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An empirical test of the role of status-quo bias in energy-related individual choices

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Abstract
The status-quo bias is a behavioral bias that may increase the energy consumption of a household through at least three channels: (1) by making consumers keep their energy-using durables as long as possible, until wearout forces them to replace their equipment (2) by making consumers choose new energy-using durables that resemble the existent ones that need replacement, and (3) by making consumers overuse appliances in an attempt to mentally amortize the initial investment cost. The results presented in this study are a first attempt to empirically investigate whether the presence of bias towards the status quo plays a role in individuals energy-related decision making. Using data from a large household survey conducted in three European countries (Switzerland, the Netherlands and Italy), we find that our measure of status-quo bias is a significant predictor of both the age of home appliances as well as the level of consumption of energy services of a household. The tendency of status-quo biased individuals to keep their current appliances longer and to use their appliances more is also reflected in the total electricity consumption of the households, which is found to be around 5.7% higher than the consumption of households in which the household head is not status-quo biased. The status-quo bias thus has the potential to create a substantial barrier to reaching the energy-efficiency targets of the European Union. These findings prompt policy makers to design policy instruments that take this barrier into account.

Keywords: status-quo bias; loss aversion; appliances replacement; residential energy consumption; energy-related financial literacy
JEL Classification Codes: D12, D91, Q41, Q50

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1. Executive summary

The European Union recently announced to aim for an improvement in energy efficiency of at least 32.5% by 2030. However, the EU is currently not on track to reach such ambitious policy goals. The slow adoption of energy efficient equipment and appliances is often explained with the so called energy efficiency gap. In the context of residential energy use, the energy efficiency gap refers to the observation that individuals fail to make seemingly cost-effective investments in energy efficienct equipment and appliances. The literature identifies several market and behavioral failures that can explain the persistence of the energy efficiency gap. One of these explanations is that individuals are not making these investments as they are biased towards the status quo, i.e. the current situation, whereas an increase in energy-efficiency would require change in the form of purchase of more efficient appliances.

The possible underlying causes for the status-quo bias are manifold and include transition costs, uncertainty in the decision situation, cognitive misperceptions like loss aversion and psychological commitment due to perceived sunk costs or other resource investments. Besides the suspected impact of status-quo bias on the efficiency level of home appliances, it is suggested that perceived sunk costs might make individuals also over-consume energy services, in an attempt to compensate for the initial cost of their energy-consuming durables. The status-quo bias could hence affect residential energy consumption in at least three ways: (1) by making consumers keep their energy-using durables as long as possible, until wearout forces them to replace their equipment (2) by making consumers choose new energy-using durables that resemble the existent ones that need replacement, and (3) by making consumers overuse appliances in an attempt to mentally amortize the initial investment cost.

This study is one of the first to empirically explore the role of the status quo bias for residential energy consumption in European households. It thereby aims to disentangle the status-quo bias from other causes for under-investment in energy-efficient appliances such as bounded rationality and related low energy and financial literacy - or time preferences. Insights from previous studies that tested the influence of risk aversion, loss aversion and time preferences on the adoption of more efficient household appliances suggest that loss aversion can impede investments in more energy-efficient appliances. As loss aversion is assumed to be an underlying cause for the status-quo bias, this study proposes that the status quo bias might explain the age of the appliance stock of a household and, together with the influence of the status-quo bias on the consumption of energy services, the overall level of electricity consumption of a household.

The results presented in this study are based on a large household survey conducted in three European countries: Switzerland, the Netherlands and Italy. As part of the survey, households were asked about the age of their current appliance stock as well as the intensity of usage of some major home appliances. Furthermore, the survey questionnaire included a set of six survey items that capture preferences for the status quo and loss aversion in various contexts, which are used to create an index to measure the status-quo bias of individuals. The study finds a consistent association of this status-quo bias index with the age of the appliance stock in a household as well as with the level of consumption of energy services. If an individual is status-quo biased, the probability that the individual's household owns at least one appliance that is more than 10 years old increases by 3.7 percentage points. This effect is relevant, considering that the share of households owning at least one appliance that is more than 10 years old is around 43% in our sample. Furthermore, our results suggest that the consumption of energy services of a household increases when the household head is strongly status-quo biased. We find that our indicator of bias towards the status quo is associated with about 5.7% higher consumption of energy services. The tendency of status-quo biased individuals to keep their appliances longer and to use their appliances more is also reflected in the total electricity consumption of the households, which is found to be about 5.7% higher than the consumption of households in which the household head is not status-quo biased. The results of the study provide some first evidence that the status-quo bias has the potential to create a substantial barrier to reaching the energy-efficiency targets of the European Union. It seems to influence both the replacement rate of electric appliances and is associated with an intense use of appliances through an increased consumption of energy services. These two behaviors are also reflected in a higher total electricity consumption of status-quo biased households.

One policy implication of this research is that traditional measures to stimulate the uptake of energy-efficient equipment and appliances might not be suited for status-quo biased individuals. On the contrary, given that the status-quo bias expresses a preference to stay with the current situation, rather than a lack-of knowledge or cognitive ability, it is more difficult to address with policy measures than other behavioral biases. It may hence constitute a severe limit to policy-makers' opportunities to narrow the energy efficiency gap. Possible ways to activate status-quo biased individuals to replace their appliance stock might be so-called scrapping incentives for electric appliances, i.e. monetary premiums for replacing old appliance by a newer and more efficient appliance. The over-consumption of energy services due to the status-quo bias, instead, could be tackled with the introduction of a carbon price that increases the price of electricity generated from fossil fuels. Alternatively, it could also be addressed by providing households with social-comparison feedback through apps or in-home displays. The latter could make individuals with a tendency to over-consume energy services aware that their use of appliances exceeds the average use of appliances in comparable households.

Future research should explore the role of the status-quo bias for electricity use induced by the three channels mentioned above (keeping old appliances, replacing appliances by products purchased before, overusing appliances) while controlling for several of the different possible underlying causes of status-quo bias. Also a further validation of the index which is used to measure the status-quo bias is left to future research.

2. Introduction

Europe faces a range of challenges when it comes to the supply of secure, sustainable, competitive, and affordable energy. Most importantly, the threat of global climate change urges to reduce CO_2 and other greenhouse gas emissions from fossil fuel consumption drastically within the next decades, to keep the increase in global average temperature well below $2°C$ above pre-industrial levels. In June 2018, the European Union announced to increase the targets of its Energy Strategy up to 2030, reinforcing its commitment to the Paris Agreement and demonstrating leadership: the latest goals foresee a share of at least 32% of renewable energy consumption by 2030 and an indicative target for an improvement in energy efficiency at EU level of at least 32.5% (compared to projections), which corresponds to the ambition to reduce greenhouse gas emissions by slightly more than 45% compared to 1990 levels (European Commission, 2018). In 2016, the European Commission presented a set of legislative proposals ('Clean Energy for All Europeans') that aimed to make the European Union's energy sector fit to achieve these policy goals (European Commission, 2016). The package provides the legislative framework to stimulate the needed investments to make Europe a global leader in the promotion of renewable energies and in tapping energy efficiency potentials while at the same time making energy affordable for all consumers.

However, actual achievements in increasing energy efficiency fall behind the policy goals. The implementation of the Energy Efficiency Directive is behind schedule and there are doubts whether the 2020 savings target can still be met (Deloitte, 2016). The literature on the energy efficiency gap (Sanstad and Howarth, 1994; Howarth and Sanstad, 1995; Greene, 2011; Allcott and Greenstone, 2012) provides various explanations for under-investment in energy efficiency. When it comes to energy efficiency in residential households, numerous market and behavioral failures can impede energy efficiency investments. One of these explanations is that individuals are not making these investments as they are biased towards the status quo (see e.g. Schleich et al. (2016); Frederiks et al. (2015); Schubert and Stadelmann (2015); Broberg and Kazukauskas (2015)). This means they have the tendency to either maintain their current situation (i.e. keeping their current stock of appliances or current level of home insulation) or to replace their current equipment by products that they have purchased previously, without considering more energy-efficient products. This phenomenon also known as the *status-quo bias* is defined as an individual's tendency to "[do] nothing or [maintain] one's current or previous decision" (Samuelson and Zeckenhauser, 1988, p.7).

According to Samuelson and Zeckenhauser (1988), the potential underlying causes for the status-quo bias are manifold and may include transition costs, uncertainty in the decision situation, cognitive misperceptions like loss aversion and psychological commitment due to perceived sunk costs or other resource investments. Frederiks et al. (2015) suggest that through the channel of perceived sunk cost, status-quo bias could also cause an over-consumption of energy services. The reasoning underlying this suggestion is that once an electric appliance has been purchased, individuals with a strong status-quo bias perceive it as beneficial to use the appliance as much as possible, in order to amortize the initial investment.

The status-quo bias could hence affect residential energy consumption in at least three ways: (1) by making consumers keep their energy-using durables as long as possible, until wearout forces them to replace their equipment (2) by making consumers choose new energy-using durables that resemble the existent ones that need replacement, and (3) by making consumers overuse appliances in an attempt to mentally amortize the initial investment cost. Of course, the first two behaviors could also be driven by other behavioral failures, such as bounded rationality (Simon, 1959; Andor et al., 2017; Houde, 2018) and a related low level of energy and financial literacy (Blasch et al., 2018b; Brent and Ward, 2018; Blasch et al., 2018a) or high subjective discount rates (Hausman, 1979; Train, 1985; Coller and Williams, 1999; Harrison et al., 2002; Epper et al., 2011; Bruderer Enzler et al., 2014; Min et al., 2014). Disentangling the different causes for under-investment in energy-efficient appliances is important because each of these causes has different policy implications.

While the status-quo bias is discussed as a theoretical concept in the literature on the energy efficiency gap (e.g. Schleich et al. (2016); Frederiks et al. (2015); Schubert and Stadelmann (2015); Broberg and Kazukauskas (2015)), we are not aware of a study that explored the role of the status-quo bias for energy efficiency investment decisions and consumption of energy services empirically. With this study we want to contribute to filling this research gap. Our paper is thus the first attempt to empirically capture the link between status-quo bias and both the age of the appliances stock as well as the (over-)consumption of energy services, while controlling for energy-related financial literacy as defined in Blasch et al. (2018a)[1] and a proxy for time preferences.

Although empirical evidence for the role of the status-quo bias for residential energy efficiency has not been provided yet, there are a range of studies that empirically explore the influence of related concepts, such as loss aversion, risk aversion and time discounting, on the choice of energy-efficient appliances and energy-efficient renovations (e.g. Farsi (2010), Qiu et al. (2014), Heutel (2017), Schleich et al. (2018)). These studies provide evidence that loss aversion can impede investments in more energy-efficient appliances and in energy-efficient home renovations. The results presented in this study are based on a large household survey conducted in three European countries: Switzerland, the Netherlands and Italy. As part of the survey, households were asked about the age of their current appliance stock as well as the frequency and intensity of using certain energy services. Furthermore, the survey questionnaire included a set of six survey items that capture preferences for the status quo and loss aversion in various contexts, which is based on the Loss Aversion Questionnaire developed by De Baets and Buelens (2012). From these six items we created an index to measure the strength of the status-quo bias of survey respondents, which were required (by use of a filter question) to be involved in the financial decision-making in their household. The binary indicator we use for analysis shows similar associations with socio-demographic characteristics as measures of loss aversion (Gächter et al., 2010; Tanaka et al., 2010; Hjorth and Fosgerau, 2011).

[1] Blasch et al. (2018a) define energy-related financial literacy as "the combination of energy-related knowledge and cognitive abilities that are needed in order to take decisions with respect to the investment for the production of energy services and their consumption." This concept thus combines both (1) the energy-related knowledge households need in order to take informed energy-related decisions and (2) the set of skills needed to process this information, which is comparable to the set of skills that is needed for financial investment decisions like pension planning.

find that our measure of status-quo bias is a significant predictor of both the age of home appliances as well as the level of consumption of energy services of a household. When an individual is biased towards the status-quo, the probability that the individual's household owns at least one appliance that is more than 10 years old increases by 3.7 percentage points. This result is relevant, considering that the share of households owning at least one appliance that is more than 10 years old is around 43% in our sample. Furthermore, the magnitude of our estimates for the marginal effect of the status-quo bias on the probability to own an old appliance becomes particularly relevant in light of the fact that the majority of households in our sample seem to replace their appliances only when they are defective.

Also the consumption of energy services of a household increases when the household head is strongly status-quo biased. We find that our indicator of bias towards the status quo is associated with about 5.7% higher consumption of energy services. An exception is represented by the number of tumble dryer cycles, whose association with the indicator of status-quo bias is not statistically significant. The tendency of status-quo biased individuals to keep their appliances longer and to use their appliances more is also reflected in the total electricity consumption of the households, which is found to be 5.7% higher than the consumption of households in which the household head is not status-quo biased.

Our results provide some first evidence that the status-quo bias has the potential to create a substantial barrier to reaching the energy-efficiency targets of the European Union. It predicts both the replacement rate of electric appliances and the intensity of appliances utilization. These two behaviors are also reflected in a higher total electricity consumption of status-quo biased households. Future research should explore the role of the status-quo bias for electricity use induced by the three channels mentioned above (keeping old appliances, replacing appliances by products purchased before, overusing appliances) while controlling for the different possible underlying causes of status-quo bias. Also a further validation of the index we used to measure the status-quo bias is left to future research.

The paper is structured as follows: Section 3 provides an overview of the literature on status-quo bias, loss aversion and their relations to investments in energy-efficient appliances as well as consumption of energy services. At the end of the section, a conceptual framework for analysis as well as testable hypotheses are derived. Section 4 explains the data set and our measure of status-quo bias. The results of our analysis are presented in Section 5 and discussed in Section 6. Section 7 concludes.

3. Theoretical background

3.1 Status-quo bias, the endowment effect and loss aversion

The *status-quo bias* was first conceptualized by Samuelson and Zeckenhauser (1988) as "doing nothing or maintaining one's current or previous decision" [p.7]. They provide experimental evidence for the existence of status-quo bias in several decision-making contexts and situations. Besides, Samuelson and Zeckenhauser (1988) discuss four potential causes for the status-quo bias: *(1) Transition costs*, which make the deviation from the status quo costly in itself, *(2)* *Uncertainty* in the decisions situation, which requires costly effort to investigate alternatives and their benefits (search and decision-making cost), *(3) Cognitive misperceptions* like loss aversion (endowment effect), anchoring or bounded rationality, and *(4) Psychological commitment* due to perceived sunk costs or other resource investments or due to regret avoidance. Thaler (1980) considers the latter cause, i.e. perceived sunk cost, itself as an implication of loss aversion according to Prospect Theory Kahneman and Tversky (1979). Samuelson and Zeckenhauser (1988) emphasize that "status-quo bias is not a mistake – like a calculation error or an error in maximizing" (Samuelson and Zeckenhauser, 1988, p.9), but a true behavioral bias that is in line with loss aversion, but not solely triggered by it.

In the literature, the status-quo bias is most often related to the concept of *endowment effect* (Thaler, 1980). Thaler (1980) describes the endowment effect as a decision-making anomaly that can be explained on the basis of loss aversion as established by prospect theory (Kahneman and Tversky, 1979). More specifically, he considers the endowment effect as an "underweighting of opportunity costs" (Thaler, 1980, p.44) as compared to out-of-pocket cost. If the opportunity cost of remaining in the current situation are perceived as foregone gains and the out-of-pocket cost of changing the situation are perceived as a loss, then, according to Thaler (1980), prospect theory's value function implies that the foregone gains (opportunity costs of remaining in the reference situation) will be weighted less than the losses (out-of-pocket costs). In other words, opportunity costs will be considered less strongly than out-of-pocket costs and, as a consequence, goods in the current endowment of the individual are valued more highly than goods that are not part of the individual's current endowment. The endowment effect can explain, for example, the differences in buying and selling prices, i.e. differences in willingness to pay (WTP) and willingness to accept (WTA) in various market situations (Kahneman and Tversky, 1984).

Kahneman et al. (1991) present their view on the interrelation between the endowment effect, loss aversion and the status-quo bias. The cited experiments on the endowment effect show that in many decision situations, individuals do not want to give up their current endowment – or want to stay with their current situation – even if it is not maximizing their utility, which can be explained by loss aversion. Hence, also Kahneman et al. (1991) consider the status-quo bias as an implication of loss aversion, or – in other words – loss aversion to be the underlying cause for the status-quo bias. Loss aversion (in riskless choices) has been conceptualized by Tversky and Kahneman (1991) as an extension of their work on the analysis of choice under uncertainty (Kahneman and Tversky, 1979, 1984), in which they propose that individuals evaluate the outcomes of risky prospects by an asymmetric, S-shaped *value function*, whose curvature is accounting for reference dependence (definition of gains and losses relative to a reference point, i.e. the origin), loss aversion (function that is steeper in the negative than in the positive domain) and diminishing sensitivity (decreasing slope both in the positive and negative domain). In their analysis of loss aversion for riskless choices, Tversky and Kahneman (1991) relate the discussion of loss aversion to the concepts of status-quo bias and endowment effect. They define loss aversion in a riskless situation such that an individual prefers x to y not because they prefer the characteristics of x over the characteristics of y but because of the relative position of the goods to the reference point (or endowment) of the decision-maker. They note, however, that even though the status-quo bias is an implication of loss aversion, there may be other causes for the status-quo bias even in the absence of loss aversion (see also Samuelson and Zeckenhauser (1988)).

3.2 Measures of status-quo bias, the endowment effect and loss aversion

As to our knowledge, there is no validated measure for the presence or intensity of the status-quo bias yet. In the following, we will therefore discuss several measures for the related concepts of loss aversion and endowment effect, which are considered as one of the underlying causes of status-quo bias (Samuelson and Zeckenhauser, 1988; Kahneman et al., 1991). With respect to the measurement of loss aversion, it has to be differentiated between loss aversion in riskless choices and loss aversion in risky choices. To measure loss aversion in riskless choices, Gächter et al. (2010), for example, use an endowment effect experiment. In this experiment, they elicit both individuals' willingness-to-accept (WTA) and their willingness-to-pay (WTP), with the gap between the two being considered as evidence for the presence of an endowment effect. Similarly, in a travel mode choice experiment, also Hjorth and Fosgerau (2011) measure loss aversion indicated by the WTA-WTP gap, yet they measure loss aversion separately in the time dimension and in the money dimension.

When it comes to risky choices, incentivized lotteries are usually used. Schleich et al. (2018) and Heutel (2017) use lottery tasks as proposed in Tanaka et al. (2010). They comprise seven choices between two lotteries with each a 50% chance of gaining money and a 50% chance of losing money, with the gains and losses being relatively larger in the second lottery. The lottery choice tasks used in Gächter et al. (2010), however, comprises six lotteries with a 50% chance of a fixed gain of 6 EUR compared to a 50% chance of a loss varying between -2 to -7 EUR.

Gächter et al. (2010) measure loss aversion in riskless and risky choices at the same time and find that both measures are strongly positively correlated ($\rho = 0.635$). Furthermore, they find that the correlation of socio-demographic variables with the two measures follow similar patterns. According to their findings, older people seem to be more loss averse than younger people. A higher level of education decreases loss aversion, while higher income and higher wealth are associated with an increase in loss aversion. Consistent with Gächter et al. (2010), Hjorth and Fosgerau (2011) find that loss aversion in terms of loss in travel time is stronger than in terms of travel cost, and that it increases with age but decreases with the level of education.

As the inclusion of lottery tasks in household surveys can easily irritate or overwhelm respondents, a survey-based measure of loss aversion has been explored by De Baets and Buelens (2012) who propose a set of 18 items that constitute a Loss Aversion Questionnaire (LAQ). Testing the LAQ with a sample of 479 students in management and economics classes, they observe a high internal consistency of the 18 items (Cronbach's $\alpha = 0.82$). Apart from the LAQ of De Baets and Buelens (2012), no other survey-based measures of loss aversion were found in the literature.

3.3 Status-quo bias, the endowment effect and energy efficiency investments

As has been mentioned before, we are not aware of any empirical study that has tested the effects of status-quo bias on the level of efficiency of electric appliances. However, a range of studies has investigated into the role of loss aversion on the choice of electric appliances. In this literature, loss aversion is frequently elicited jointly with risk and time preferences.

For energy-efficient renovations, Farsi (2010) shows empirically that more risk averse individuals are less likely to invest in an energy-efficient renovation of their homes (insulation and ventilation), due to the uncertainty of the benefits and the irreversibility of the investment. From a choice experiment in Switzerland he derives that risk-averse consumers demand a relatively high risk premium for these investments. For appliances, Qiu et al. (2014) test in a laboratory experiment the influence of risk and time preferences on energy-efficient investments. They use a multiple-price list experiment and self-reported energy-efficiency investments of households. They observe that risk averse individuals are less likely to adopt energy efficient technologies (with the exception of energy efficient air-conditioners). Regarding time preferences, they find that a higher probability of the household to move houses also negatively impacts the likelihood for energy-efficient renovations.

Regarding loss aversion, Greene (2011) analyzes data on the costs of increased fuel economy of new passenger cars to detect the influence of risk and loss aversion on the adoption of efficient cars. He suggests that a so-called uncertainty-loss aversion bias (ULAB) leads to an undervaluation of energy-efficient cars in the market. Heutel (2017) tests whether prospect theory (Kahneman and Tversky, 1979) can explain the energy efficiency gap. Based on survey data from about 2000 US households with (partly) incentivized multiple price lists to elicit risk and time preferences, while accounting for loss aversion, he finds that loss averse individuals are less likely to invest in fuel-efficient cars, energy-efficient light bulbs and energy-efficient ACs. He is able to rule out that these results are driven by time preferences.

Schleich et al. (2018) test the influence of risk and time preferences as well as present bias and loss aversion on energy-efficiency investments of households in eight European countries, also using multiple price list experiments (all implemented in a neutral context, partly incentivized). Their results are based on a survey among 15000 households in eight EU countries. They find that individuals with higher loss aversion were less likely to have adopted LEDs and energy-efficient appliances. However, they do not find an effect of loss aversion on the adoption of energy-efficient renovations.

Thus, there is evidence that loss aversion can negatively affect the level of efficiency of household appliances, and hence total energy consumption of a household.

3.4 Status-quo bias, sunk cost and consumption of energy services

According to Samuelson and Zeckenhauser (1988), also sunk cost are one of the possible underlying causes of the status-quo bias. Sunk cost describe the phenomenon that individuals, once having made an initial investment in a good or service, aim to use the respective good or service as much as possible to "amortize" the initial investment. Arkes and Blumer (1985, p.124) define the sunk-cost fallacy as "a greater tendency to continue an endeavor once an investment in money, effort, or time has been made" and show that such behavior is rooted in the desire not to appear wasteful. Thaler (1980) considers the sunk-cost fallacy as an implication of loss aversion according to prospect theory.

Frederiks et al. (2015) discuss the role of sunk cost for the intensity of use of electrical appliances, i.e. the consumption of energy services. They reason that consumers that are prone to the sunk-cost fallacy, tend to use their appliances more – in order to justify the cost for the initial investment. While an empirical testing of this potential theoretical relation is lacking in the domain of energy, previous research has investigated the role of the sunk-cost fallacy for the use of a home water purification solution in a field experiment in Zambia. They do not find a sunk-cost effect on the use of the water purification solution (Ashraf et al., 2010). This may of course also be due to the fact that there is a natural upper limit to the consumption of drinking water per individual and household. The situation might be different for the use of electric household appliances for which the upper limit to consumption is dependent on individual preferences.

3.5 Conceptual framework and hypotheses

The literature suggest that the status-quo bias may cause both the under-investment in efficient electrical appliances and the over-consumption of energy services (Frederiks et al., 2015). Status-quo bias is explained by various underlying causes, among them the endowment effect and the sunk-cost fallacy (Samuelson and Zeckenhauser, 1988), which both are considered consequences of loss aversion (Thaler, 1980; Kahneman et al., 1991). We therefore derive the following conceptual framework as a basis for the development of our hypotheses (Figure 1).

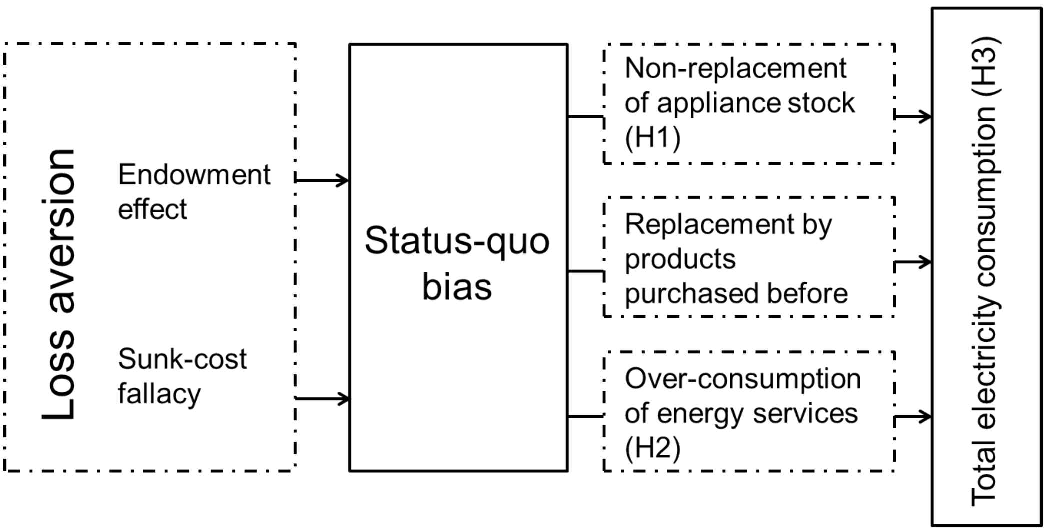


Figure 1: Conceptual framework for our analysis.

As Figure 1 visualizes, the literature suggests, on the one hand, that the aspect of loss aversion that makes individuals value goods that are part of their current endowment more than goods that are not part of their endowment (endowment effect) causes individuals to keep their appliances as long as possible, until wearout forces them to replace them. At the same time, individuals may also be more inclined to purchase appliances they had purchased before if one of their appliance needs replacement (replacement by product purchased before). On the other hand, it is suggested that the aspect of loss aversion that makes individuals use goods or services more often after an initial investment has been made, to mentally amortize this investment (sunk cost fallacy), makes individuals over-consume energy services. Both behaviors can, hence, be explained by the part of status-quo bias that is implied by loss aversion. Further, both keeping appliances longer and using appliances more intensely should be reflected in the total electricity consumption of a household.

In our empirical analysis, we are only able to observe two of the above described three channels through which loss aversion and the resulting status-quo bias can influence the total electricity consumption of a household. Apart from the total electricity consumption we can observe the age of the appliance stock of a household and the consumption of certain energy services. From the conceptual framework laid out above, we therefore derive three hypotheses to be tested in Section 5 of this report.

- H1: Households in which the decision-makers are status-quo biased keep their appliances as long as households in which the decision-makers are not status-quo biased.

- H2: Households in which the decision-makers are status-quo biased consume the same level of energy services as households in which the decision-makers are not status-quo biased.

- H3: Households in which the decision-makers are status-quo biased have the same total electricity consumption as households in which the decision-makers are not status-quo biased.

4. Data and measurement of status-quo bias

In this section we describe the data we use to empirically investigate the theoretical predictions about the role of status-quo bias on energy-related individual choices. We provide descriptive statistics of the variables used as a measure of individuals' economic choices and describe the definition of our measure for status-quo bias.

4.1 The PENNY data

The empirical analysis is based on data coming from a household survey conducted in 2017 in three different countries in Europe (Italy, Netherlands, Switzerland) in the context of the EU H2020 Project PENNY (Psychological social & financial barriers to energy efficiency). The survey was implemented in collaboration with different utilities in the three countries (Italy: ENI, Netherlands: Qurrent, Switzerland: Stadtwerk Winterthur and Aziende Industriali

Lugano).[2] Customers of each electric utility were invited with a letter accompanying the electricity bill to access an online survey. A total of 4,796 households took the survey in the three countries. Details about the recruitment process, implementation of the survey, as well as the representativeness of the sample are reported in Appendix (7).

The data contain detailed information on households' socio-economic characteristics, behavior related to energy consumption and energy-related knowledge. In addition, the survey includes questions that aim at eliciting the respondents' degree of bias towards the status quo.

Table 1: Selected household characteristics by country of residence

	Italy	Netherlands	Switzerland
Respondent characteristic			
Age	53.20	48.86	51.96
Female	0.31	0.38	0.36
Working	0.61	0.71	0.69
Education of respondent			
Lower secondary education and less	0.11	0.06	0.01
Upper secondary/Vocational	0.54	0.24	0.40
Tertiary	0.35	0.70	0.58
Gross monthly household income (in Euro/CHF)			
below 1'500	0.15	0.08	0.01
1'501 to 4'500	**0.51**	**0.48**	0.11
4'501 to 6'000	0.09	0.18	0.12
6'001 to 9'000	0.06	0.15	**0.28**
9'001 to 12'000 CHF	0.02	0.06	0.23
more than 12'000 CHF	0.18	0.05	0.25
Household type			
Couple with/without children	0.76	0.69	0.72
Single with/without children	0.22	0.28	0.23
Non-family household	0.02	0.02	0.04
Residence characteristic			
Single-family house	0.43	0.73	0.50
Apartment in multi-family house	0.56	0.27	0.49
Home ownership status			
Owned	0.85	0.73	0.58

Note: The table reports the average value for some selected socio-economic characteristics used in the empirical analysis, by participants' country of residence.

In Table 1 we report descriptive statistics about selected socio-economic characteristics for the three countries in the PENNY sample. Average age in the sample varies between countries, with Italian respondents being almost five years older, on average, then Dutch respondents. Educational attainments also differ substantially across the countries in our sample, with the share of respondents having a *tertiary degree* ranging from around 35% in Italy to around 70%

[2]Although the same survey has been carried out also in Germany, in collaboration with the local utility of Munster, we decided to exclude these data from our analysis due to the limited sample size available at the time this report has been written.

in the Netherlands.[3]

The median household income in each country is consistent with the national statistics on household income for the three countries as reported by OECD. This ranges from between 1'500 and 4'500 Euros in the Italian and Dutch samples to between 6'000 and 9'000 CHF in the Swiss sample. Couples represent the most common household type in the sample, accounting for around 73 percent of total households.

The share of households in the sample living in single-family houses varies between 44% in the Italian sample and 73% in the Dutch sample.[4] The majority of households in the sample own the dwelling they live in. The home ownership rate ranges from around 58% in Switzerland to around 85% in Italy.[5]

Age of appliances and consumption of energy services As laid out in Section 3, in the context of energy-related decision making, status-quo bias might make individuals keep their current stock of energy-consuming durables longer, with implications in terms of the frequency with which they replace their old appliances. For this reason, in contrast to Schleich et al. (2018), who study possible implications of loss aversion on the level of energy efficiency of newly purchased appliances, we consider the age of the major home appliances as economic outcome. The age of the stock of durables that households use to produce their energy services is an important predictor of the energy-efficiency level of the household, especially in a context with substantial technological progress.

The PENNY data contain information about whether households own the following five major home appliances: fridge, freezer, dishwasher, washing machine and tumble dryer. When the household owns the appliance, the respondent was also asked to provide information about its age.[6] The share of households with a home appliance whose age is lower than 5 years, between 6 and 10 years, and more than 10 years, for each major home appliance and by country of residence, is reported in Table 2. Ownership rates of each appliance are also reported. The share of households that own an appliance that is more than 10 years old ranges between 16 percent (for dishwashers and washing machines) and 26 percent (in the case of freezers). These figures vary significantly among different countries. For instance, while the share of households that own a washing machine older than 10 years is only 14 percent in Italy, this figure is around 23 percent in Switzerland.

As shown in Table 3, 43 percent of households in the sample own at least one appliance that is older than 10 years. This figure ranges from 37 percent in Italy to 52 percent in Switzerland.

[3]While this heterogeneity across countries in tertiary educational attainments reflects heterogeneity in the national statistics, the share of respondents with *tertiary education* is consistently higher in the sample than in the population in each country (see Appendix for details).

[4]These figures are consistent with the corresponding statistics at the national level. In contrast, households living in single-family houses are slightly over-represented in the Swiss sample, with a figure of 51% compared to the 37% in the national statistics.

[5]This heterogeneity reflects differences in the home ownership rates across countries as indicated in the national statistics. However, home-owners are slightly overrepresented in the sample in all three countries.

[6]The question was phrased as follows: "Do you have the following appliances? If yes, how old are they?". Respondents were asked to choose one of the alternative options: "Yes, less than 1 year; Yes, between 2 and 5 years; Yes, between 6 and 10 years; Yes, more than 10 years; Yes, don't know the age; No"

Table 2: Appliances ownership and age

	Italy	Netherlands	Switzerland	Total
Fridge				
Ownership rate	0.99	1.00	1.00	1.00
Age: <= 5	0.50	0.53	0.44	0.50
Age: 6-10	0.30	0.26	0.26	0.27
Age: > 10	0.19	0.17	0.25	0.20
Freezer				
Ownership rate	0.30	0.54	0.64	0.48
Age: <= 5	0.45	0.45	0.35	0.42
Age: 6-10	0.26	0.31	0.32	0.30
Age: > 10	0.26	0.22	0.31	0.26
Dishwasher				
Ownership rate	0.73	0.78	0.90	0.80
Age: <= 5	0.53	0.60	0.47	0.54
Age: 6-10	0.30	0.25	0.28	0.27
Age: > 10	0.17	0.13	0.21	0.16
Washing machine				
Ownership rate	1.00	1.00	0.95	0.99
Age: <= 5	0.60	0.55	0.44	0.54
Age: 6-10	0.26	0.27	0.30	0.27
Age: > 10	0.14	0.16	0.23	0.16
Clothes dryer				
Ownership rate	0.23	0.62	0.71	0.52
Age: <= 5	0.72	0.48	0.43	0.50
Age: 6-10	0.20	0.30	0.30	0.28
Age: > 10	0.07	0.20	0.23	0.19

Note: The table reports home appliances ownership rates and the share of households owning appliances that are less than 5 years old, between 6 and 10 years old, and more than 10 years old. Statistics are reported separately for fridge, freezer, dishwasher, washing machine and clothes dryer and by respondents' country of residence.

Table 3: Presence of old appliances (> 10 years) in the household.

		Italy	Netherlands	Switzerland	Total
At least one appliance > 10 years		0.37	0.43	0.52	0.43
Number of appliances older than 10 years	1	0.20	0.26	0.18	0.20
	2	0.09	0.13	0.14	0.12
	3	0.04	0.04	0.08	0.05
	4	0.01	0.02	0.06	0.02
	5	0.001	0.005	0.02	0.01

Note: The table reports the share of households in the sample that own at least one appliance that is more than 10 years old, by respondents' country of residence.

Table 4: Energy services

	Italy	Netherlands	Switzerland	Total
Average number of cycles				
Dishwasher	4.11	4.49	3.86	4.2
Washing machine	4.21	3.89	3.72	3.96
Clothes dryer	2.88	3.02	1.98	2.64
Total (washing and drying cycles)	12.42	12.62	9.88	11.61

Note: The Table reports the average number of times households in our sample use dishwasher, washing machine and clothes dryer per week, by country of residence.

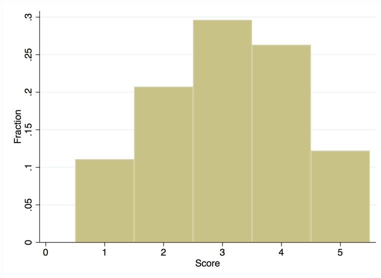
20 percent of the households own at least two appliances older than 10 years, and around 1 percent of the households own all the appliances considered in this study with more than 10 years of age.

As part of our analysis, we are also interested in testing the behavioral hypothesis suggesting that consumers that are prone to status-quo bias will utilize their appliances more often. This is important as the level of utilization is a key determinant of the electricity consumption of appliances as dishwashers, washing machines and clothes dryers. In the PENNY questionnaire, for each of these home appliances, we ask how many times the appliances are used in a typical week.

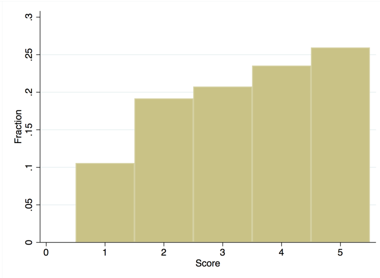
We then exploit unique data on the intensity of home appliances utilization as a measure of energy services. Table 4 provides the average number of times households in our sample use dishwasher, washing machine and clothes dryer per week, by country of residence. Households in our sample use both dishwasher and washing machine around 4 times per week on average, while the clothes dryer is used less often. Swiss households seem to use their home appliances less often than Italian and Dutch households.

4.2 Measure of the status-quo bias

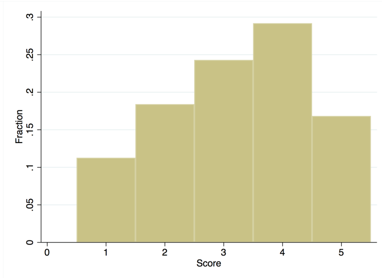
Because we are interested in investigating the role of the status-quo bias in energy-related decision making, we need to elicit a measure of the status-quo bias that is not directly related to energy-related choices. Our measure of the extent with which an individual is prone to the status-quo bias is based on six survey items, taken from the Loss Aversion Questionnaire (LAQ) developed by De Baets and Buelens (2012). From the questionnaire proposed by De Baets and Buelens (2012), which includes a total of 18 items, we selected six items which specifically capture an individual's tendency to stick to the status quo, rather than items that capture loss aversion more broadly. Respondents were asked to indicate to what extent, assigning a value between 1 (*Do not agree*) and 5 (*Completely agree*), they agree with the following statements: (i) I get easily attached to material things (my car, my furniture, etc.); (ii) I would have problems with having to move to a smaller place; (iii) I tend to keep old stuff around; (iv) I feel very bad if I lose something, even when it's not that important; (v) I think I could cope losing all my belonging in a fire; (vi) I would have no problem accepting a job



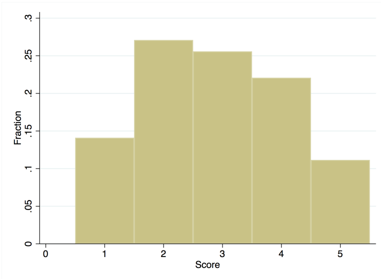
(a) Material loss



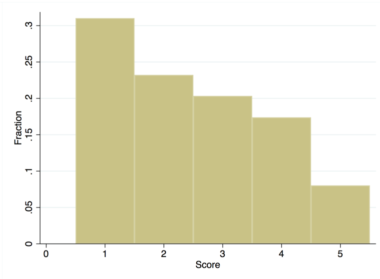
(b) Small place



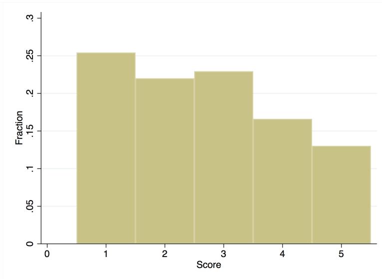
(c) Old stuff



(d) Lose something



(e) Fire loss



(f) Job downgrade

Figure 2: Qualitative measures of status-quo bias

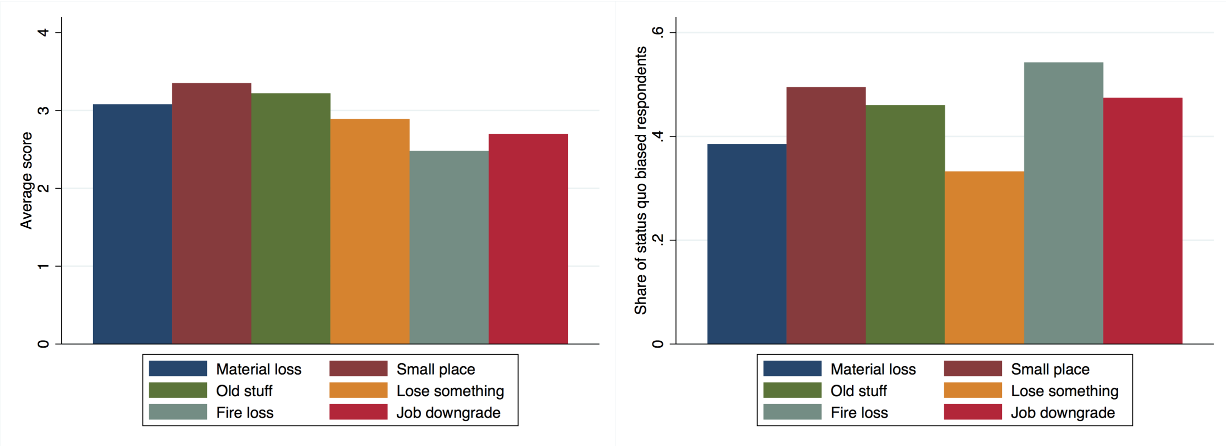
that has less pay than my previous/current one.

Figure 2 reports the distribution of the scores for each status quo survey question in the sample. The average observed scores for each survey item are reported in Figure 3.a. Also, Figure 3.b reports the share of respondents that indicate a degree of agreement equal to 4 (agree) or 5 (fully agree) to survey items (i) to (iv), and that answer 1 (do not agree at all) or 2 (do not agree) to survey items (v) and (vi). Substantial heterogeneity in the degree of bias towards the status quo is revealed across the different contexts considered in the survey. While only 33 percent of respondents say they feel very bad when losing something, around 50 percent of respondents say they would have problems to move to a smaller place, they could not cope with losing their belongings in a fire and would have problems accepting a job that pays less than the current one.

Table 5: Correlation between answers to different status-quo survey items

	Material loss	Small place	Old stuff	Lose something	Fire loss	Job downgrade
Material loss	1.00					
Small place	0.23	1.00				
Old stuff	0.28	0.13	1.00			
Lose something	0.32	0.16	0.38	1.00		
Fire loss	-0.15	-0.12	-0.09	-0.15	1.00	
Job downgrade	-0.16	-0.19	0.02	-0.04	0.23	1.00

Note: The table reports the correlation matrix for the survey items used to elicit bias towards the status quo. The items "Fire loss" and "Job downgrade" are reverse coded.



(a) Average scores for status-quo questions

(b) Share of status-quo biased

Figure 3: Status-quo bias in the PENNY sample

The survey items we consider refer to different contexts with different implications for ones' well-being. Also, as shown in Table 5, the observed scores associated to the different survey items exhibit a certain degree of correlation. For these reasons, to address the question of what is the role of the status-quo bias on energy-related behavior, we decide to aggregate the information in the data to a single indicator of the status-quo bias.

To this end, we start by creating binary indicators for whether a respondent exhibits bias towards the status quo in the contexts considered by each of the survey items (i) to (vi). This allows us to avoid that high scores obtained in certain specific survey items compensate for low scores obtained in other survey items, and vice versa. We define a respondent to exhibit bias towards the status quo in the context considered by one survey item when indicating a degree of agreement equal to 4 (agree) or 5 (fully agree) to survey items (i) to (iv), and a degree of agreement equal to 1 (do not agree at all) or 2 (do not agree) to survey items (v) and (vi).

We then create an index that adds up the number of contexts in which a respondent exhibits bias towards the status quo.[7] This takes values between 0 (the respondent never reports a degree of agreement equal to 4 or 5 to survey items (i) to (iv) nor 1 or 2 to survey items (v) and (vi)) and 6 (the respondent always reports a degree of agreement equal to 4 or 5 to survey items (i) to (iv) and 1 or 2 to survey items (v) and (vi)). Figure 4 reports the distribution of the *status-quo bias index*.

Finally, we construct a *binary indicator for the status-quo bias* that takes value 1 if the status-quo bias index is above or equal to its median value (equal to three). 53% of respondents in our sample are status quo biased according to this definition. In the rest of the paper, we will refer to *status-quo biased* individuals to indicate respondents whose value of the binary indicator for status-quo bias is equal to 1. Using a binary indicator for the status-quo bias instead of the index as a continuous variable in the empirical analysis allows us to exclude results being

[7]The status quo bias index is simply generated adding up the values taken by each binary indicator corresponding to survey items (i) and (vi).

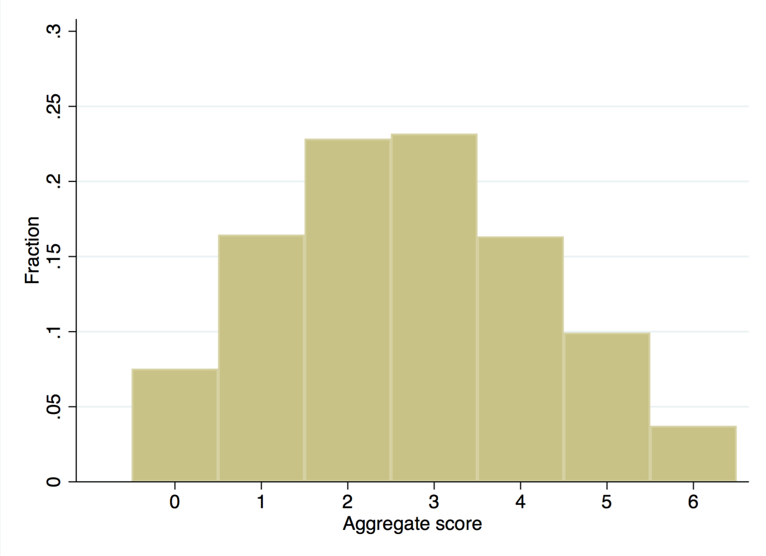


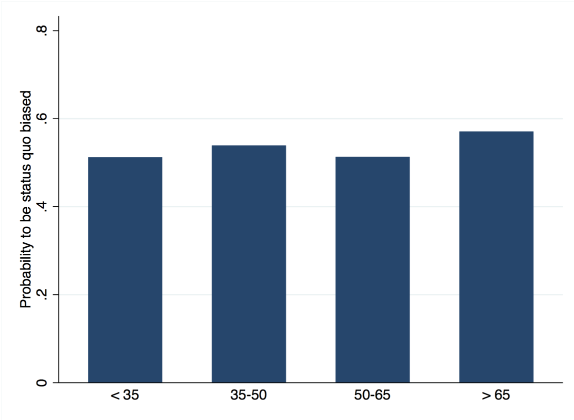
Figure 4: Distribution of the status-quo bias index

driven by the behavior of individuals with extreme values of the index. Furthermore, we do not need to assume linearity in the association between our outcome measures and different levels of the index. Finally, a dichotomous indicator for a high level of bias is consistent with the idea that the status quo bias expresses a relative rather than an absolute measure. This motivates our choice of using the binary indicator that labels respondents as status-quo biased based on whether their value of the status-quo bias index is above the median of its distribution as main measure of status-quo bias in the empirical analysis. However, we also show that our findings are robust to considering definitions of the indicator of status-quo bias that exploit alternative quantiles of the distribution of the status-quo bias index.

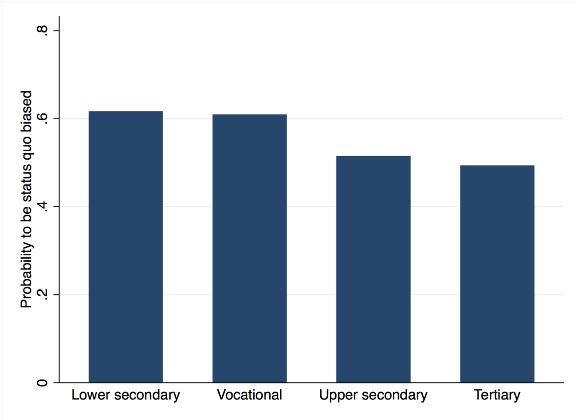
4.3 Validating the measure of status-quo bias

Previous studies have elicited measures of loss aversion using either survey questions (De Baets and Buelens, 2012), lottery instruments (Gächter et al., 2010; Tanaka et al., 2010; Heutel, 2017; Schleich et al., 2018) or (choice) experiments that compare an individual's WTA and WTP (Gächter et al., 2010; Hjorth and Fosgerau, 2011). To validate our measure of status-quo bias, we show that our status-quo bias indicator exhibits associations with individuals' covariates, consistently with what the literature has previously found.

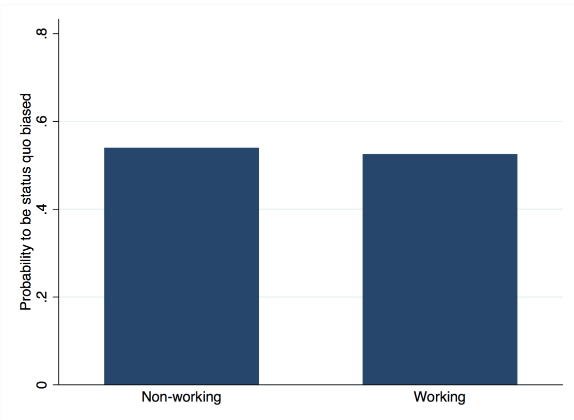
As shown in Figure 5, the share of status-quo biased respondents, according to our measure, increases with age. Also, lower educated individuals tend to exhibit higher degrees of bias towards the status quo (with the share of status-quo biased individuals ranging from above 60 percent among those respondents with lower secondary education or lower to below 50 percent among those respondents with tertiary education). We find a small difference in the status-quo bias of working respondents compared to respondents out of the labor force. Finally, higher degrees of bias towards the status quo are associated with higher income levels, in all the three countries considered. It is worth noticing the large heterogeneity in our measure



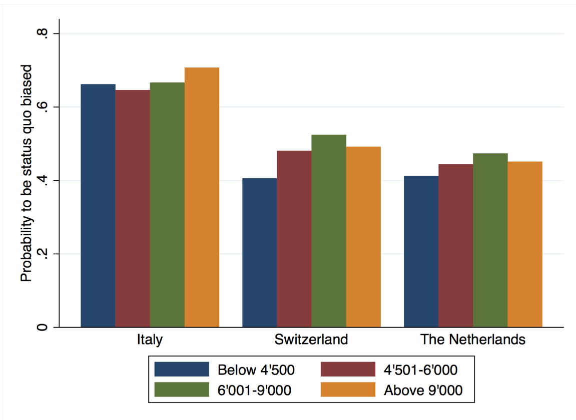
(a) Age



(b) Education



(c) Employment



(d) Income

Figure 5: Share of status-quo biased respondents by individual characteristics

of status-quo bias across countries, with the share of status-quo biased respondents being significantly larger among Italian respondents. The evidence coming from the disaggregation of our measure of status-quo bias by individuals characteristics is consistent with previous findings in the literature (see Gächter et al. (2010); Hjorth and Fosgerau (2011); Tanaka et al. (2010)).

The associations between our measure of status-quo bias and individual characteristics are confirmed by the results of a probit model where the dependent variable is the binary status-quo bias indicator as well as those of an ordered probit model where the dependent variable is the status-quo bias index (see Table 6).

Table 6: Status-quo bias and respondents' characteristics

	(1) Binary indicator *Marginal effects*	(2) Index *Regression coefficients*
Age	-0.0087**	-0.0328**
	(0.0035)	(0.0131)
Age squared	0.000008**	0.00033**
	(0.00004)	(0.00013)
Female	0.0067	0.0063
	(0.0163)	(0.0496)
Vocational education	-0.0660*	-0.137
	(0.0339)	(0.0998)
Upper secondary education	-0.0429	-0.129
	(0.0354)	(0.105)
Tertiary education	-0.0742**	-0.179*
	(0.0323)	(0.0956)
Income: 4501-6000	0.0270	0.0772
	(0.0261)	(0.0811)
Income: 6000-9000	0.0596**	0.171**
	(0.0261)	(0.0803)
Income: Above 9000	0.0460*	0.117
	(0.0248)	(0.074)
Income: Not reported	0.0196	0.089
	(0.0225)	(0.0681)
Household type: Couple	0.0275	0.0835
	(0.0175)	(0.0534)
Non-working	-0.0256	-0.1002
	(0.0205)	(0.0643)
IT	0.2388***	0.833***
	(0.0189)	(0.0604)
CH	0.0406*	0.0919
	(0.0209)	(0.0638)
Constant		3.254***
		(0.3360)
Observations	4390	4390

Note: Column 1 reports the estimated marginal effects from the Probit model for the binary indicator of status quo bias. In column 2 are reported OLS estimates for the status quo bias index. Regressions control also for the household's saving rate.
Standard errors are reported in parentheses in Column (1). Robust standard errors are reported in parentheses in Column (2). */**/*** indicate statistical significance at the 10, 5, and 1 percent level, respectively.

5. Status-quo bias and energy-related economic choices

Our main goal is to investigate whether the presence of bias towards the status quo plays a role for individuals energy-related decision making. First, we wish to study the predictive power of our measure of status-quo bias on the probability for households to own old appliances. Second, we test whether our indicator of status-quo bias is a predictor of the consumption of energy services. Finally, the empirical analysis will investigate whether the theoretical link between the presence of status-quo bias an both the (lack-of) replacement of old appliances and the level of use of home appliances is reflected in a higher household electricity consumption.

The investigation of the link between the presence of status-quo bias and individuals' energy-related choices is performed using econometric methods. In this context, the identification of a causal link between status-quo bias and individuals' energy-related choices requires assuming that the presence of bias towards the status quo does not depend on unobservable factors that influence the energy-related choices that we are considering. We first present the main results focusing on the predictive power of our measure of status quo bias on these choices. Then, in Section 6, we discuss in more detail under which conditions our estimates can be assigned a causal interpretation in light of the theoretical links between the status-quo bias and other individual preferences as well as recent empirical findings in the literature. In the regression analysis we control for the individual characteristics that we found associated with our measure of status-quo bias. In addition, we include a large number of factors that are typically considered as determinants of these energy-related choices.

5.1 Status-quo bias and age of appliance stock

First, we aim to understand whether our indicator of status-quo bias is associated with the age of a household's appliances. In the econometric analysis, we use two outcome variables as a proxy for households owning old appliances: (i) a binary indicator that takes the value 1 if the household owns at least one appliance that is more than 10 years old; (ii) an ordinal indicator that counts the number of appliances that are more than 10 years old. We then estimate a probit model in which the dependent variable is a binary indicator that takes the value 1 if the household owns at least one appliance that is more than 10 years old and an ordered probit model for the number of appliances that are more than 10 years old (see, e.g., Greene 2003 and Wooldridge 2002).

We control for a rich set of individual and household characteristics. This includes individual characteristics that we found to be associated with our measure of status-quo bias and that are potentially correlated with the age of a household's appliances, such as the respondent's education, age and age squared, employment status (working/non-working) and total household income. Then, because we aim at disentangling the role of bias towards the status quo on the (lack-of) replacement of old appliances from other behavioral failures that have been considered as potential causes for under-investment in energy-efficient appliances, we control for the level of energy-related knowledge and skills to perform an investment calculation. In particular, we include the energy-related financial literacy index, as defined by Blasch et al. (2018a). Also, because of the suggested indirect relation between time discounting and loss aversion, we also control for the households' saving rate that, after conditioning on household income, we take as a proxy for time preferences.[8] Finally, we control for the respondents' gender, the number of weeks per year during which the main residence is completely unoccupied, number of days per week in which the residence is typically unoccupied, an indicator for whether the household owns or rents the main residence, dwelling type (multifamily/single family houses), dwelling size and year in which the dwelling was built, an indicator for whether the household moved in the current residence in the last five years, and country dummies.

Table 7: Status-quo bias and ownership of old appliances

	(1) Binary indicator	(2) Number of 10+ old appliances					
		0	1	2	3	4	5
Status-quo bias indicator	0.0372**	-0.0413***	0.0105***	0.0139***	0.0088***	0.0057***	0.0022**
	(0.0157)	(0.0145)	(0.0037)	(0.0049)	(0.0031)	(0.0021)	(0.0009)
Observations	3636	3430					

Note: Dependent variable in Column 1 is a binary indicator for households that own at least one appliance that is more than 10 years old. The estimated marginal effect of the status-quo bias indicator from the Probit model is reported. Dependent variable in column 2 is the number of appliances that are more than 10 years old at home. The marginal effects of the status-quo bias indicator from the ordered probit model are reported. Regression models control for the respondent's gender, age and age squared, education, level of energy-related financial literacy, employment status (working/non-working), household's income and saving rate, the number of weeks per year during which the main residence is completely unoccupied, the number of days per week in which the residence is typically unoccupied, home-ownership, dwelling type, size and age, an indicator for whether the household moved in the current residence in the last five years, and country dummies.
Standard errors in parentheses. */**/*** indicate statistical significance at the 10, 5, and 1 percent level, respectively.

Column (1) of Table 7 shows that the indicator of status-quo bias is positively associated with households having at least one appliance that is more than 10 years old.[9] In particular, when the respondent is biased towards the status quo according to our qualitative indicator, the probability to have at least one appliance that is more than 10 years old increases by 3.7 percentage points. The results of the ordered probit estimation for the number of appliances that are more than 10 years old complement these findings. The marginal effects for order probit regression are reported in Column (2) to (5) of Table 7.[10] In particular, being biased towards the status quo increases the probability to own 1, 2, 3, 4 and 5 appliances that are more than 10 years old of 1, 1.4, 0.9, 0.6 and 0.2 percentage points, respectively. Conversely, being status-quo biased decreases the probability to own only appliances that are less than 10 years old by more than 4 percentage points.

5.2 Status-quo bias and consumption of energy services

To gain insights into whether a bias towards the status quo is also associated with the intensity of utilization of the home appliances, we regress measures of energy services on the indicator of

[8] While Andersen et al. (2008) suggest an interrelation between time discounting and risk aversion, prospect theory proposes a link between risk and loss aversion (Abdellaoui et al., 2007).

[9] The complete estimated coefficients of the Probit model for the presence of at least one appliance that is more than 10 years old are reported in Table 13, Column (1).

[10] The complete estimation results of the Ordered Probit model for the number of appliances that are more than 10 years old are reported in Table 13, Column (2).

status-quo bias and the same set of controls described above. We consider four measures for the consumption of energy services: (i) the log of the annual number of times the household uses the dishwasher; (ii) the log of the annual number of times the household uses the washing machine; (iii) the log of the annual number of times the household uses the tumble dryer; (iv) the log of the sum of annual dishwashing cycles, clothes washing cycles and drying cycles. Estimation results are reported in Columns (1) to (4) of Table 8.[11] We find that our indicator of bias towards the status quo is associated with about 5.7 percent higher consumption of energy services. Households where the head exhibits bias towards the status quo are associated with around 7.6 percent higher intensity of dishwasher utilization and around 4.4 percent higher usage of the washing machine, net to other factors. An exception is represented by the intensity of utilization of the tumble dryer, whose association with the indicator of status-quo bias is not statistically significant.

Table 8: Status-quo bias and consumption of energy services

	(1)	(2)	(3)	(4)	(5)
		Energy services (log nr. cycles)			Electricity consumption
	Dishwasher	Washing machine	Clothes dryer	Total	(log kWh)
Status-quo bias indicator	0.0764**	0.0440**	0.0993	0.0567**	0.0566**
	(0.0350)	(0.0186)	(0.0638)	(0.0225)	(0.0248)
Observations	3258	3727	1905	1765	1993

Note: Dependent variable in Column 1 is the log of the number of times the household uses the dishwasher. Dependent variable in Column 2 is the log of the number of times the household uses the washing machine. Dependent variable in Column 3 is the log of the number of times the household uses the tumble dryer. Dependent variable in Column 4 is the log of the sum of dishwashing cycles, clothes washing cycles and drying cycles. Dependent variable in Column 5 is the log of electricity consumption (in kWh). OLS estimates are reported. Regression models control for the respondent's gender, age and age squared, education, level of energy-related financial literacy, employment status (working/non-working), household's income and saving rate, the number of weeks per year during which the main residence is completely unoccupied, the number of days per week in which the residence is typically unoccupied, home-ownership, dwelling type, size and age, an indicator for whether the household moved in the current residence in the last five years, and country dummies.
Robust standard errors in parentheses. */**/*** indicate statistical significance at the 10, 5, and 1 percent level, respectively.

5.3 Status-quo bias and total electricity consumption

The efficiency level of the energy-consuming durables is an important determinant of residential energy consumption. In a context with substantial technological progress, the lack-of replacement of old appliances might have important consequences on the households' energy consumption, given a certain level of usage. Our findings about the positive association between the indicator of status-quo bias and both the probability for the household to use old appliances to produce energy services as well as the intensity of their usage suggest that a bias towards the status quo might predict higher electricity consumption. We test this hypothesis using a direct measure of electricity consumption provided by the respondents' energy util-

[11] The complete estimation results are reported in Table 13.

ity.[12] We then regress the log of annual electricity consumption (in kWh) on the indicator of status-quo bias and the usual set of controls. Results in Column (5) of Table 8 show that households where the head exhibits bias towards the status quo consume about 5.7 percent more electricity.

5.4 Robustness

We presented evidence on the association between the presence of bias towards the status-quo and individual choices using a binary indicator for whether the respondent's status-quo bias index is above the median value. We conduct a robustness check using indicators for whether the respondent's status-quo bias index falls within the first, second, third or fourth quartile of its distribution. The results reported in Table (9) confirm our main findings about the predictive power of the status-quo bias on energy-related choices.

Table 9: Robustness - different quartiles of the status-quo bias index distribution

	(1) Ownership old appliances Marginal effects	(2) Energy services Log Total	(3) Electricity consumption (log kWh)
Second quartile of status quo bias index	0.0223	0.0882***	0.0516
	(0.0227)	(0.0326)	(0.0353)
Third quartile of status quo bias index	0.0523**	0.0938***	0.0840**
	(0.0226)	(0.0348)	(0.0344)
Fourth quartile of status quo bias index	0.0456**	0.1058***	0.0825**
	(0.0218)	(0.0316)	(0.0333)
Observations	3636	1765	1993

Note: Dependent variable in Column 1 is a binary indicator for households that own at least one appliance that is more than 10 years old. The estimated marginal effect of the status-quo bias indicators from the Probit model is reported. Dependent variable in Column 2 is the log of the sum of dishwashing cycles, clothes washing cycles and drying cycles. Dependent variable in Column 3 is the log of electricity consumption (in kWh). OLS estimates are reported. Regression models control for the respondent's gender, age and age squared, education, level of energy-related financial literacy, employment status (working/non-working), household's income and saving rate, the number of weeks per year during which the main residence is completely unoccupied, the number of days per week in which the residence is typically unoccupied, home-ownership, dwelling type, size and age, an indicator for whether the household moved in the current residence in the last five years, and country dummies.
Standard errors are reported in parentheses in Column (1). Robust standard errors in parentheses in Column (2) and (3).
*/**/*** indicate statistical significance at the 10, 5, and 1 percent level, respectively.

6. Discussion

Our estimates of the increase in the probability to own old appliances associated with the presence of bias towards the status quo are relevant. In fact, considering that the share of households owning at least one appliance that is more than 10 years old is around 43% in our sample, the estimated 3.7 percentage points increase in the probability to own at least one appliance that is more than 10 years old when status-quo biased is substantial. Moreover, our

[12] To reduce the effect of extreme values in the electricity consumption data, we winsorize the distribution of electricity consumption at 5%.

results suggest the status-quo bias assumes larger importance in explaining the presence of more than one old energy-consuming durable. Consider our ordered probit estimates of the increase in the probability to own 1, 2, 3, 4 and 5 appliances that are more than 10 years old (see Table 7). Given the share of households owning such a number of old appliances, as reported in Table 3, these estimates imply that the importance of status-quo bias in explaining the presence of old appliances in households grows with their number in the residence.

In addition, the magnitude of our estimates for the marginal effect of status-quo bias on the probability to own an old appliance becomes particularly relevant in light of the fact that a large share of households seem to replace their appliances only when they are defective.[13]

Our findings about the predictive power of status-quo bias on the probability for households to keep using old appliances to produce energy services is important. In a context with substantial technological progress, the investment in energy-efficient technologies is a major factor determining the increase in energy efficiency that is needed to reach the European energy-efficiency targets.

The interpretation of the association between our measure of status-quo bias and economic choices as causal impacts crucially relies on two assumptions: (i) the presence of bias towards the status quo is a "deep" feature of the individuals' system of preferences that is not correlated with other dimensions that influence the energy-related decision making process (i.e., it is exogenous); (ii) we measure status-quo bias without error. We argue that our measure of status-quo bias can be considered as exogenous, conditional on our large set of control variables, in the context of energy-related decision making. In fact, as discussed in Section 3, we relate our findings to the role played by cognitive misperception (endowment effect) and psychological commitment due to perceived sunk costs. Also, starting from Thaler (1980), the literature relates the endowment effect to loss aversion as conceptualized by prospect theory. Although prospect theory suggests a joint measurement of risk and loss aversion (Abdellaoui et al., 2007) and Andersen et al. (2008) argue for the simultaneous measurement of risk and time preferences, Schleich et al. (2018) provide empirical evidence that omitting one of the three measures (loss aversion, risk aversion or time preference measures) does not lead to an omitted variable bias when considering households decisions with respect to the adoption of energy efficient technologies. While we proxy time preference with the household total saving rate (conditional on household income), we do not control for risk aversion in the main specification because a measure of risk aversion is not available for the majority of individuals in our sample.[14] Hence, a potential threat to identification comes from omitting a measure of risk aversion in our analysis. We follow the indication of Schleich et al. (2018), who conclude that empirical research interested in the impact of risk or loss aversion can focus on one single preference measure individually. However, although we believe that the threats to the validity of the identifying assumptions are not severe in this context, we want to be cautious in interpreting our results as casual effects as we believe that an experimental setting that exploits some exogenous variation in the bias towards the status quo would be better suited to unpack

[13] In the Swiss panel of the PENNY survey, we ask the question about the reason for the replacement of the last major appliance. Around 55% of the households in the Swiss sample replaced the last appliance because it was defective.

[14] A direct, qualitative, measure of risk aversion is available only for Swiss sample.

the causal chain from the presence of status quo bias to economic decision making.

Finally, it can be debated whether the qualitative index that we use to measure the status-quo bias is appropriate. The previous literature only offers measures for loss aversion, either in the form of questionnaire items (De Baets and Buelens, 2012), in the form of incentivized lottery tasks (Gächter and Fehr, 1999; Tanaka et al., 2010; Heutel, 2017; Schleich et al., 2018) or (choice) experiments to elicit an individuals WTA and WTP (Gächter et al., 2010; Hjorth and Fosgerau, 2011). While the measures derived from (incentivized) lottery tasks are preferable from the point of view of incentive-compatibility, they can easily irritate and overwhelm individuals in a regular survey questionnaire, and furthermore require a substantial amount of answering time, which increases the risk of drop-outs. To avoid drop-outs, survey items such as those proposed by De Baets and Buelens (2012), can be a more appropriate way to measure the concept in household surveys. For the same reason, Falk et al. (2016) have also proposed survey items to measure risk, time and social preferences. The fact that the qualitative index that is used in this analysis shows similar associations with socio-demographic characteristics as the incentivized measures of Gächter et al. (2010) and Tanaka et al. (2010) gives support to our approach. A further validation of the six survey items we used is left for future research.

7. Conclusions

Our study presents results from a large household survey among customers of European energy utilities in Italy, Switzerland and the Netherlands. It empirically explores the role of the status-quo bias for the persistence of the energy-efficiency gap in residential households as well as for the over-consumption of energy services. In particular, we analyse the influence of a status-quo bias on the age of the appliance stock of a household and on the consumption of energy services. To measure the status-quo bias, we use six survey items taken from a loss aversion questionnaire proposed by De Baets and Buelens (2012). The index shows similar associations with socio-demographic characteristics as measures of loss aversion (Gächter et al., 2010; Tanaka et al., 2010; Hjorth and Fosgerau, 2011).

Our results suggest that our measure of status-quo bias is an important predictor of both the age of home appliances as well as the level of consumption of energy services of a household. When an individual is status-quo biased the probability that the individual's household owns at least one appliance that is more than 10 years old increases by 3.7 percentage points. Considering that the share of households owning at least one appliance that is more than 10 years old is around 43% in our sample, this result is non-negligible. Furthermore, our estimates imply that the importance of status-quo bias in explaining the presence of old appliances in the household grows with the number of old appliances in the residence. The magnitude of our estimates for the marginal effect of status-quo bias on the probability to own an old appliance becomes particularly relevant in light of the fact that the majority of households in our sample seem to replace their appliances only when they are defective.

Also the consumption of energy services of a household increases when the household head is status-quo biased. Our binary indicator of bias towards the status quo is associated with an about 5.7 percent higher consumption of energy services. The tendency of status-quo biased individuals to own older (less efficient) appliances and to use their appliances more is also reflected in the total electricity consumption of the households, which is found to be around 5.7% higher than the consumption of households in which the household head is not status-quo biased. Our results provide some first evidence that the status-quo bias is an important determinant of the level of energy consumption of European households.

Our results provide novel insights into what drives the energy-efficiency gap and electricity consumption of households and have important policy implications. Given that the status-quo bias expresses a preference to stay with the current situation, rather than a lack-of knowledge or cognitive ability, it is more difficult to address with policy measures than other behavioral biases. It may hence constitute a severe limit to policy-makers' opportunities to narrow the energy efficiency gap.

Yet, one way to overcome individuals' tendency to remain with the status quo could be the introduction of so-called scrapping incentives for electric appliances, i.e. monetary premiums for replacing old appliance by a newer and more efficient appliance. If those scrapping incentives were conditional on handing in the old appliance for recycling it could be avoided that old appliances are kept as a backup instead of being discarded – a problem that has been observed with rebates on energy-efficient appliances. The over-consumption of energy services due to the status-quo bias, instead, could be tackled with the introduction of a carbon price that increases the price of electricity generated from fossil fuels. Alternatively, it could also be addressed by providing households with social-comparison feedback (Allcott, 2011) through apps or in-home displays. The latter could make individuals with a tendency to over-consume energy services aware that their use of appliances exceeds the average use of appliances in comparable households.

Future research should focus on replicating these results adopting alternative measures of the status-quo bias. Furthermore, it would be desirable to further disentangle the different sources of the status-quo bias, to better understand through which channels the status-quo bias works and which aspects of behavior it influences most.

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PENNY data

In this Appendix we provide details about the collection of data. The PENNY survey has been carried out in collaboration with four utilities in three European countries. ENI and Qurrent serve customers everywhere in Italy and the Netherlands, respectively. Stadtwerk Winterthur is a city utility located in the German part of Switzerland and Aziende Industriali di Lugano is a regional utility serving a district in the Italian part of Switzerland.

The recruitment process for the survey targeted customers of the four electric utilities. In Italy, households were selected to be representative of the population of customers of ENI based on the place of residence, contract characteristics, and historical consumption. In the Netherlands, households have been invited to take the survey if they had been customers of Qurrent for at least six months at the time of the recruitment and if a smart meter had been installed in their residences. Finally, target households have been randomly drawn from the population of customers of the local utilites both in Winterthur and in the district of Lugano.[15] In Italy and the Netherlands, the households were contacted via e-mail, while in Switzerland target customers have been invited with a letter accompanying the electricity (or gas) bill. Both the letters and the emails contained a link to access an online questionnaire. Table 10 reports details and statistics about the recruitment process.

In addition, Table 11 provides details about the number of customers contacted in each country, the number of customers that accessed the survey and the number of respondents that finished the questionnaire. Overall 3.22% of the households that received the invitation completed the survey (the country-specific response rates can be found in Table 11).

Table 10: Implementation of the large sample survey in the different countries.

	Switzerland	Netherlands	Italy
No. of households contacted	28,100	19,000	102,000
Means of contact	postal letter	e-mail	e-mail
Recruitment	Random sample of customers of two utilities: 13,100 in Lugano (city and surrounding municipalities) and 15,000 in Winterthur (city)	Participants with a smart meter. Customer for at least 6 months[16]	ENI customers who have provided ENI with an explicit and written consent to be contacted by third parties for research purposes. The customer sample is layered so that it is representative[17] based on the place of residence, contract characteristics, and historical consumption.

[15] In Switzerland, the electricity market is not yet open to competition for residential customers. Thus, the partner utilities in Winterthur and Lugano serve the whole population in the respective service area.

Table 11: Number of respondents in the sample.

	Switzerland	Netherlands	Italy
No. of participants in the sample			
Entered the survey	1,477	2,252	1,508
Completed the survey	1,080	1,923	1,475
Response rate	3.69%	11.85%	1.48%

Table 12: Selected household characteristics in the sample and in the national statistics

	Italy		**Netherlands**		**Switzerland**	
	Sample (%)	Statistic	Sample (%)	Statistic	Sample (%)	Statistic
Residence characteristic						
Single-family house	43.63	47.20	73.32	76.50	50.87	37.00
Apartment in multi-family house	56.37	52.20	26.68	19.90	49.13	60.10
Ownership status						
Owned	84.68	72.90	73.41	67.80	58.11	44.50
Household type						
Couple with/without children	76.33	47.48	69.40	53.19	72.10	56.32
Single with/without children	21.55	35.76	28.49	41.39	23.46	40.87
Non-family household	2.12	16.75	2.11	5.42	4.44	2.05
Gross monthly household income (in Euro/CHF)						
below 1'500	15.12		8.41		0.97	
1'501 to 4'500	**50.93**		**48.16**		10.84	
4'501 to 6'000	8.95		17.92		12.50	
6'001 to 9'000	5.74		14.53		**28.34**	
9'001 to 12'000 CHF	1.75		5.54		22.54	
more than 12'000 CHF	17.51		5.45		24.81	
Household disposable income		4417.95		4614.34		6993.87
Education of respondent						
Lower secondary education and less	11.21	41.60	5.82	27.90	1.92	18.20
Upper secondary/Vocational	54.24	42.70	24.07	41.10	40.06	46.30
Tertiary	34.55	15.70	70.10	31.00	58.01	35.40

Representativeness of the sample cannot be ensured ex-ante due to two reasons: (1) Part of the sample has not been randomly drawn from the target population and (2) a self-selection might occur when invited individuals decide to take the survey. The comparison of some relevant household characteristics in the sample and in the national statistics can be informative about the degree of representativeness of the survey sample. The majority of households in the Dutch sample (around 73%) and in the Swiss sample (51%) live in single-family houses, while 56% of the Italian households in the sample live in multi-family houses. The majority of the households in the sample also own the dwelling they live in. Compared to the national statistics, home-owners are slightly overrepresented in the sample in all three countries. The

[16] The research team in the Netherlands tried to go for 12 months (instead of 6 month), but then there would not be enough customers.

[17] Representative on the customer level of ENI.

median gross monthly household income in the sample varies substantially across countries: In the Italian and the Dutch sample this figure ranges between 1,500 and 4,500 Euros, in the Swiss sample it ranges between 6,000 and 9,000 CHF. This is consistent with the median household income for the three countries as reported by OECD statistics. Further, educational attainments in the sample differ largely across the countries, with the share of respondents with tertiary education ranging from around 35% in Italy to around 70% in the Netherlands.

Estimation results

Table 13: Estimation results

	(1)	(2)	(3)	(4)
	Old appliances			
	Binary indicator	Number of old appliances	Log energy services	Log electricity consumption
Status quo bias indicator	0.107**	0.120***	0.0567**	0.0567**
	(0.0453)	(0.0423)	(0.0225)	(0.0248)
Energy-related financial literacy	0.0258*	0.00931	-0.00340	-0.0176**
	(0.0152)	(0.0143)	(0.00798)	(0.00830)
Age	0.0460***	0.0472***	-0.00144	0.0116*
	(0.0125)	(0.0120)	(0.00710)	(0.00656)
Age squared	-0.000359***	-0.000379***	-0.0000189	-0.0000950
	(0.000121)	(0.000115)	(0.0000694)	(0.0000634)
Female	0.149***	0.0992**	-0.00904	-0.0768***
	(0.0512)	(0.0477)	(0.0314)	(0.0277)
Education: vocational	-0.259**	-0.194**	-0.0615	-0.110**
	(0.103)	(0.0971)	(0.0635)	(0.0509)
Education: upper secondary	-0.363***	-0.254**	-0.0135	-0.00952
	(0.110)	(0.1022)	(0.0633)	(0.0567)
Education: tertiary	-0.234**	-0.157*	-0.0538	-0.0856*
	(0.101)	(0.0947)	(0.0627)	(0.0511)
Household size: 2	-0.0782	-0.134	0.420***	0.161***
	(0.0888)	(0.0834)	(0.0645)	(0.0509)
Household size: 3	-0.154	-0.215**	0.676***	0.328***
	(0.0972)	(0.0919)	(0.0676)	(0.0554)
Household size: 4	-0.156	-0.183*	0.781***	0.393***
	(0.1057)	(0.0989)	(0.0729)	(0.0589)
Household size: 5	-0.0958	-0.230**	0.915***	0.387***
	(0.1242)	(0.1160)	(0.0751)	(0.0713)
Household type: couple	-0.0893	-0.0792	0.151***	0.0756*
	(0.0752)	(0.0709)	(0.0412)	(0.0433)
Non-working	0.000554	-0.000846	-0.0128	-0.0155
	(0.0624)	(0.0579)	(0.0335)	(0.0348)
Income: 4501-6000	-0.0504	-0.0555	0.0432	-0.00512
	(0.0777)	(0.0731)	(0.0345)	(0.0516)
Income: 6001-9000	-0.0415	0.0109	0.0282	0.111**
	(0.0792)	(0.0734)	(0.0356)	(0.0447)
Income: Above 9000	-0.120	-0.0760	0.0889**	0.103**
	(0.0748)	(0.0695)	(0.0373)	(0.0420)
Income: not reported	-0.103	-0.0474	0.0621	0.128***
	(0.0685)	(0.0646)	(0.0389)	(0.0382)
Saving rate: 0 percent	0.141*	0.118	0.0991**	0.168***
	(0.0795)	(0.0746)	(0.0434)	(0.0433)
Saving rate: 1-5 percent	-0.0363	-0.0184	0.108***	0.0657
	(0.0726)	(0.0677)	(0.0381)	(0.0409)
Saving rate: 6-20 percent	0.0157	0.0307	0.0620*	-0.0314
	(0.0702)	(0.0652)	(0.0347)	(0.0403)
Saving rate: above 20 percent	0.0807	0.0591	-0.0148	-0.0716
	(0.0857)	(0.0794)	(0.0431)	(0.0482)
Tenant	-0.00128	-0.0523	-0.0447	-0.131***
	(0.0641)	(0.0611)	(0.0444)	(0.0322)
Dwelling size (log)	0.133**	0.181***	0.116***	0.300***
	(0.0613)	(0.0573)	(0.0325)	(0.0375)
Weeks off: 2	0.178***	0.203***	-0.0908***	-0.0624**
	(0.0526)	(0.0494)	(0.0299)	(0.0292)
Weeks off: 3	0.231**	0.212**	-0.163***	-0.123**
	(0.101)	(0.0940)	(0.0550)	(0.0577)
Weeks off: 4	0.150	0.148	-0.119**	-0.172***
	(0.106)	(0.1000)	(0.0530)	(0.0603)
Days off: 2	-0.0909	-0.0715	-0.0247	-0.130***
	(0.0674)	(0.0638)	(0.0385)	(0.0390)
Days off: 3	0.0662	0.0721	-0.0352	-0.0679
	(0.112)	(0.1064)	(0.0500)	(0.0688)
Multi-family house	-0.0702	-0.0616	0.0451	-0.230***
	(0.0699)	(0.0662)	(0.0481)	(0.0394)
Moved in recently	-0.758***	-0.703***	-0.0466	-0.118***
	(0.0589)	(0.0570)	(0.0284)	(0.0307)
Period dwelling built: 1970-2000	0.126*	0.0826	0.0242	-0.0473
	(0.0719)	(0.0664)	(0.0342)	(0.0426)
Period dwelling built: before 1970	-0.0113	-0.0914	0.0148	-0.0730**
	(0.0634)	(0.0601)	(0.0320)	(0.0370)
IT	-0.261***	-0.227***	-0.144***	-0.0805**
	(0.0680)	(0.0642)	(0.0369)	(0.0402)
CH	0.207***	0.333***	-0.325***	0.330***
	(0.0685)	(0.0627)	(0.0358)	(0.0396)
Constant	-1.785***		5.299***	6.030***
	(0.440)		(0.231)	(0.240)
Observations	3636	3430	1765	1993

Note: Dependent variable in Column 1 is a binary indicator for households that own at least one appliance that is more than 10 years old. The estimated Probit coefficients are reported. Dependent variable in column 2 is the number of appliances that are more than 10 years old at home. The coefficients estimated using an Ordered Probit model are reported. Dependent variable in Column 3 is the log of the sum of dishwashing cycles, clothes washing cycles and drying cycles. Dependent variable in Column 4 is the log of electricity consumption (in kWh). OLS estimates are reported.
Standard errors are reported in parentheses in Columns (1) and (2). Robust standard errors in parentheses in Columns (3) and (4). */**/*** indicate statistical significance at the 10, 5, and 1 percent level, respectively.