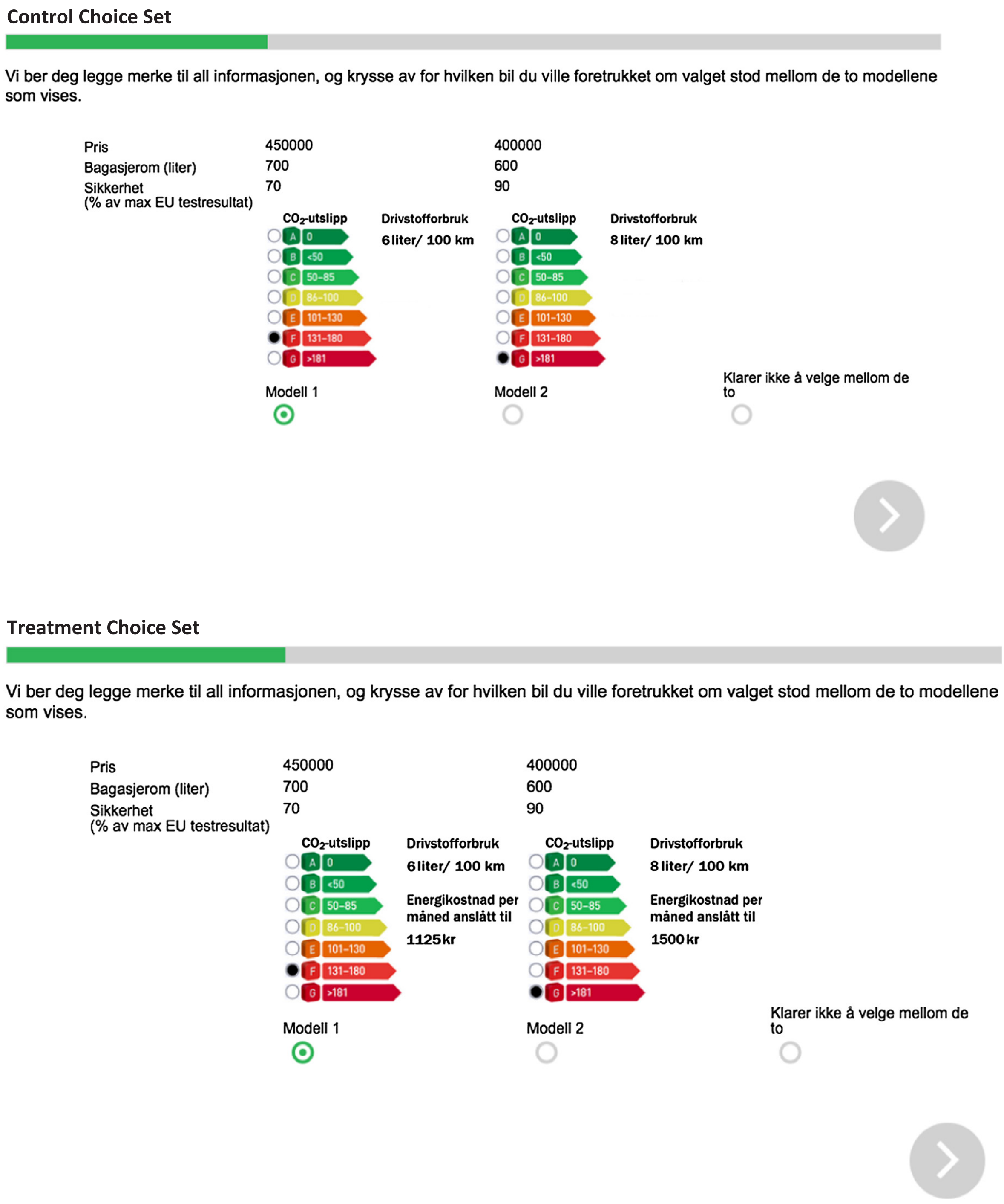

Fig. 2. Screenshots of illustrative choice set labels (control group above and treatment group below).

Table 2
Sample descriptive statistics – means.

	Control	Treatment
Age (years)	48.4	49.2
Female share (%)	48.6	49.8
Stated environmental concern (1–5)	2.5	2.6

Table 3
Mixed logit model results from Norway car discrete choice experiment.

	Model 1			Model 2		
	Coef.		Prob. |z| > Z*	Coef.		Prob. |z| > Z*
Mean						
Price[C]	−0.009	***	0.000	−0.009	***	0.000
Luggage space 400L[D]	*reference group*			*reference group*		
Luggage space 500L[D]	0.385	***	0.000	0.393	***	0.000
Luggage space 600L[D]	0.701	***	0.000	0.726	***	0.000
Luggage space 700L[D]	0.761	***	0.000	0.754	***	0.000
Safety Score 70%[D]	*reference group*			*reference group*		
Safety Score 80%[D]	0.462	***	0.000	0.534	***	0.000
Safety Score 90%[D]	0.937	***	0.000	1.013	***	0.000
Treatment[D]	0.174		0.601	2.813		0.000
Fuel Efficiency 8L[D]	*reference group*			*reference group*		
Fuel Efficiency 7L[D]	0.909	***	0.000			
Fuel Efficiency 6L[D]	1.435	***	0.000			
Fuel Efficiency 5L[D]	2.023	***	0.000			
Fuel Efficiency 4L[D]	2.720	***	0.000			
Treatment[D] * Fuel Efficiency 7L[D]	0.061		0.598			
Treatment[D] * Fuel Efficiency 6L[D]	0.017		0.885			
Treatment[D] * Fuel Efficiency 5L[D]	0.306	**	0.013			
Treatment[D] * Fuel Efficiency 4L[D]	0.753	***	0.000			
Fuel Efficiency[C]				0.659	***	0.000
Treatment[D] * Fuel Efficiency[C]				0.234	***	0.000
Constant (neither option)	−5.550	***	0.000	0.210		0.641
Standard deviation						
Price[C]	0.005	***	0.000	0.007	***	0.000
Luggage space 500L[D]	0.007		0.945	−0.024		0.779
Luggage space 600L[D]	0.706	***	0.000	0.618	***	0.000
Luggage space 700L[D]	0.164		0.445	0.141		0.507
Safety Score 80%[D]	0.155		0.244	0.298	***	0.001
Safety Score 90%[D]	0.645	***	0.000	0.574	***	0.000
Treatment[D]	0.233		0.345	−7.415	***	0.000
Fuel Efficiency 7L[D]	−0.006		0.956			
Fuel Efficiency 6L[D]	0.001		0.994			
Fuel Efficiency 5L[D]	−0.030		0.887			
Fuel Efficiency 4L[D]	1.059	***	0.000			
Treatment[D] * Fuel Efficiency 7L[D]	0.015		0.941			
Treatment[D] * Fuel Efficiency 6L[D]	0.054		0.723			
Treatment[D] * Fuel Efficiency 5L[D]	−0.261		0.391			
Treatment[D] * Fuel Efficiency 4L[D]	1.524	***	0.000			
Fuel Efficiency[C]				0.240	***	0.000
Treatment[D] * Fuel Efficiency[C]				0.512	***	0.000
Constant (neither option)	3.459	***	0.000	2.605	***	0.000
Model statistics						
Number of Alternatives per Scenario			3			3
Number of Scenarios per Respondent			8			8
Number of Respondents			1093			1093
Halton Draws			500			500
LR chi2			2335			2474
Prob > chi2			0.000			0.000

Source: Own calculations.
Notes: Estimated using maximum simulated likelihood ('mixlogit' module) in Stata 14. For the 'neither' option, attributes, treatment dummy and interactions are replaced with zeros. ***, ** and * indicate significance at 1%, 5% and 10% level. [D] indicates dummy variable and [C] indicates continuous variable. The model is estimated under maximum simulated likelihood.

about 110,000 NOK more to increase their efficiency from 8L (worst category) to 7L, and then between 70,000 NOK for each additional litre reduction thereafter. The average marginal increase in WTP across the full efficiency range (Model 2) is just over 70,000 NOK.[3]

Fig. 3 displays the WTP for each fuel efficiency level compared to the reference group (the least efficient cars). In Model 1 (dummy coded efficiency), treatment has significantly increased the WTP in the two highest efficiency classes only (significance based on the

[3] While not shown, we also estimated the models controlling for income. In this regard, the sample was split into two income groups: below and above the mean income. However, we do not find that results are sensitive to income differences. Furthermore, the treatment effects are statistically identical.

Table 4
WTP estimates for Car DCE attributes in Norway.

	Model 1	Model 2
Luggage space 500L[D]	45.226	42.494
Luggage space 600L[D]	82.298	78.574
Luggage space 700L[D]	89.377	81.513
Safety Score 80%[D]	54.219	57.701
Safety Score 90%[D]	109.963	109.615
Fuel Efficiency 7L[D]	106.689	
Fuel Efficiency 6L[D]	168.486	
Fuel Efficiency 5L[D]	237.559	
Fuel Efficiency 4L[D]	319.395	
Treatment[D] * Fuel Efficiency 7L[D]	7.115	
Treatment[D] * Fuel Efficiency 6L[D]	1.998	
Treatment[D] * Fuel Efficiency 5L[D]	35.962	
Treatment[D] * Fuel Efficiency 4L[D]	88.366	
Fuel Efficiency[C]		71.321
Treatment[D] * Fuel Efficiency[C]		25.264

Source: Own calculations.
Notes: All estimates are in Norwegian Krone (000′s). WTP estimates are calculated as the attribute coefficient divided by the price coefficient.

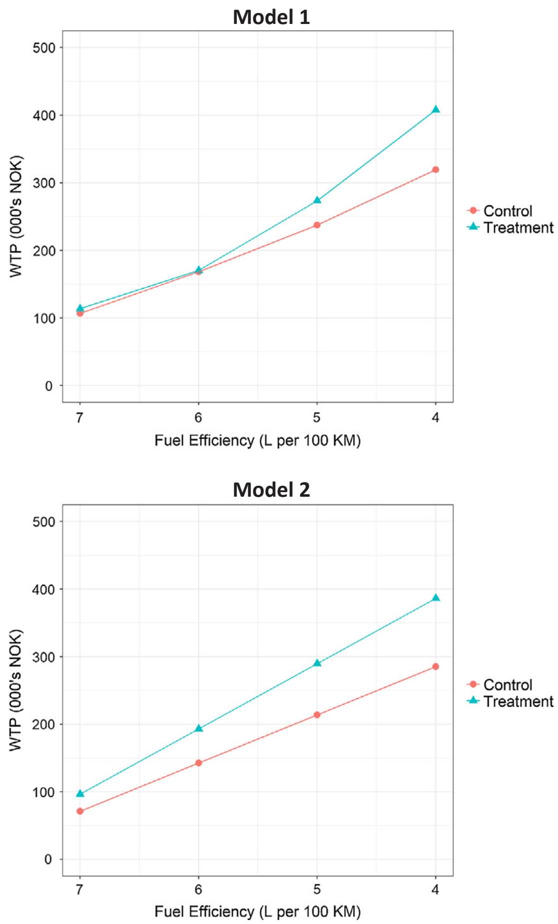

Fig. 3. Willingness to pay (WTP) (000′s NOK) for fuel efficiency by treatment and model (base: 8L/100 km). Source: Own calculations. Notes: All WTP estimates are in Norwegian Krone (000's) and are relative to the worst fuel efficiency level (8 L/100 km).

interaction terms in Table 3) – the WTP for 5L/100 km cars has increased from 237,559 to 273,521 NOK (15% increase), while the WTP for the most efficient cars has increased from 319,395 to 407,762 NOK (28% increase). In Model 2 (continuous fuel efficiency), results show that the marginal WTP has increased from 71,320 96,584 NOK (35% increase).

3.3. Experimental limitations

As the purpose of this research was primarily to investigate the potential role of monetary information interventions in new car sales, a number of simplifications had to be made when representing the attributes that a consumer may consider when purchasing a new vehicle. As a result of these simplifications, we cannot claim that the scenarios presented in the surveys encompass all the factors that individuals may consider when deciding whether or not to buy a new vehicle. This, in conjunction with the visual prominence afforded to the fuel information, may be the reason for the high WTP estimates that emerged from the analysis. However, as this research is more concerned with relative differences in WTP estimates arising from the framing techniques under examination, rather than estimating precise WTP values for fuel efficiency in the Norwegian new car market, this is not considered to be a major drawback. This over-valuation of fuel/energy efficiency savings is not unprecedented and has been previously seen in the findings of Andor et al. (2017). Overall, however, the hypothetical approach employed is a potential impediment to the generalisability of our results, and we would encourage field trials to support our analysis. Furthermore, our results may be country-specific, and future work from other countries would help to support or oppose the roll-out of monetary labelling in the EU.

4. Conclusions

Greater effort is required to curtail transport emissions. The sector contributes 20% of total EU carbon emissions, and reductions have been significantly slower than in other sectors. This research set out to examine methods to increase the demand for fuel efficiency by reducing information failures related to vehicle fuel costs. Such failures could act as barriers to the promotion and adoption of vehicles with lower environmental impacts. Within the overall energy literature, numerous studies have highlighted the presence of an energy efficiency gap, where, through both market and information failures, consumer are unable to make optimal investment decisions. This study sought to reduce these failures (the γ term in Allcott and Greenstone (2012)'s model (2012)) by providing consumers with energy information augmented by the estimated operation costs (in Norwegian Krone) for the cars available to them.

The findings from our models suggest that with the addition of fuel cost estimates, individuals' WTP for more efficient vehicles can be significantly increased, in the case of this research by up to 28%. Based upon the findings outlined in this study, it appears that the inclusion of fuel cost estimates nudges consumers to select more fuel efficient vehicles with lower associated fuel costs. While the experimental design may have led to an over-valuation of fuel efficiency, the relative increase in WTP for fuel efficiency in the treatment group compared to the control group is likely robust.

These results highlight the current inefficiencies with regard to presenting fuel consumption and efficiency information for cars, and while this research was undertaken within the Norwegian market, the labelling regime examined is used in all EU countries as well. From a policy perspective these findings indicate that including fuel costs estimates in energy labels may be a useful strategy for accelerating the adoption of more fuel efficient cars. While this research focused on internal combustion vehicles, such a labelling approach would be highly valuable in the context of promoting electric vehicles or hybrids, as the reduction in fuel costs is quite sizeable for an electric car when compared with a gasoline or diesel car. In order to achieve current stated political ambitions at both national and European level to gradually phase out sales of fossil-fuel powered vehicles, the inclusion of fuel costs in energy labels would appear to be a relatively simple but effective measure.

We acknowledge that the provision of energy cost labelling would be a significant challenge for the EU, particularly given that fuel prices differ across countries, and within countries, prices can vary significantly in the short-term as a result of external geo-political events. In this regard, country-specific energy cost labelling would need to be based on average prices and mileage within each country, and would likely need to be updated at regular intervals (annually, for example) to reflect fuel price changes. Alternatively, such price heterogeneity could be accommodated by providing cost labelling online and supplemented with electronic interfaces at car dealerships at the point of sale, which would allow revisions of prices and mileage at trivial cost compared with printed labels. This approach has the merit of providing buyers with tailored energy cost forecasts based on their specific mileage and fuel price expectations.

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Appendix A. Supplementary material

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