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Does Size Matter? Empirical Evidence for Product Specification Rebound Effects

Navn: Mikkel Enstad, Artem Myreev

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# Does Size Matter? Empirical Evidence for Product Specification Rebound Effects

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Supervisor:
**Erik L. Olson**

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# Table of Contents

**List of Figures and Tables**

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# Abstract

The current study explores a new field with the concept of rebound effects that have been receiving scant attention – namely, product specification rebound effects which occur when consumers choose larger or more powerful specifications of the product as a response to improvements in energy efficiency. Although there is a theoretical foundation for their existence, almost no empirical study has previously focused on product specification rebound effects. Hence, the study aimed to empirically confirm whether efficiency improvements lead to product specification rebound effects, as well as to explore different factors that may affect their magnitude.

Our findings support the existence of product specification rebound effects and show that a significant share of the anticipated energy efficiency gains can be lost due to product specification rebound effects. The study also finds that greater efficiency improvements tend to lead to greater product specification rebound effects. As energy efficiency is seen as one of the most fundamental approaches to tackle climate change, this raises a question over the effectiveness of energy efficiency measures as a way of tackling climate change.

The study has significant implications for both policy makers and manufacturers, as the introduction of more energy efficient technologies results in consumers making product upgrades. From the policy making perspective, this means that expected energy gains from efficiency measures will be vastly offset by product specification rebound effects. As a result, there will not be any significant reduction in energy consumption, which is critical for tackling climate change. At the same time, from the business perspective, marketing energy efficiency seems to be a potentially successful strategy to induce product upselling. By introducing more energy efficient technologies, manufacturers can sell bigger and more powerful specifications of the product, which are usually more profitable.

# 1. Introduction

*"You say you love your children above all else and yet you are stealing their future in front of their very eyes"* – climate activist Greta Thunberg at the UN plenary in Katowice, Poland.

The "School Strike for Climate" started by the 16-year-old Swedish climate activist Greta Thunberg has become a worldwide movement fighting for the youths' future on a planet affected by climate change (BBC News, 2019). School Strike for Climate is just one of the several movements fighting for politicians and companies to demand action on climate change. Global warming is now one of the top issues across the EU, and the rising concerns about climate change helped the Greens secure a 37% increase in the number of seats as a result of the last European Parliament elections (Henley, 2019). It seems like people have started to take actions against global warming and its consequences. However, what if these actions are diluted by unconscious behavior of consumers?

In 2015, 175 countries signed the Paris agreement to strengthen the global response to climate change and keep the rising temperature below a 2 °C increase to the pre-industrial levels (UNFCCC, 2018). There are no regulations concerning actions towards achieving this goal in the agreement. Each country has to report annually on what measures have been implemented (UNFCCC, 2018). However, governments and intergovernmental organizations highlight the importance of energy efficiency in tackling climate change and ensuring sustainable growth. The United Nations states that *"energy is the dominant contributor to climate change, accounting for around 60 percent of global greenhouse gas emissions"* (UNDP, 2015).

It is commonly agreed that improvements in energy efficiency can reduce energy consumption and associated greenhouse emissions. EEB Policy Officer on Energy and Climate, Roland Joebstl, claims that *"energy efficiency is the cheapest and most effective route to cut climate-harming emissions and protect citizens from devastating climate change"* (European Environmental Bureau, 2018).

However, global energy consumption continues to rise despite all the political debate and actions on energy efficiency. In the European Union, electricity consumption increased by 0.7% in 2017 compared to the previous year, showing an increase for the third year in a row (Sandbag & Agora Energiewende, 2018). This increase raises questions over the sufficiency of the EU's measures on energy efficiency (Sandbag & Agora Energiewende, 2018).

A similar trend can be observed in Norway. From the year 2000 to 2015, the reported increase in energy efficiency for final consumers was 19% (Odyssee-Mure, 2018). At the same time, Norway has experienced a rise in electricity consumption of final consumers by 10.8% for the same period (SSB, 2019). Despite this promising increase in energy efficiency, why does electricity consumption continue to grow significantly?

Research shows that advancements in energy efficient technologies have often led to lower reductions in energy consumption than expected (Sorrell, 2007). Particularly, the introduction of more efficient technologies has been in many cases accompanied by rebound effects that offset gains of efficiency improvements (De Haan, Mueller, & Peters, 2006). It has been widely observed that efficiency measures lead to an increase in the utilization of energy consuming products, as a result of changes in consumer behavior (Berkhout, Muskens & Velthuijsen, 2000; Greening, Greene & Difiglio, 2000; Frondel & Vance, 2013).

Most research in the field of rebound effects examines an increase in direct usage of energy consuming products. However, there is also evidence that consumer preferences for other product attributes change, as the product become more energy efficient. For instance, it has been observed that the median size of TV screens increased from 34 to 47 inches, between 2004 and 2007, as TVs became more energy efficient (Olson, 2013). The same can be said about cars: the average vehicle weight of cars in Switzerland increased from 1309 to 1462 kg, between 1996 and 2004 (De Haan et al., 2006).

These product upgrades can indicate the existence of product specification rebound effects. They can be observed when consumers choose larger or more powerful specifications of the product as a result of efficiency improvements (Olson, 2013).

This will ultimately offset some of the efficiency gains. Thus, the efficiency improvements can be diluted by product specification upgrades resulting because of such improvements. Despite its great importance, this field has received scant attention, and to the best of our knowledge, only Olson (2013) found some evidence supporting the existence of rebound effects in the form of product specification upgrades.

Hence, in our study, we studied product specification rebound effects further and focused on the following question: Will anticipated energy gains from efficiency measures be eroded due to product specification rebound effects? This study has a substantial contribution to the existing literature since no other empirical research has focused on product specification upgrades caused by changes in consumer preferences as a result of efficiency measures.

In addition, the study focused not only on personal transportation as most empirical studies did but also on other areas of residential energy use to examine a broader spectrum of rebound effects. The current study examined the existence of product specification rebound effects on the example of cars, TVs, and refrigerators. The study confirmed the presence of product specification rebound effects for all the three product categories, which suggests that all areas of residential energy use may be affected by product specification rebound effects.

The study has a great implication for both policy makers and manufacturers. Policy makers may be overestimating the potential effectiveness of energy efficiency to tackle climate change, as our study showed that product specification rebound effects cause a significant reduction in anticipated energy gains. For manufacturers, our results mean that more energy efficient technologies can lead to upselling and more profitable sales.

# 2. Literature and background

## 2.1 History of rebound effects

The phenomenon of rebound effects was first described by William S. Jevons (1865) who noticed a strange paradox: the introduction of a new, more coal-efficient steam engine resulted in increased total coal consumption, despite the expectations that the new technology would reduce total coal consumption. In his famous work, The Coal Question, Jevons (1865) wrote: "*It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth.*". Even though Jevons did not call this paradox a rebound effect, he concluded that improvements in technology would result in a reduced price of providing such services, and therefore would lead to an increased demand for those or other services (Azevedo, 2014).

Jevons' paradox, as it is called now, was the first step in studying rebound effects. However, there was not much discussion about it until the late 1970s–early 1980s. During the appearance of global energy efficiency policies and the oil crisis in 1973, Jevons' insightful theories received renewed enthusiasm among various scholars (Vivanco, McDowall, Freire-González, Kemp & van der Voet, 2016). Khazzoom (1980; 1987) and Brookes (1979; 1990) revived the debate and independently came to a conclusion that greater energy efficiency paradoxically can lead to increased, not decreased, energy demand. Saunders (1992) later labeled this paradox as the Khazzoom-Brookes postulate and stipulated that *"energy efficiency gains will increase energy consumption above what it would be without these gains."*

It is now believed that these four primary studies laid the foundation for developing the concept of rebound effects (Azevedo, 2014). The formulation of the Khazzoom-Brookes postulate was followed by an array of both theoretical and empirical studies mainly in energy economics (Greene, 1992; Berkhout et al., 2000; Greening et al., 2000). However, in recent years, this concept has also received high attention in behavioral and environmental studies, raising questions over the effectiveness of energy efficiency policies globally (De Haan et al., 2006; Sorrell & Dimitropoulos, 2008).

Today, after 30 years of debates and academic research, there is a broad agreement of the rebound effects' existence (Vivanco et al., 2016). Nevertheless, the debate regarding the rebound effects continues, as there is still ambiguity about how the rebound effects should be defined and measured (Azevedo, 2014). Empirical studies on the rebound effects tend to have significantly disparate results, which suggests the need for further research in this area. Furthermore, the increased discussion about tackling climate change highlights the importance of research on the rebound effects, as they should be considered in policy making.

## 2.2 Taxonomy of rebound effects

The rebound effects can be defined as *"the extent to which some of the anticipated energy gains from energy efficiency measures will be eroded due to consumer behavior"* (Azevedo, 2014). For instance, a rebound effect of 20% would mean 20% of the anticipated energy gains from energy efficiency measures are offset by consumer responses (Berkhout et al., 2000). The rebound effects are believed to be the result of "*behavioral and systemic responses to changes in consumption and production factors, mainly prices, income and factors of production"* (Greening et al., 2000).

Most researchers agree on the following taxonomy: rebound effects are decomposed into direct, indirect, and macroeconomic (sometimes also called economy-wide) rebound effects (Berkhout et al., 2000; Greening et al., 2000; Sorrell & Dimitropoulos, 2008).

The direct rebound effect occurs when a decrease in the price of a good or service caused by improved energy efficiency leads to an increase in consumption of that good or service (Sorrell & Dimitropoulos, 2008). For instance, if consumers have a more fuel-efficient car, they may react by driving further or more often, thereby counterbalancing the fuel savings. Another example is when consumers have a more energy-efficient heater, they may use the heater more intensely setting higher temperature.

The indirect rebound effect occurs when the reduced price of a good or service leads to increased consumption of other goods or services that also require energy for their provision (Sorrell & Dimitropoulos, 2008). For instance, consumers with a more fuel-efficient car may spend the “saved” money on a transatlantic flight, which will require even more fuel.

Lastly, the macroeconomic, or economy-wide, rebound effect occurs when the price of energy services declines, and it reduces the price of other goods or services across the whole economy (Sorrell & Dimitropoulos, 2008). For instance, as a result of significant fuel efficiency measures, there will be changes in the equilibrium between supply and demand for all goods and services in the economy. This can lead to a chain reaction of price and quantity adjustments across the whole economy.

## 2.3 Empirical evidence for rebound effects

Quite a few empirical studies have estimated the rebound effect in different areas of energy use and by researchers from various fields. However, due to the difficulty of observations, almost all studies are partial, meaning that they are usually limited to only one area of energy consumption: for instance, personal transportation, lighting or heating (Berkhout et al., 2000). Furthermore, most studies have focused on direct rebound effects, as indirect and macroeconomic rebound effects are difficult to estimate due to their methodological complexity (Dütschke, Frondel, Schleich & Vance, 2018).

As Dütschke et al. (2018) noted, the direct rebound effect of personal transportation is by far the most studied area, and most studies estimated an increase in the distance traveled after the adoption of fuel-efficient cars. Greening et al. (2000) reported a rise in the distance traveled of 10-30% as a result of improvements in fuel efficiency, based on seven empirical studies on the direct rebound effect of personal transportation in the US market. Frondel, Peters, and Vance (2007) estimated the direct rebound effect for single-car German households to lie in the range of 46-70%. A recent meta-analysis of 74 studies by Dimitropoulos, Oueslati, and Sintek (2018), found that the direct rebound effect of personal transportation is 10-12% in the short run and 26-29% in the long term.

On the contrary, the rebound effect of other household energy efficiency improvements received less attention (Dütschke et al., 2018). The rebound effects in the residential area can be observed in such areas as lighting, space heating, space cooling, water heating, etc. (Azevedo, 2014). In this area, a considerable amount of research has focused on residential space heating. This focus is well-justified by the fact that residential space heating accounts for about 53% of the household's energy consumption (Schwartz & Taylor, 1995, as cited in Greening et al., 2000). For instance, Azevedo (2014) found a direct rebound effect of 2-60% for space heating. Estimates by Sorrell and Dimitropoulos (2008) lay in the range 10-58% in the short run and 1.4-60% in the long run. Haas and Biermayr (2000) investigated the magnitude of the rebound effect for space heating in Austria and found a rebound effect between 20 and 30%.

As for other areas of the residential sector, Azevedo (2014) found a direct rebound effect of 10-40% in water heating. Greening et al. (2000) estimated that the rebound effect of residential lighting is 5-12%. According to Schleich, Mills, and Dütschke (2014), the rebound effect of residential lighting is approximately 6%, the larger part of this rebound effect being from the increase in bulb luminosity and the smaller part being from the increase in burn time.

As seen above, the estimates vary significantly across studies, despite a relatively large number of empirical studies focusing on rebound effects. This suggests their high dependence on the scope of analysis, time period, and region. Moreover, empirical studies have focused on a narrow spectrum of product categories. Hence, further empirical research in different areas of energy consumption is necessary.

## 2.4 Product specification rebound effects

As mentioned previously, there is still ambiguity about how rebound effects should be measured and what dimensions they can occur in. According to Sorrell and Dimitropoulos (2008), efficiency improvements may lead to (1) an increase in the number of energy consuming products, (2) an increase in their size, (3) an increase in their utilization, and (4) a decrease in their load factor. For example, as a result of efficiency improvements, consumers can (1) buy additional cars, (2) buy bigger cars, (3) drive them further and more often, or (4) share them less (Sorrell & Dimitropoulos, 2008). Similarly, we can derive dimensions in which rebound effects can occur for other products.

Despite the growing interest in rebound effects, most empirical studies still focus on an increase in the utilization of energy consuming products: e.g., the distance traveled in case of personal transportation, burn time in case of residential lighting, etc. Very few studies have focused on an increase in the number of energy consuming products, and almost no empirical study has examined an increase in size or load factor. Nonetheless, Greene (2012) noted that rebounds effects in personal transportation might occur as "a shift in sales towards larger or more powerful vehicles," although without empirically confirming this. It is fair to assume the similar may be observed in other areas of energy use.

Olson (2013) suggested calling this phenomenon "product specification rebound effects." Product specification rebound effects occur when consumers feel the efficiency gains allow them to afford larger or more powerful specifications of the product, which will ultimately offset some of the efficiency gains (Olson, 2013). Since this field of research has been getting little attention, there is no clear definition of product specification rebound effects. Therefore, we suggest defining product specification rebound effects as *the extent to which some of the anticipated energy gains from energy efficiency measures are offset due to product specification upgrades*.

In his study on green product preference and choice, Olson (2013) found support for the existence of product specification rebound effects, as green technology buyers showed a stronger preference for higher energy consuming specifications of the products. Although the effects found were rather small, the study laid a good foundation for further research in this, previously neglected area of rebound effects. As Sorrell & Dimitropoulos (2008) noted, due to the limited scope of empirical studies in this field, any increases in vehicle size caused by efficiency improvements, as well as decreases in load factor had been overlooked by policymakers.

Therefore, we would like to focus on this research gap – namely, whether efficiency improvements lead to product specification rebound effects. Maximizing utility lies in human nature, and getting bigger and better products for the same cost is very likely (Varian, 2014). Based on this, our main research question is as following:

*RQ1: Do efficiency improvements lead to product specification rebound effects?*

If efficiency improvements indeed lead to product specification rebound effects, it is also worth to consider the magnitudinal aspect of this relationship. It is of critical importance, not only for researchers but also for policymakers, to know whether there is any relationship between the level of efficiency measures and the level of product specification rebound effects as a result of those measures. Hence, another important question is as following:

*RQ2: How does the magnitude of efficiency improvements affect the magnitude of product specification rebound effects?*

### 2.5 Rebound heterogeneity

Madlener and Turner (2016) noted that there is so-called rebound heterogeneity, meaning that rebound effects vary across different energy-using groups. Indeed, as previously mentioned, empirical studies in different markets or under different socioeconomic conditions found different estimates of the rebound effect for the same products. Therefore, one can talk about the presence of rebound heterogeneity.

Considering that energy efficiency measures are closely related to environmental concerns, it is essential to understand whether green attitude and behavior are reasons behind rebound heterogeneity. Research suggests that consumers with pro-green attitudes show a stronger preference for environmentally friendly products (Haws, Winterich & Naylor, 2014). However, despite the growing concerns for the environment, it has been noted that consumers tend to favor energy-thirstier specifications of energy consuming products (Olson, 2013).

This value–action gap between consumers' strong pro-green attitudes and rare pro-green behaviors, has been recognized as a significant barrier that is restraining environmental measures from achieving intended results (Bamberg, 2003; Olson, 2013). Hence, it is necessary to consider what effect the consumer's green attitude and behavior would have on the magnitude of product specification rebound effects, which leads us to the following questions of interest:

*RQ3: How does the consumer's green attitude affect the magnitude of product specification rebound effects?*

*RQ4: How does the consumer's green behavior affect the magnitude of product specification rebound effects?*

Besides the green attitude and behavior, there are also other factors that may impact the magnitude of rebound effects. Chitnis, Sorrell, Druckman, Firth, and Jackson (2014) and Galvin (2015) considered the impact of socioeconomic characteristics on rebound effects, and paradoxically, both studies found that economically disadvantaged consumer segments tend to show larger rebound effects. The main reasoning for this kind of behavior is that such consumer segments are far from 'satiation' of their energy services needs, and thus, they will choose to consume more in order to improve their quality of life (Sorrell & Dimitropoulos, 2008). Since there is little empirical evidence in this field, we would also like to examine whether this behavior will also be the case for product specification rebound effects:

*RQ5: How do the consumer's financial concerns affect the magnitude of product specification rebound effects?*

Another important aspect worth considering is the relationship between the consumer's knowledge about the technology and product specification rebound effects. Despite the key assumption in economics that agents are fully informed, it is quite the opposite in real life. Whether it is uncertainty about price (Salop & Stiglitz, 1977), or uncertainty about other non-price product attributes (Shapiro, 1982), consumer decisions are hugely affected by imperfect information. Research shows that imperfect information about both price and non-price product attributes can inhibit efficiency in various choice settings (Jessoe & Rapson, 2014). Furthermore, Jessoe and Rapson (2014) found that more informed households tend to be more responsive to price changes. Hence, we would also like to study this in the context of product specification rebound effects:

*RQ6: How does the consumer's knowledge about the technology affect the magnitude of product specification rebound effects?*

# 3. Methodology

## 3.1 Research design

The current study relies on an experimental research design that consists of two experimental conditions. In the experimental conditions, only the level of efficiency improvement varied; all the other variables were held as constant as possible in order to isolate the studied effect. We have chosen a between-subject design since each score needed to be obtained from a different participant. Therefore, participants were randomly assigned to only one of the experimental conditions.

To ensure the internal validity of the study, we have taken measures to control for any confounds that could contaminate the results. Person confounds were controlled by the random assignment of participants to the experimental conditions. Procedural confounds were controlled by keeping situational characteristics across the experimental groups as identical as possible. Measures have also been taken to minimize response bias through the randomization of questions, instruction in the questionnaire, and the use of wording guidelines. Furthermore, pre-testing was performed to check whether the questionnaire works as intended. The questionnaire has been then modified in terms of its understandability, as the pre-test indicated some language barriers occurring due to the majority of the sample being non-native English speakers.

The data was collected via a self-reporting online survey with structured questions, developed in Qualtrics. In order to test for the effects, we used paired-samples t-test, factor, and regression analyses. Other statistical manipulations had also been used to clean, describe, and analyze the collected data. The paired-samples t-test was used to study RQ1 by comparing the effects of the two experimental conditions. The remaining research questions were examined using ordinary least squares linear regressions based on the results of the factor analysis.

## 3.2 Sample

The study randomly assigns the participants to two conditions: a 10% improvement in energy efficiency and 30% improvement in energy efficiency. As a rule of thumb, each group should have at least 30 respondents to provide meaningful and reliable data. Thus, we should aim for at least 60 responses. Since we will perform a factor analysis, we should also take into consideration the minimum sample size for factor analysis. Malhotra (2010) states that the sample size for a factor analysis should be five times the number of items. In our case, it would be a minimum of 70 responses. In total, the study had 122 full responses, which meets both requirements for the minimum sample size.

A non-probability convenience sampling technique was used due to resource constraints. The sample was collected through social media platforms like Facebook and LinkedIn, where the survey was shared with our networks. After the first round of data collection, we still needed more respondents to ensure valid data and generalizable results. Therefore, we chose a snowball sampling technique to reach more respondents. Our closest acquaintances were encouraged to share the survey link to their networks to reach a broader audience and broaden the demographics. As non-probability sampling is a sampling technique where the sample is not entirely random, the study could suffer from external validity as the sample is not representable of the whole population (Malhotra, 2010). To make the results generalizable to the entire population, we posted our survey on several online forums to reach different audiences with differences characteristics.

As most of the respondents were collected through convenience sampling, the majority of the respondents were expected to be students and graduates, considering our networks. Synodinos (1990) found evidence for student sample responses to be highly similar to responses recorded by general public samples, meaning our sample should be generalizable to the whole population. However, we ensured some variety in the demographics by utilizing the snowball sampling technique and sharing the survey on online forums. Moreover, to control for person confounds, we only allowed respondents with Norwegian IP-addresses to take the survey. This ensured that all the participants are homogeneous in terms of geographic location. However, we should note that the Norwegian population is considered to be above the global average in environmental concerns, which might impact the study's external validity (Olson, 2013).

## 3.3 Pre-test

To provide a logical and coherent questionnaire, a pre-test was conducted in the survey development process. The pre-test was conducted on ten respondents *(n=10),* who were acquaintances and willing to submit detailed feedback on the entire questionnaire. Based on the feedback, the energy consumption was converted into energy or fuel costs, as the respondents lacked knowledge about the relation between energy or fuel use and the actual energy or fuel costs. Secondly, some phrases and wordings were replaced as many of our respondents were Norwegians with a limited English vocabulary. Further, some descriptions were added to make the attributes more understandable. Another concern was the length of the questionnaire, as Qualtrics estimated 23 minutes, which could cause fatigue effects. The pre-test respondents spent on average 8 minutes to complete the survey, which was adequate, and this information was included in the introduction of the final survey to give a clear indication of completion time.

After the changes were made, we ran a new test to see whether the changes improved the questionnaire and resolved the errors. The sample size was still ten (*n=10),* and the same procedures as the first pre-test were followed. In the second pre-test, no errors were found, and no significant improvements were needed. We thus concluded that the final questionnaire works as intended. The 20 respondents who took part in the pre-tests were excluded from the main survey since they were already exposed to the content of the survey.

## 3.4 Main study

The final questionnaire consisted of 4 blocks: (1) introduction, (2) product choice sets, (3) questions on consumer attitudes, behaviors and knowledge, and (4) demographic questions (Figure 1).

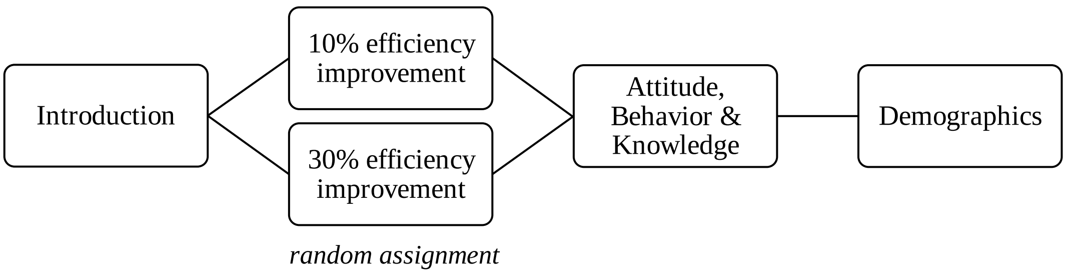


*Figure 1 – Survey Flow*

The introduction indicated the duration of the questionnaire, highlighted the scientific purpose of the study, and included a consent form (Appendix 1 & 2). Since sensitive topics may be confounded by socially desirable responding, we also stressed the anonymity of the study and the importance of honest answers (Mick, 1996).

The second block consisted of four product choice sets and included experimental conditions. The experimental conditions varied by the level of efficiency improvement: a 10% increase in energy efficiency vs. a 30% increase in energy efficiency. The order of product choice sets was randomized to dilute the context effects and minimize response order bias (Rooderkerk, Van Heerde & Bijmolt, 2011).

To represent a broader spectrum of products that may be subject to product specification rebound effects, the product categories of interest were TVs, cars, and refrigerators. Hence, they formed the three out of four product choice sets in the questionnaire. To be able to compare the results with consumer preference shifting on non-energy attributes, we also included a product choice set that did not involve any efficiency improvement – namely, coffee machines. In case of coffee machines, the manipulation was either a 10% or 30% improvement in brewing time.

Each product choice set consisted of six real-life alternatives for which three product attributes were given. For TVs, the product attributes were screen size in inches, energy consumption in kWh per annum, and energy cost in NOK per annum. For cars, the product attributes were horsepower, fuel consumption in liters per 10 kilometers, and fuel cost in NOK per annum. For refrigerators, the product attributes were a size in liters and centimeters, energy consumption in kWh per annum, and energy cost in NOK per annum. For coffee machines, such product attributes were brewing time in seconds, water capacity in liters, and price. Hence, the "non-energy" product choice set did not involve any information about energy consumption. All alternatives for each of the product choice set are based on real-life products to make the survey more realistic.

First, the respondents were asked to imagine they were to buy a product. To control for any externalities, we also asked the respondents to assume that the alternatives they were asked to consider were from their favorite brand(s), favorite type or style, and are all within your their range. After their initial product choice, the respondents were presented with information that there has been a 10% or 30% improvement in the attribute of interest to the study. Based on this new information, they were asked to make a product choice again. Percentage changes in the attribute between the two product choices were later used as dependent variables in our analyses.

The third block consisted of questions on consumer attitudes, behavior, and knowledge that were designed to study RQ3–RQ6. We developed new measures, as well as adapted a scale that had been previously validated – GREEN-scale by Haws, Winterich, and Naylor (2014). We then performed a confirmatory factor analysis on the attitudinal and behavioral items, which grouped the items into three factors based on the “Eigenvalue > 1” criteria. The Bartlett’s test showed that the correlation between the items was high enough for a factor structure (Table 1). According to the KMO test, the global measure of sampling adequacy was higher than the critical value of .500 (Table 1). The individual values on the diagonal of the anti-image correlation matrix were also greater than the critical value, which suggests us that the results of the factor analysis are meaningful (Jannsens, Wijnen, De Pelsmacker & Van Kenhove, 2008).

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | | .835 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 741.137 |
| | df | 91 |
| | Sig. | .000 |

*Table 1 – KMO and Bartlett’s Test*

Hence, consumer attitudes and behaviors were measured using the following four measures (Appendix 3):

(1) Green attitude
(2) Green behavior
(3) Financial concerns

Each item was measured on a 7-point Likert scale, from “Strongly disagree” to “Strongly agree.” The items were randomized in order to avoid response order bias

(Rooderkerk et al., 2011). During the data analysis, we calculated the "summated scales" of the related items for each observation. Hence, every respondent was assigned a value from 1 to 7 on each of the four measures. This made it easier to interpret the results when the measures were used as predictors.

In the last block of the questionnaire, the respondents were asked to answer demographic questions. This block included questions about age, gender, education beyond high school, and income level. The demographic questions were placed at the end of the questionnaire to minimize the dropout rate, as respondents may perceive such questions as sensitive (Malhotra, 2010).

### 3.5 Data cleaning

The survey initially received 201 responses. The data was transferred from Qualtrics to SPSS for statistical analysis as Qualtrics is not suitable for more advanced data analysis. Before we could analyze the results, data cleaning had to be implemented. 71 responses were deleted as they were not complete and thereby considered as not valid. One response was removed for not having a Norwegian IP-address.

Furthermore, all responses were checked manually, as Qualtrics indicated some outliers. Seven responses were deleted as they were considered as "unreasonable." For instance, a 21-year-old respondent wrote he had 45 years of education beyond high school; or there was an11-year-old respondent who earned more than 1 million NOK. After cleaning the dataset, 122 responses were left and considered valid for further analysis, resulting in a survey completion rate of 60.1%. The number of valid responses was in order with our aforementioned sample size calculations.

# 4. Results

## 4.1 Descriptives

After the data cleaning, our sample of 122 respondents was represented by 59.8% *(n = 73)* female and 40.2% *(n = 49)* male, a predominance of females. The sample was within the range of 18–69 years. The mean age of the respondents was 28.68 years *(SD = 10.9)*. Furthermore, the respondents on average have 4.3 years of education beyond high school *(SD = 1.9*). 49.2% of the respondents have an annual income of less than NOK 200,000. These support our expectations having a majority of students and recent graduates in the sample. However, 37.7% of the respondents had an annual income above NOK 400,000, indicating a more representative sample of the population.

The respondents' knowledge about the technologies on the 7-point Likert scale differs across the product categories. Among the respondents, knowledge about TV qualities and technology was the highest *(M = 3.88, SD = 1.76)*. Knowledge about car qualities and technology had a mean of 3.42 *(SD = 1.65),* while knowledge about refrigerator qualities and technology was the lowest *(M = 2.89, SD = 1.59).*

Analyzing the respondents' attitudes and behaviors measured on the 7-point Likert scale, one can note that financial concerns had the highest mean *(M = 4.95, SD = 1.24)* supporting the expectations of a sample that predominantly consists of students and recent graduates. Furthermore, one can see that green attitude *(M = 4.85, SD = 1.06)* had a higher mean than green behavior *(M= 4.52, SD = 1.25)*, indicating a value–action gap that restrains environmental measures from achieving intended results (Bamberg, 2003).

## 4.2 Product specification rebound effects

To compare the effects of the two experimental conditions, we ran a paired-samples t-tests for each of the product choice sets. This statistical analysis has been chosen because each pair of consumer choices essentially measures the same item at two different moments of time – consumer choice before and after the information about an improvement in the manipulated attribute. Manipulated attributes were as following:

| | | |
|---|---|---|
| Manipulation on energy attribute | TVs<br>Cars<br>Refrigerators | energy consumption in kWh / year<br>fuel consumption in l / 10 km<br>energy consumption in kWh / year |
| Manipulation on non-energy attribute | Coffee machines | brewing time in sec |

*Table 2 – Manipulated attributes*

The changes in the size-related attributes have then been studied (Table 3). As seen in the paired samples statistics in Appendix 4, the means of the studied size-related attributes for TVs, cars, and refrigerators tend to increase between the first and second choices – both in case of a 10% and 30% improvements. It suggests that on average the respondents made a product upgrade when presented with more energy efficient specifications of the product.

| | | |
|---|---|---|
| Manipulation on energy attribute | TVs<br>Cars<br>Refrigerators | screen size in inches<br>horsepower in hp<br>size in l |
| Manipulation on non-energy attribute | Coffee machines | water capacity in l |

*Table 3 – Studied attributes*

The paired-samples t-test analysis showed that the mean differences of the studied attributes between Choice 1 and Choice 2 are statistically significant for all the three product categories of interest: TVs – 10% improvement *(.000 < .05)*, TVs – 30% improvement *(.001 < .05)*, Cars – 10% improvement *(.000 < .05)*, Cars – 30% improvement *(.000 < .05)*, Refrigerators – 10% improvement *(.000 < .05)*, and Refrigerators – 30% improvement *(.025 < .05)*. This means that the difference between the means of studied attributes, comparing Choice 1 with Choice 2, is statistically significant across all the three product categories. Furthermore, the mean differences are bigger in case of 30% efficiency improvements for all the three product categories, which suggests us that the level of efficiency improvements has a significant impact on the magnitude of product specification rebound effects (Table 4).

| | Manipulation level | Mean Difference | Std. Deviation | t | Sig. (2-tailed) |
|---|---|---|---|---|---|
| TVs | 30% | 4.07692 | 5.34821 | 6.146 | .000 |
| | 10% | 2.17544 | 4.79629 | 3.424 | .001 |
| Cars | 30% | 36.83077 | 43.39159 | 6.843 | .000 |
| | 10% | 26.84211 | 32.83769 | 6.171 | .000 |
| Refrigerators | 30% | 38.64615 | 57.23429 | 5.444 | .000 |
| | 10% | 8.84211 | 28.91106 | 2.309 | .025 |
| Coffee machines | 30% | -.01538 | .21230 | -.584 | .561 |
| | 10% | .00175 | .10131 | .131 | .896 |

*Studied attributes: TVs – screen size in inches; Cars – horsepower in hp; Refrigerators – size in l; Coffee machines – water capacity in l*

*Table 4 – Paired Differences of Studied Attributes between Choice 1 and Choice 2*

The paired-samples t-test analysis also indicates that the means differences of the studied attributes are not statistically significant *(.561 ≮ .05)* when a non-energy attribute is manipulated. This suggests the preference shifting indeed was caused by the manipulation on energy attributes.

Hence, regarding RQ1 and RQ1, we can conclude:

(RQ1) energy efficiency improvements result in product specification rebound effects that occur in the form of an increased size;

(RQ2) the greater efficiency improvement, the greater product specification rebound effect.

As the next step, we have performed regression analyses on the product categories of interest, where the percentage changes in product size were used as dependent variables. Consumers' green attitudes, green behaviors, financial concerns, and knowledge about the technology, as well as the energy attribute manipulation dummy, were used as predictors. The energy attribute manipulation dummy essentially represents the level of the energy efficiency improvement that had been communicated to respondents, and can only take two values: 0 = a 10% efficiency improvement; 1 = a 30% efficiency improvement.

A regression model for TVs is statistically significant *(.015 < .05)*, meaning that there is a relationship between the DV and at least one of the predictors. As seen in

Table 5, only the financial concerns *(.010 < .05)* and energy attribute manipulation dummy *(.040 < .05)* are statistically significant predictors. More financially concerned consumers tend to have a smaller change in TV screen size when presented with more energy efficient specifications, compared to less financially concerned consumers. We also confirm our previous conclusion that the level of efficiency improvements has a direct positive effect on the magnitude of product specification rebound effects. Moreover, the level of energy efficiency improvements *($\beta$ = .044)* has a bigger absolute impact on the dependent variable than the consumer's financial concerns *($\beta$ = -.024)*.

| | **Unstandardized** | **Coefficients** | | |
|---|---|---|---|---|
| | **B** | **Std. Error** | **t** | **Sig.** |
| (Constant) | .158 | .063 | 2.513 | .013 |
| Green attitude | -.007 | .013 | -.504 | .615 |
| Green behavior | .011 | .011 | 1.045 | .298 |
| Financial concerns | -.024 | .009 | -2.607 | .010 |
| Energy attribute manipulation dummy | .044 | .021 | 2.079 | .040 |
| Knowledge about TV technology | -.004 | .006 | -.665 | .507 |

*Dependent variable: % change in TV screen size*

*Table 5 – Regression model of product specification rebound effects for TVs*

Hence, for TVs, our conclusions regarding the research questions are as following:

(RQ2) the greater efficiency improvement, the greater product specification rebound effect;

(RQ3) consumer's green attitude does not have a statistically significant effect on the magnitude of product specification rebound effects;

(RQ4) consumer's green behavior does not have a statistically significant effect on the magnitude of product specification rebound effects;

(RQ5) the greater consumer's financial concerns, the smaller product specification rebound effect;

(RQ6) consumer's knowledge about the technology does not have a statistically significant effect on the magnitude of product specification rebound effects.

A regression model for Cars is also statistically significant *(.000 < .05)*. As seen in Table 6, following predictors are statistically significant in case of cars: green attitude *(.015 < .05)*, financial concerns *(.005 < .05)*, and energy attribute manipulation dummy *(.010 < .05)*. The level of energy efficiency improvements *($\beta$ = .104)* has the biggest impact on the dependent variable, followed by the consumer's green attitude *($\beta$ = -.062)* and financial concerns *($\beta$ = -.049)*. It is interesting to note that consumers with more pro-green attitudes also tend to have a smaller change in Car horsepower when presented with more energy efficient specifications, compared to consumers with less pro-green attitudes.

| | **Unstandardized** | **Coefficients** | | |
|---|---|---|---|---|
| | **B** | **Std. Error** | **t** | **Sig.** |
| (Constant) | .576 | .109 | 5.263 | .000 |
| Green attitude | -.062 | .025 | -2.463 | .015 |
| Green behavior | .022 | .020 | 1.104 | .272 |
| Financial concerns | -.049 | .017 | -2.869 | .005 |
| Energy attribute manipulation dummy | .104 | .040 | 2.607 | .010 |
| Knowledge about car technology | -.001 | .012 | -.056 | .955 |

*Dependent variable: % change in Car horsepower*

*Table 6 – Regression model of product specification rebound effects for Cars*

Hence, for cars, we can conclude:

(RQ2) the greater efficiency improvement, the greater product specification rebound effect;

(RQ3) the greater consumer's green attitude, the smaller product specification rebound effect;

(RQ4) consumer's green behavior does not have a statistically significant effect on the magnitude of product specification rebound effects;

(RQ5) the greater consumer's financial concerns, the smaller product specification rebound effect;

(RQ6) consumer’s knowledge about the technology does not have a statistically significant effect on the magnitude of product specification rebound effects.

Finally, a regression model for Refrigerators is statistically significant *(.005 < .05)*. The only significant predictor, in this case, was the energy attribute manipulation dummy *(.001 < .05)* (Table 7).

| | **Unstandardized** | **Coefficients** | | |
|---|---|---|---|---|
| | **B** | **Std. Error** | **t** | **Sig.** |
| (Constant) | .050 | .082 | .608 | .544 |
| Green attitude | -.008 | .019 | -.405 | .686 |
| Green behavior | .018 | .015 | 1.201 | .232 |
| Financial concerns | -.016 | .013 | -1.188 | .237 |
| Energy attribute manipulation dummy | .105 | .030 | 3.476 | .001 |
| Knowledge about refrigerator technology | .003 | .009 | .372 | .711 |

*Dependent variable: % change in Refrigerator size*

*Table 7 – Regression model of product specification rebound effects for Refrigerators*

Hence, for refrigerators, we conclude:

(RQ2) the greater efficiency improvement, the greater product specification rebound effect;

(RQ3) consumer’s green attitude does not have a statistically significant effect on the magnitude of product specification rebound effects;

(RQ4) consumer’s green behavior does not have a statistically significant effect on the magnitude of product specification rebound effects;

(RQ5) consumer’s financial concerns do not have a statistically significant effect on the magnitude of product specification rebound effect;

(RQ6) consumer’s knowledge about technology does not have a statistically significant effect on the magnitude of product specification rebound effects.

The only statistically significant predictor across all the three regression models was the energy attribute manipulation dummy. This indicates that the level of efficiency improvements indeed has a direct positive effect on the magnitude of product specification rebound effects, regardless of the product type. But what is more important, this also suggests that product specification rebound effects are present for all types of consumers, irrespective of their attitudes, behaviors, or knowledge.

### 4.3 Post-rebound energy efficiency gains

Having found evidence for the existence of product specification rebound effects, we also calculated how much of the energy efficiency gains are lost due to product specification rebound effects. To do that, we first ran regressions using the log-log model to see the relationship between energy use and product size, based on real-life datasets. Each regression looked as following:

$$\ln(Y) = \beta_0 + \beta_1 * \ln(X) + u,$$

so that $b_1$ is the elasticity of Y with respect to X. This means that a 1% change in X will be associated with a $\beta_1$% change in Y. The dependent variables in each regression were ln(Energy use) for the respective product category, and predictors were: (1) ln(TV screen size), (2) ln(Car horsepower, and (3) ln(Refrigerator size) respectively. The elasticities for each product category are given by unstandardized betas of the predictors (Tables 8, 9 and 10).

| | **Unstandardized** | **Coefficients** | | |
|---|---|---|---|---|
| | **B** | **Std. Error** | **t** | **Sig.** |
| (Constant) | -2.337 | .474 | -4.935 | .000 |
| ln(Screen size in inches) | 1.832 | .118 | 15.458 | .000 |
| *Dependent variable: ln(Energy consumption)* | | | | |

*Table 8 – Regression model of TV energy consumption*

| | **Unstandardized** | **Coefficients** | | |
|---|---|---|---|---|
| | **B** | **Std. Error** | **t** | **Sig.** |
| (Constant) | -2.417 | .406 | -5.950 | .000 |
| ln(Car horsepower) | .370 | .079 | 4.681 | .000 |
| *Dependent variable: ln(Fuel consumption )* | | | | |

*Table 9 – Regression model of Car energy consumption*

| | Unstandardized | Coefficients | | |
|---|---|---|---|---|
| | **B** | **Std. Error** | **t** | **Sig.** |
| (Constant) | 2.025 | .792 | 2.555 | .017 |
| ln(Refrigerator size in l) | .603 | .139 | 4.336 | .000 |
| *Dependent variable: ln(Energy consumption)* | | | | |

*Table 10 – Regression model of Refrigerator energy consumption*

We then calculated the post-rebound efficiency gains for each case using the following formula:

$$\text{Post-rebound efficiency gains} = (\text{Expected efficiency gains}) - (\text{Average percentage change in size}) * \beta_1,$$

where Post-rebound efficiency gains – actual efficiency gains in % after product specification rebound effects; Expected efficiency gains – efficiency improvements manipulated in the questionnaire: 10% or 30%; Average percentage change in size – average change in product size between Choice 1 and Choice 2 in %; and $\beta_1$ – elasticities of energy use with respect to size as given in Tables 8–10.

As seen in Table 11, product specification rebound effects offset the expected efficiency gains for all the three product categories. TVs show the greatest difference between expected and post-rebound efficiency gains. For instance, a 10% efficiency improvement caused a 4.45% increase in TV size, and almost all expected efficiency gains were diluted by product specification rebound effects. The post-rebound efficiency gains are only 1.85%, while one should have been expecting 10%.

| | Expected efficiency gains | Average percentage change in size | Post-rebound efficiency gains |
|---|---|---|---|
| TVs | 30% | 8.61% | 14.23% |
| | 10% | 4.45% | 1.85% |
| Cars | 30% | 27.76% | 19.73% |
| | 10% | 13.97% | 4.83% |
| Refrigerators | 30% | 13.63% | 21.78% |
| | 10% | 2.55% | 8.46% |

*Table 11 – Post-rebound efficiency gains*

Even though cars and refrigerators showed a higher increase in size as a result of efficiency improvements, the post-rebound efficiency gains were not as diluted as in case of TVs. This is due to cars and refrigerators having lower elasticities of energy use with respect to size. Hence, we can conclude that for products with high elasticity of energy use with respect to size, product specification rebound effects may offset most of the anticipated efficiency gains.

Overall, in case of 30% efficiency improvements, 27.4%–52.6% of the expected energy gains were lost due to product specification rebound effects. In case of 10% efficiency improvements, the expected energy gains that were lost varied between 15.4%–81.5%. This suggests that product upgrades are an important dimension in which rebound effects can occur, offsetting a significant share of expected energy efficiency gains. There is a great chance that product specification rebound effects combined with other rebound effects can fully dilute any expected efficiency gains.

# 5. Discussion

## 5.1 Conclusion

The aim of this study was to explore the product specification rebound effects that occur as a product upgrade caused by energy efficiency improvements. Since very limited research has addressed this dimension of rebound effects, our findings greatly contribute to the existing body literature and provide a good foundation for further research in this previously neglected research field.

Our findings show that efficiency improvements indeed lead to product specification rebound effects (RQ1). We found that consumers tend to make a product upgrade when presented with more energy efficient specifications of a product, which offsets some of the anticipated energy gains from energy efficiency measures.

Furthermore, this relationship has been observed in all of the three studied product categories, which suggests that product specification rebound effects can occur in different areas of energy use. Empirical studies have previously neglected other areas of energy use, focusing mostly on personal transportation and other energy-intensive areas such as residential heating. Our findings, however, show that even efficiency improvements of TVs and refrigerators can be diluted due to product specification rebound effects.

The study finds a positive relationship between the magnitude of efficiency improvements and product specification rebound effects (RQ2). For all three categories, the change in preferred size was greater within the 30% energy efficiency improvements than the 10% energy efficiency improvements, confirming that higher efficiency improvements result in higher product specification rebound effects.

Green attitude has been found to have a negative effect on the magnitude of product specification rebound effects in case of cars, while no such relationship has been observed for neither TVs nor refrigerators (RQ3). In our opinion, this might be due to the perceived “greenness” of cars. It is fair to assume that consumers associate cars with a more negative impact on the environment, compared to TVs and refrigerators. Consumers with pro-green attitudes would not necessarily make a product upgrade when presented with more fuel-efficient cars – hence, a negative impact of green attitude on the magnitude of product specification rebound effects. At the same time, such consumers would still make a product upgrade when presented with more energy efficient specifications of the product – if it involves products with lower perceived harm on the environment, such as TVs and refrigerators.

Green behavior has not been found to significantly affect the magnitude of product specification rebound effects in any of the product categories (RQ4). This indicates that product specification rebound effects are present for all types of consumers, regardless of their green behavior. One could expect that product specification rebound effects should be lower or should not occur at all for greener consumers. The reason is that they are more aware of the environmental consequences of increasing energy consumption. However, our findings did not find any evidence supporting this, which indicates the presence of the value–action gap.

Financial concerns negatively affect the magnitude of product specification rebound effects when it comes to TVs and cars, even though it had the least impact in both categories (RQ5). This can be reasoned as the financially concerned consumers would rather save money than upgrade the product attributes. In addition, the negative effect was greater in case of cars than for TVs, as the possible savings from fuel efficiency were considerably greater. For refrigerators, financial concerns did not affect the magnitude of product specification rebound effects.

Consumer knowledge about the technology has not been found to have a statistically significant effect on the magnitude of product specification rebound effects across all the three product categories (RQ6). Hence, we conclude that product specification rebound effects are present for all consumers, regardless of their level of technology knowledge.

Overall, product specification rebound effects have been found to offset the anticipated energy efficiency gains significantly. As our findings show, 15.4%–81.5% of the expected energy efficiency gains were lost due to product specification rebound effects, depending on the product category and the magnitude of efficiency improvements. The anticipated energy efficiency gains would probably be offset even further by other well-known direct rebound effects, such as an increase in the number of energy-consuming products and an increase in their utilization. Hence, this raises a question over the effectiveness of energy efficiency measures as a way to tackle climate change, as there will not be any significant reduction in energy consumption when all rebound effects are taken into consideration.

## 5.2 Limitations and future research

The study has covered a new area in the broad field of rebound effects, examining the product specification rebound effects. Nevertheless, some limitations need to be taken into account when interpreting the results of the study and could be interpreted in future research.

As aforementioned, a significant share of the sample is likely students from Norway, a population which is considered to be above the global average in environmental concerns (Olson, 2013). This can impact the results of the study in green favor and make the results less generalizable or overestimated, compared to the global population. However, our study did not find significant evidence for product specification rebound effects being affected by neither green attitude nor behavior.

Furthermore, as a consequence of the feedback in the first pre-test, the choice options in the final questionnaire contained monetary energy costs in addition to energy consumption. In reality, consumers are not presented with monetary energy costs when making a purchase. Being able to see the direct change in energy costs may have had an impact on consumer preferences, as opposed to being presented the energy consumption only.

Lastly, as to make the study as realistic as possible, real product specifications were collected at electronic retailers and car lists. For instance, 49” and 55” on TV screens, and 230 liters and 275 liters in refrigerators. Hence, a shift in preferences from 49” to 55” (12%) is a lower shift than switching from 230 liters to 275 liters (19%). This issue results in a non-comparable shift in sizes across the product categories in the study. Thus, one cannot draw a conclusion of whether TVs suffer larger product specification rebound effects than, for instance, refrigerators.

In retrospect, comparable sizes should have been prioritized ahead of a questionnaire close to reality. For further research, we recommend slider bars instead of predefined options, enabling each respondent to choose the exact preferred size for each product. Further research could also try to gather more reliable data, using observational methods at car dealers or electronic retailers across different countries to enhance external validity.

## 5.3 Implications

The current study suggests that improvements in energy efficiency can be eroded due to product specification rebound effects. As scientists, governments, and intergovernmental organizations around the world highlight the importance of energy efficiency in tackling climate change, the study has important public policy implications. Despite the empirical evidence for rebound effects, policy makers do not seem to consider them when promoting the environmental benefits of efficiency improvements. It is reasonable to believe that rebound effects at the macro level are likely eliminating all the environmental benefits of efficiency regulations and efficiency-based marketing.

Our study on the product specification rebound effect complements previous research within the field of rebound effects. It is fair likely that previous estimates are underestimated as they only considered an increase in the number of energy-consuming products and an increase in their utilization. This put even more doubt into the effectiveness of the actions towards climate changes. There is a great risk that efficiency measures may be fully diluted by all the rebound effects and therefore, policy makers should not use energy efficiency as the primary way of tackling climate changes.

Our results will also have considerable implications for manufacturers and marketers. The study's findings suggest that more energy efficient technologies will drive consumer preferences towards upgraded product attributes. Therefore, improvements in the energy efficiency of products enable manufacturers to sell upgraded and more profitable specification of the product. Hence, marketers should highlight the environmental benefits and the energy efficiency improvements in their marketing, leading to product upsells. However, this field requires further research, and could be the next field to examine within the broad spectrum of rebound effects.

# 6. References

Azevedo, I. M. (2014). Consumer end-use energy efficiency and rebound effects. *Annual Review of Environment and Resources*, *39,* 393-418.

Bamberg, S. (2003). How does environmental concern influence specific environmentally related behaviors? A new answer to an old question. *Journal of environmental psychology*, *23*(1), 21-32.

BBC News. (2019). *Students walk out in global climate strike*. Retrieved from BBC News: https://www.bbc.com/news/world-48392551. Accessed (27.05.2019).

Berkhout, P. H., Muskens, J. C., & Velthuijsen, J. W. (2000). Defining the rebound effect. *Energy policy*, *28*(6-7), 425-432.

Brookes, L. (1979). A Low Energy Strategy for the UK by G Leach et al: a Review and Reply. *Atom*, *269*, 3-8.

Brookes, L. (1990). The greenhouse effect: the fallacies in the energy efficiency solution. *Energy policy*, *18*(2), 199-201.

Chitnis, M., Sorrell, S., Druckman, A., Firth, S. K., & Jackson, T. (2014). Who rebounds most? Estimating direct and indirect rebound effects for different UK socioeconomic groups. *Ecological Economics*, *106*, 12-32.

De Haan, P., Mueller, M. G., & Peters, A. (2006). Does the hybrid Toyota Prius lead to rebound effects? Analysis of size and number of cars previously owned by Swiss Prius buyers. *Ecological Economics*, *58*(3), 592-605.

Dimitropoulos, A., Oueslati, W., and Sintek, C. (2018). The Rebound Effect in Road Transport: A Meta-Analysis of Empirical Studies. *Energy Economics, 75*(2018), 163–179.

Dütschke, E., Frondel, M., Schleich, J., & Vance, C. (2018). Moral Licensing—Another Source of Rebound? *Frontiers in Energy Research, 6*, 1-10.

European Environmental Bureau. (2018). *Energy efficiency compromise fails Paris Agreement*. Retrieved from European Environmental Bureau: https://eeb.org/energy-efficiency-compromise-fails-paris-agreement/. Accessed (27.05.2019).

Frondel, M., & Vance, C. (2013). Re-identifying the rebound: what about asymmetry?. *The Energy Journal*, 43-54.

Frondel, M., Peters, J., & Vance, C. (2007). Identifying the rebound-Evidence from a German household panel. *Ruhr Economic Paper*, (32).

Galvin, R. (2015). The rebound effect, gender and social justice: A case study in Germany. *Energy Policy*, *86*, 759-769.

Greene, D. L. (1992). Vehicle Use and Fuel Economy: How Big is the" Rebound" Effect?. *The Energy Journal*, 117-143.

Greene, D.L. (2012). Rebound 2007: analysis of U.S. light-duty vehicle travel statistics. *Energy Policy*, *41*, 14–28.

Greening, L. A., Greene, D. L., & Difiglio, C. (2000). Energy efficiency and consumption—the rebound effect—a survey. *Energy policy*, *28*(6-7), 389-401.

Haas, R., & Biermayr, P. (2000). The rebound effect for space heating Empirical evidence from Austria. *Energy policy*, *28*(6-7), 403-410.

Haws, K. L., Winterich, K. P., & Naylor, R. W. (2014). Seeing the world through GREEN-tinted glasses: Green consumption values and responses to environmentally friendly products. *Journal of Consumer Psychology*, *24*(3), 336-354.

Henley, J. (2019). *European elections: triumphant Greens demand more radical climate action*. Retrieved from The Guardian: https://www.theguardian.com/environment/2019/may/28/greens-eu-election-mandate-leverage-climate-policy. Accessed (08.06.2019).

Jannsens, W., Wijnen, K., De Pelsmacker, P., & Van Kenhove, P. (2008). *Marketing research with SPSS.* Pearson/Prentice Hall.

Jessoe, K., & Rapson, D. (2014). Knowledge is (less) power: Experimental evidence from residential energy use. *American Economic Review*, *104*(4), 1417-38.

Jevons, W. S. (1865). The Coal Question; An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of our Coal-Mines. *Fortnightly*, *6*(34), 505-507.

Khazzoom, J. D. (1980). Economic implications of mandated efficiency in standards for household appliances. *The energy journal*, *1*(4), 21-40.

Khazzoom, J. D. (1987). Energy saving resulting from the adoption of more efficient appliances. *The Energy Journal*, *8*(4), 85-89.

Madlener, R., & Turner, K. (2016). After 35 Years of Rebound Research in Economics: Where Do We Stand?. *Rethinking Climate and Energy Policies*, 17-36.

Malhotra, N. K. (2010). Marketing research: An applied orientation (Global edition). Upper Saddle River, NJ: Pearson/Prentice Hall.

Mick, D. G. (1996). Are studies of dark side variables confounded by socially desirable responding? The case of materialism. *Journal of consumer research*, *23*(2), 106-119.

Odyssee-Mure. (2018). *Norway Energy Efficiency Summary*. Retrieved from: http://www.odyssee-mure.eu/publications/efficiency-trends-policies-profiles/norway.html. Accessed (08.06.2019).

Olson, E. L. (2013). It's not easy being green: the effects of attribute tradeoffs on green product preference and choice. *Journal of the Academy of Marketing Science*, *41*(2), 171-184.

Rooderkerk, R. P., Van Heerde, H. J., & Bijmolt, T. H. (2011). Incorporating context effects into a choice model. *Journal of Marketing Research*, *48*(4), 767-780.

Salop, S., & Stiglitz, J. (1977). Bargains and ripoffs: A model of monopolistically competitive price dispersion. *The Review of Economic Studies*, *44*(3), 493-510.

Sandbag & Agora Energiewende. (2018). *The European Power Sector in 2017: State of Affairs and Review of Current Developments*. Retrieved from Sandbag: https://sandbag.org.uk/wp-content/uploads/2018/01/EU-power-sector-report-2017.pdf (Accessed 07.01.2019).

Saunders, H. D. (1992). The Khazzoom-Brookes postulate and neoclassical growth. *The Energy Journal*, 131-148.

Schleich, J., Mills, B., & Dütschke, E. (2014). A brighter future? Quantifying the rebound effect in energy efficient lighting. *Energy Policy*, *72*, 35-42.

Shapiro, C. (1982). Consumer information, product quality, and seller reputation. *The Bell Journal of Economics*, 20-35.

Sorrell, S. (2007). The Rebound Effect: An Assessment of the Evidence for Economy-Wide Energy Savings From Improved Energy Efficiency. London: UK Energy Research Centre.

Sorrell, S., & Dimitropoulos, J. (2008). The rebound effect: Microeconomic definitions, limitations and extensions. *Ecological Economics*, *65*(3), 636-649.

SSB. (2019). *Statistikkbanken Elektrisitet.* Retrieved from: https://www.ssb.no/statbank/table/08311/tableViewLayout1/ (Accessed 08.05.2019).

Synodinos, N. E. (1990). Environmental attitudes and knowledge: A comparison of marketing and business students with other groups. *Journal of Business Research*, *20*(2), 161-170.

UNDP. (2015). *Goal 7: Affordable and clean energy.* Retrieved from UNDP: http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-7-affordable-and-clean-energy.html (Accessed 12.01.2019).

UNFCCC. (2018). *The Paris Agreement.* Retrieved from: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (Accessed 12.05.2019)

Varian, H. R. (2014). *Intermediate microeconomics with calculus: a modern approach*. WW Norton & Company.

Vivanco, D. F., Kemp, R., & van der Voet, E. (2015). The relativity of eco-innovation: environmental rebound effects from past transport innovations in Europe. *Journal of Cleaner Production*, *101*, 71-85.

Vivanco, D. F., McDowall, W., Freire-González, J., Kemp, R., & van der Voet, E. (2016). The foundations of the environmental rebound effect and its contribution towards a general framework. *Ecological Economics*, *125*, 60-69.

# 7. Appendices

## Appendix 1 – Questionnaire with a 10% manipulation

**Welcome to the research study!**

Thank you very much for participating in our study. You will be presented with information related to some products and asked to answer questions about them and yourself. We kindly ask you to answer honestly. Please be assured that the study is completely anonymous.

The study should take you around 5-8 minutes to complete. Your participation in this research is voluntary. You have the right to withdraw at any point during the study, for any reason, and without any prejudice.

By clicking the button below, you acknowledge that your participation in the study is voluntary and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.

Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

○ I consent, begin the study (1)

○ I do not consent, I do not wish to participate (2)

**Q2a**

Imagine you were to buy a new TV. Please assume that the alternatives you are asked to consider are from your favorite brand(s), favorite type or style, and are all within your price range.

Based on the information below, which of the following TVs would you choose? (1 NOK = 0.1 €).

- ◯ Screen size: **32-inch**
  Energy consumption: **54 kWh / year**
  Energy cost: **29.6 NOK / year** (1)
- ◯ Screen size: **49-inch**
  Energy consumption: **176 kWh / year**
  Energy cost: **96.4 NOK / year** (2)
- ◯ Screen size: **55-inch**
  Energy consumption: **215 kWh / year**
  Energy cost: **117.8 NOK / year** (3)
- ◯ Screen size: **65-inch**
  Energy consumption: **298 kWh / year**
  Energy cost: **163.3 NOK / year** (4)
- ◯ Screen size: **75-inch**
  Energy consumption: **395 kWh / year**
  Energy cost: **216.5 NOK / year** (5)
- ◯ Screen size: **82-inch**
  Energy consumption: **412 kWh / year**
  Energy cost: **225.8 NOK / year** (6)

**Q2b**

Now imagine that new TV technology has led to 10% greater energy efficiency and lower electricity consumption. Based on this new information, which of the following energy efficient TVs would you choose? (1 NOK = 0.1 €)

Your previous choice was:

________________________________

- ◯ Screen size: **32-inch**
  Energy consumption: **48.6 kWh / year**
  Energy cost: **26.6 NOK / year** (1)

- ◯ Screen size: **49-inch**
  Energy consumption: **158.5 kWh / year**
  Energy cost: **86.8 NOK / year** (2)

- ◯ Screen size: **55-inch**
  Energy consumption: **193.5 kWh / year**
  Energy cost: **106.0 NOK / year** (3)

- ◯ Screen size: **65-inch**
  Energy consumption: **268.2 kWh / year**
  Energy cost: **147.0 NOK / year** (4)

- ◯ Screen size: **75-inch**
  Energy consumption: **355.5 kWh / year**
  Energy cost: **194.8 NOK / year** (5)

- ◯ Screen size: **82-inch**
  Energy consumption: **370.8 kWh / year**
  Energy cost: **203.2 NOK / year** (6)

**Q3a**

Imagine you were to buy a new coffee machine. Please assume that the alternatives you are asked to consider are from your favorite brand(s), favorite type or style, and are all within your price range.

Based on the information below, which of the following coffee machines would you choose? (1 NOK = 0.1 €).

**Brewing time is the time it takes to make coffee.*

- ◯ Brewing time: **180 sec**
  Water capacity: **0.8 liter**
  Price: **699 NOK** (1)

- ◯ Brewing time: **210 sec**
  Water capacity: **1.2 liter**
  Price: **999 NOK** (2)

- ◯ Brewing time: **120 sec**
  Water capacity: **1.0 liter**
  Price: **1899 NOK** (3)

- ◯ Brewing time: **90 sec**
  Water capacity: **1.5 liter**
  Price: **3799 NOK** (4)

- ◯ Brewing time: **90 sec**
  Water capacity: **1.75 liter**
  Price: **4199 NOK** (5)

- ◯ Brewing time: **60 sec**
  Water capacity: **1.75 liter**
  Price: **5199 NOK** (6)

**Q3b**

Now imagine that new technology has led to 10% faster coffee brewing. Based on this information, which of the following fast brewing coffee machines would you choose? (1 NOK = 0.1 €)

**Brewing time is the time it takes to make coffee.*

Your previous choice was:

___________________________________

- ○ Brewing time: **160 sec**
  Water capacity: **0.8 liter**
  Price: **699 NOK** (1)

- ○ Brewing time: **190 sec**
  Water capacity: **1.2 liter**
  Price: **999 NOK** (2)

- ○ Brewing time: **110 sec**
  Water capacity: **1.0 liter**
  Price: **1899 NOK** (3)

- ○ Brewing time: **80 sec**
  Water capacity: **1.5 liter**
  Price: **3799 NOK** (4)

- ○ Brewing time: **80 sec**
  Water capacity: **1.75 liter**
  Price: **4199 NOK** (5)

- ○ Brewing time: **55 sec**
  Water capacity: **1.75 liter**
  Price: **5199 NOK** (6)

**Q4a**

Imagine you were to buy a new car. Please assume that the alternatives you are asked to consider are from your favorite brand(s), favorite type or style, and are all within your price range.

Based on the information below, which of the following cars would you choose? (1 NOK = 0.1 €).

**Horsepower rates the engine performance of a car.*

- ○ Horsepower: **95**
  Fuel consumption: **0.50 L / 10 km**
  Fuel cost: **12 075 NOK / year** (1)

- ○ Horsepower: **136**
  Fuel consumption: **0.52 L / 10 km**
  Fuel cost: **12 558 NOK / year** (2)

- ○ Horsepower: **177**
  Fuel consumption: **0.64 L / 10 km**
  Fuel cost: **15 456 NOK / year** (3)

- ○ Horsepower: **245**
  Fuel consumption: **0.76 L / 10 km**
  Fuel cost: **18 354 NOK / year** (4)

- ○ Horsepower: **306**
  Fuel consumption: **0.84 L / 10 km**
  Fuel cost: **20 286 NOK / year** (5)

- ○ Horsepower: **385**
  Fuel consumption: **1.13 L / 10 km**
  Fuel cost: **27 290 NOK / year** (6)

**Q4b**

Now imagine that new engine technology has led to a 10% improvement in fuel economy and hence lower fuel usage. Based on this new information, which of the following energy efficient cars would you choose? (1 NOK = 0.1 €)

**Horsepower rates the engine performance of a car.*

Your previous choice was:

________________________________

- ◯ Horsepower: **95**
  Fuel consumption: **0.45 L / 10 km**
  Fuel cost: **10 868 NOK / year** (1)
- ◯ Horsepower: **136**
  Fuel consumption: **0.47 L / 10 km**
  Fuel cost: **11 302 NOK / year** (2)
- ◯ Horsepower: **177**
  Fuel consumption: **0.58 L / 10 km**
  Fuel cost: **13 910 NOK / year** (3)
- ◯ Horsepower: **245**
  Fuel consumption: **0.68 L / 10 km**
  Fuel cost: **16 519 NOK / year** (4)
- ◯ Horsepower: **306**
  Fuel consumption: **0.76 L / 10 km**
  Fuel cost: **18 257 NOK / year** (5)
- ◯ Horsepower: **385**
  Fuel consumption: **1.02 L / 10 km**
  Fuel cost: **24 561 NOK / year** (6)

**Q5a**

Imagine you were to buy a new refrigerator. Please assume that the alternatives you are asked to consider are from your favorite brand(s), favorite type or style, and are all within your price range.

Based on the information below, which of the following refrigerators would you choose? (1 NOK = 0.1 €).

- ◯ Size: **121 cm, 173 liter**
  Energy consumption: **215 kWh / year**
  Energy cost: **117.8 NOK / year** (1)
- ◯ Size: **159 cm, 230 liter**
  Energy consumption: **242 kWh / year**
  Energy cost: **132.6 NOK / year** (2)
- ◯ Size: **177 cm, 275 liter**
  Energy consumption: **299 kWh / year**
  Energy cost: **163.9 NOK / year** (3)
- ◯ Size: **186 cm, 307 liter**
  Energy consumption: **345 kWh / year**
  Energy cost: **189.1 NOK / year** (4)
- ◯ Size: **177 cm, 427 liter** (Side-by-side)
  Energy consumption: **450 kWh / year**
  Energy cost: **246.6 NOK / year** (5)
- ◯ Size: **186 cm, 555 liter** (Side-by-side)
  Energy consumption: **539 kWh / year**
  Energy cost: **295.4 NOK / year** (6)

**Q5b**

Now imagine that new refrigerator technology has led to 10% greater energy efficiency and lower electricity consumption. Based on this new information, which of the following energy efficient refrigerators would you choose? (1 NOK = 0.1 €)

Your previous choice was:

____________________________________

◯ Size: **121 cm, 173 liter**
Energy consumption: **193.5 kWh / year**
Energy cost: **106.0 NOK / year** (1)

◯ Size: **159 cm, 230 liter**
Energy consumption: **217.8 kWh / year**
Energy cost: **119.4 NOK / year** (2)

◯ Size: **177 cm, 275 liter**
Energy consumption: **269.1 kWh / year**
Energy cost: **147.5 NOK / year** (3)

◯ Size: **186 cm, 307 liter**
Energy consumption: **310.5 kWh / year**
Energy cost: **170.2 NOK / year** (4)

◯ Size: **177 cm, 427 liter** (Side-by-side)
Energy consumption: **405 kWh / year**
Energy cost: **221.9 NOK / year** (5)

◯ Size: **186 cm, 555 liter** (Side-by-side)
Energy consumption: **485.1 kWh / year**
Energy cost: **265.8 NOK / year** (6)

**Q6–Q19**

Please indicate your level of agreement or disagreement with each of the statements. There are no right or wrong answers; we are only interested in your viewpoints.

Strongly disagree (1)
Disagree (2)
Somewhat disagree (3)
Neither agree nor disagree (4)
Somewhat agree (5)
Agree (6)
Strongly agree (7)

- It is important to me that the products I use do not harm the environment.
- I consider the potential environmental impact of my actions when making many of my decisions.
- My purchase habits are affected by my concern for our environment.
- I am concerned about wasting the resources of our planet.
- I would describe myself as environmentally responsible.
- I am willing to make some sacrifice in order to take actions that are more environmentally friendly.
- I am willing to pay a higher price for more environmentally friendly products.
- I would likely buy a bigger/faster version of a product when it uses environmentally friendly technology.
- I am concerned about how much money a new product will cost me to operate/use.
- I consider myself careful with how I spend my money.
- I consider myself to be knowledgeable about TV qualities and technology.
- I consider myself to be knowledgeable about car qualities and technology.
- I consider myself to be knowledgeable about refrigerator qualities and technology.
- I consider myself to be knowledgeable about environmental issues.

**Q20** What is your age?

________________________

**Q21** What is your gender?

- ◯ Male (1)
- ◯ Female (2)

**Q22** How many years of education after high school do you have?

________________________

**Q23** What is your annual income before tax in NOK? (1 NOK = 0.1 €)

- ◯ < 200 000 (1)
- ◯ 200 000 – 399 999 (2)
- ◯ 400 000 – 599 999 (3)
- ◯ 600 000 – 799 999 (4)
- ◯ 800 000 – 1 000 000 (5)
- ◯ > 1 000 000 (6)

## Appendix 2 – Questionnaire with a 30% manipulation

**Welcome to the research study!**

Thank you very much for participating in our study. You will be presented with information related to some products and asked to answer questions about them and yourself. We kindly ask you to answer honestly. Please be assured that the study is completely anonymous.

The study should take you around 5-8 minutes to complete. Your participation in this research is voluntary. You have the right to withdraw at any point during the study, for any reason, and without any prejudice.

By clicking the button below, you acknowledge that your participation in the study is voluntary and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.

Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

- ○ I consent, begin the study (1)
- ○ I do not consent, I do not wish to participate (2)

**Q2a**

Imagine you were to buy a new TV. Please assume that the alternatives you are asked to consider are from your favorite brand(s), favorite type or style, and are all within your price range.

Based on the information below, which of the following TVs would you choose? (1 NOK = 0.1 €).

- ◯ Screen size: **32-inch**
  Energy consumption: **54 kWh / year**
  Energy cost: **29.6 NOK / year** (1)
- ◯ Screen size: **49-inch**
  Energy consumption: **176 kWh / year**
  Energy cost: **96.4 NOK / year** (2)
- ◯ Screen size: **55-inch**
  Energy consumption: **215 kWh / year**
  Energy cost: **117.8 NOK / year** (3)
- ◯ Screen size: **65-inch**
  Energy consumption: **298 kWh / year**
  Energy cost: **163.3 NOK / year** (4)
- ◯ Screen size: **75-inch**
  Energy consumption: **395 kWh / year**
  Energy cost: **216.5 NOK / year** (5)
- ◯ Screen size: **82-inch**
  Energy consumption: **412 kWh / year**
  Energy cost: **225.8 NOK / year** (6)

**Q2b**

Now imagine that new TV technology has led to 30% greater energy efficiency and lower electricity consumption. Based on this new information, which of the following energy efficient TVs would you choose? (1 NOK = 0.1 €)

Your previous choice was:

__________________________________

- ○ Screen size: **32-inch**
  Energy consumption: **37.8 kWh / year**
  Energy cost: **20.7 NOK / year** (1)
- ○ Screen size: **49-inch**
  Energy consumption: **123.2 kWh / year**
  Energy cost: **67.5 NOK / year** (2)
- ○ Screen size: **55-inch**
  Energy consumption: **150.5 kWh / year**
  Energy cost: **82.5 NOK / year** (3)
- ○ Screen size: **65-inch**
  Energy consumption: **208.6 kWh / year**
  Energy cost: **114.3 NOK / year** (4)
- ○ Screen size: **75-inch**
  Energy consumption: **276.5 kWh / year**
  Energy cost: **151.5 NOK / year** (5)
- ○ Screen size: **82-inch**
  Energy consumption: **288.4 kWh / year**
  Energy cost: **158.0 NOK / year** (6)

**Q3a**

Imagine you were to buy a new coffee machine. Please assume that the alternatives you are asked to consider are from your favorite brand(s), favorite type or style, and are all within your price range.

Based on the information below, which of the following coffee machines would you choose? (1 NOK = 0.1 €).

**Brewing time is the time it takes to make coffee.*

- ◯ Brewing time: **180 sec**
  Water capacity: **0.8 liter**
  Price: **699 NOK** (1)
- ◯ Brewing time: **210 sec**
  Water capacity: **1.2 liter**
  Price: **999 NOK** (2)
- ◯ Brewing time: **120 sec**
  Water capacity: **1.0 liter**
  Price: **1899 NOK** (3)
- ◯ Brewing time: **90 sec**
  Water capacity: **1.5 liter**
  Price: **3799 NOK** (4)
- ◯ Brewing time: **90 sec**
  Water capacity: **1.75 liter**
  Price: **4199 NOK** (5)
- ◯ Brewing time: **60 sec**
  Water capacity: **1.75 liter**
  Price: **5199 NOK** (6)

**Q3b**

Now imagine that new technology has led to 30% faster coffee brewing. Based on this information, which of the following fast brewing coffee machines would you choose? (1 NOK = 0.1 €)

**Brewing time is the time it takes to make coffee.*

Your previous choice was:

________________________________

- ◯ Brewing time: **125 sec**
  Water capacity: **0.8 liter**
  Price: **699 NOK** (1)
- ◯ Brewing time: **150 sec**
  Water capacity: **1.2 liter**
  Price: **999 NOK** (2)
- ◯ Brewing time: **85 sec**
  Water capacity: **1.0 liter**
  Price: **1899 NOK** (3)
- ◯ Brewing time: **65 sec**
  Water capacity: **1.5 liter**
  Price: **3799 NOK** (4)
- ◯ Brewing time: **65 sec**
  Water capacity: **1.75 liter**
  Price: **4199 NOK** (5)
- ◯ Brewing time: **40 sec**
  Water capacity: **1.75 liter**
  Price: **5199 NOK** (6)

**Q4a**

Imagine you were to buy a new car. Please assume that the alternatives you are asked to consider are from your favorite brand(s), favorite type or style, and are all within your price range.

Based on the information below, which of the following cars would you choose? (1 NOK = 0.1 €).

**Horsepower rates the engine performance of a car.*

- ◯ Horsepower: **95**
  Fuel consumption: **0.50 L / 10 km**
  Fuel cost: **12 075 NOK / year** (1)

- ◯ Horsepower: **136**
  Fuel consumption: **0.52 L / 10 km**
  Fuel cost: **12 558 NOK / year** (2)

- ◯ Horsepower: **177**
  Fuel consumption: **0.64 L / 10 km**
  Fuel cost: **15 456 NOK / year** (3)

- ◯ Horsepower: **245**
  Fuel consumption: **0.76 L / 10 km**
  Fuel cost: **18 354 NOK / year** (4)

- ◯ Horsepower: **306**
  Fuel consumption: **0.84 L / 10 km**
  Fuel cost: **20 286 NOK / year** (5)

- ◯ Horsepower: **385**
  Fuel consumption: **1.13 L / 10 km**
  Fuel cost: **27 290 NOK / year** (6)

**Q4b**

Now imagine that new engine technology has led to a 30% improvement in fuel economy and hence lower fuel usage. Based on this new information, which of the following energy efficient cars would you choose? (1 NOK = 0.1 €)

**Horsepower rates the engine performance of a car.*

**Your previous choice was:**

____________________________________

○ Horsepower: **95**
Fuel consumption: **0.35 L / 10 km**
Fuel cost: **8 453 NOK / year** (1)

○ Horsepower: **136**
Fuel consumption: **0.36 L / 10 km**
Fuel cost: **8 791 NOK / year** (2)

○ Horsepower: **177**
Fuel consumption: **0.45 L / 10 km**
Fuel cost: **10 819 NOK / year** (3)

○ Horsepower: **245**
Fuel consumption: **0.53 L / 10 km**
Fuel cost: **12 848 NOK / year** (4)

○ Horsepower: **306**
Fuel consumption: **0.59 L / 10 km**
Fuel cost: **14 200 NOK / year** (5)

○ Horsepower: **385**
Fuel consumption: **0.79 L / 10 km**
Fuel cost: **19 103 NOK / year** (6)

**Q5a**

Imagine you were to buy a new refrigerator. Please assume that the alternatives you are asked to consider are from your favorite brand(s), favorite type or style, and are all within your price range.

Based on the information below, which of the following refrigerators would you choose? (1 NOK = 0.1 €).

- ◯ Size: **121 cm, 173 liter**
  Energy consumption: **215 kWh / year**
  Energy cost: **117.8 NOK / year** (1)

- ◯ Size: **159 cm, 230 liter**
  Energy consumption: **242 kWh / year**
  Energy cost: **132.6 NOK / year** (2)

- ◯ Size: **177 cm, 275 liter**
  Energy consumption: **299 kWh / year**
  Energy cost: **163.9 NOK / year** (3)

- ◯ Size: **186 cm, 307 liter**
  Energy consumption: **345 kWh / year**
  Energy cost: **189.1 NOK / year** (4)

- ◯ Size: **177 cm, 427 liter** (Side-by-side)
  Energy consumption: **450 kWh / year**
  Energy cost: **246.6 NOK / year** (5)

- ◯ Size: **186 cm, 555 liter** (Side-by-side)
  Energy consumption: **539 kWh / year**
  Energy cost: **295.4 NOK / year** (6)

**Q5b**

Now imagine that new refrigerator technology has led to 30% greater energy efficiency and lower electricity consumption. Based on this new information, which of the following energy efficient refrigerators would you choose? (1 NOK = 0.1 €)

Your previous choice was:

________________________________

- ◯ Size: **121 cm, 173 liter**
  Energy consumption: **150.5 kWh / year**
  Energy cost: **82.5 NOK / year** (1)
- ◯ Size: **159 cm, 230 liter**
  Energy consumption: **169.4 kWh / year**
  Energy cost: **92.8 NOK / year** (2)
- ◯ Size: **177 cm, 275 liter**
  Energy consumption: **209.3kWh / year**
  Energy cost: **114.7 NOK / year** (3)
- ◯ Size: **186 cm, 307 liter**
  Energy consumption: **241.5 kWh / year**
  Energy cost: **132.3 NOK / year** (4)
- ◯ Size: **177 cm, 427 liter** (Side-by-side)
  Energy consumption: **315 kWh / year**
  Energy cost: **172.6 NOK / year** (5)
- ◯ Size: **186 cm, 555 liter** (Side-by-side)
  Energy consumption: **377.3 kWh / year**
  Energy cost: **206.8 NOK / year** (6)

**Q6–Q19**

Please indicate your level of agreement or disagreement with each of the statements. There are no right or wrong answers; we are only interested in your viewpoints.

Strongly disagree (1)
Disagree (2)
Somewhat disagree (3)
Neither agree nor disagree (4)
Somewhat agree (5)
Agree (6)
Strongly agree (7)

- It is important to me that the products I use do not harm the environment.
- I consider the potential environmental impact of my actions when making many of my decisions.
- My purchase habits are affected by my concern for our environment.
- I am concerned about wasting the resources of our planet.
- I would describe myself as environmentally responsible.
- I am willing to make some sacrifice in order to take actions that are more environmentally friendly.
- I am willing to pay a higher price for more environmentally friendly products.
- I would likely buy a bigger/faster version of a product when it uses environmentally friendly technology.
- I am concerned about how much money a new product will cost me to operate/use.
- I consider myself careful with how I spend my money.
- I consider myself to be knowledgeable about TV qualities and technology.
- I consider myself to be knowledgeable about car qualities and technology.
- I consider myself to be knowledgeable about refrigerator qualities and technology.
- I consider myself to be knowledgeable about environmental issues.

**Q20** What is your age?

________________________________

**Q21** What is your gender?

- ○ Male (1)
- ○ Female (2)

**Q22** How many years of education after high school do you have?

________________________________

**Q23** What is your annual income before tax in NOK? (1 NOK = 0.1 €)

- ○ < 200 000 (1)
- ○ 200 000 – 399 999 (2)
- ○ 400 000 – 599 999 (3)
- ○ 600 000 – 799 999 (4)
- ○ 800 000 – 1 000 000 (5)
- ○ > 1 000 000 (6)

## Appendix 3 – Measures and items

### Measure 1: Green attitude

- I am willing to make some sacrifice in order to take actions that are more environmentally friendly
- I consider myself to be knowledgeable about environmental issues
- I would describe myself as environmentally responsible
- It is important to me that the products I use do not harm the environment
- I am willing to pay a higher price for more environmentally friendly products
- I am concerned about wasting the resources of our planet
- I consider the potential environmental impact of my actions when making many of my decisions

### Measure 2: Green behavior

- I would likely buy a bigger/faster version of a product when it uses environmentally friendly technology.
- My purchase habits are affected by my concern for our environment

### Measure 3: Financial concerns

- I am concerned about how much money a new product will cost me to operate/use.
- I consider myself careful with how I spend my money.

## Appendix 4 – Paired Samples Statistics

| | Manipulation level | | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|---|
| TVs | 10% | Choice 1 | 52.0000 | 65 | 10.00312 | 1.24073 |
| | 30% | Choice 2 | 56.0769 | 65 | 10.39126 | 1.28888 |
| | 10% | Choice 1 | 57.8070 | 57 | 12.66384 | 1.67737 |
| | 30% | Choice 2 | 59.9825 | 57 | 12.93596 | 1.71341 |
| Cars | 10% | Choice 1 | 168.6615 | 65 | 58.81653 | 7.29529 |
| | 30% | Choice 2 | 205.4923 | 65 | 74.41000 | 9.22942 |
| | 10% | Choice 1 | 191.0175 | 57 | 72.57840 | 9.61324 |
| | 30% | Choice 2 | 217.8596 | 57 | 87.36938 | 11.57236 |
| Refrigerators | 10% | Choice 1 | 291.2462 | 65 | 72.48169 | 8.99025 |
| | 30% | Choice 2 | 329.8923 | 65 | 93.91105 | 11.64823 |
| | 10% | Choice 1 | 312.9474 | 57 | 94.17621 | 12.47394 |
| | 30% | Choice 2 | 321.7895 | 57 | 102.70741 | 13.60393 |
| Coffee machines | 10% | Choice 1 | 1.1446 | 65 | .32693 | .04055 |
| | 30% | Choice 2 | 1.1292 | 65 | .32726 | .04059 |
| | 10% | Choice 1 | 1.1798 | 57 | .32167 | .04261 |
| | 30% | Choice 2 | 1.1816 | 57 | .31476 | .04169 |

*Studied attributes: TVs – screen size in inches; Cars – horsepower in hp; Refrigerators – size in l; Coffee machines – water capacity in l*