

Behavioral anomalies and energy-related individual choices: the role of status-quo bias

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Abstract

The literature on the energy-efficiency gap discusses the status-quo bias as a behavioral anomaly that potentially increases a household's energy consumption. We empirically investigate the extent to which the status-quo bias is linked to residential electricity consumption through two channels: non-replacement of old appliances and overuse of appliances. Using data from a large household survey conducted in three European countries, we find that our measure of status-quo bias is a significant predictor of both the age of home appliances and the level of a household's consumption of energy services. This is reflected in the total electricity consumption, which is found to be around 5.7% higher when the household head is status-quo biased. We thus provide empirical evidence that the status-quo bias may represent a substantial barrier to increasing residential energy efficiency. Our findings prompt policy makers to design instruments that take this barrier into account.

Keywords: status-quo bias; loss aversion; appliances replacement; energy efficiency; residential energy consumption; energy-related financial literacy

JEL Classification Codes: D12, D91, Q41, Q50

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1. Introduction

The literature on the energy efficiency gap (Sanstad and Howarth, 1994; Howarth and Sanstad, 1995; Greene, 2011; Allcott and Greenstone, 2012; Gillingham and Palmer, 2014) provides various explanations for under-investment in energy efficiency. Regarding energy efficiency in residential households, numerous market and behavioral failures as well as behavioral anomalies may impede energy efficiency investments. One of these explanations is that individuals are biased towards the status quo (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 options. This phenomenon is more generally known as the *status-quo bias* and is defined as an individual's tendency to "[do] nothing or [maintain] one's current or previous decision" (Samuelson and Zeckhauser, 1988, p.7).

According to Samuelson and Zeckhauser (1988), the potential underlying causes for the status-quo bias may include transition costs, uncertainty, 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 may also cause an over-consumption of energy services: once an electric appliance has been purchased, individuals with a strong status-quo bias may perceive it as beneficial to use the appliance as much as possible, in order to justify 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 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; Collier 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 as they have different policy implications.

While the relation between status-quo bias and energy efficiency has thus far mainly been discussed as a theoretical concept (Schleich et al., 2016; Frederiks et al., 2015; Schubert and Stadelmann, 2015; Broberg and Kazukauskas, 2015), empirical evidence for the link between the status-quo bias and residential electricity consumption is lacking. Some of the existing studies investigate 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)). Yet, apart from the recent work of Martin-Bonnel de Longchamp et al. (2018) on the role of the status-quo bias for the energy performance gap in low-energy buildings, 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 aims to capture the relationship between the level of status-quo bias of the household head 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. Our analysis is based on 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. 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. Also the consumption of energy services of a household increases when the household head is status-quo biased: our indicator of bias towards the status quo is associated with an about 5.7% higher consumption of energy services. This is also reflected in the total electricity consumption of the respective households, which is found to be 5.7% higher than the consumption of households in which the household head is not status-quo biased.

The paper is structured as follows: Section 2 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 3 explains the data set and our measure of status-quo bias. The results of our analysis are presented in Section 4 and discussed in Section 5. Section 6 concludes.

2. Theoretical background

2.1 *Status-quo bias, the endowment effect and loss aversion*

The *status-quo bias* was first conceptualized by Samuelson and Zeckhauser (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. Samuelson and Zeckhauser (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. Samuelson

¹Blasch 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.

and Zeckhauser (1988) emphasize that "status-quo bias is not a mistake – like a calculation error or an error in maximizing" (Samuelson and Zeckhauser, 1988, p.9), but a true behavioral anomaly.

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). Thaler 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). 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).

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. Also Kahneman et al. (1991) consider this bias towards the status-quo 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, as Samuelson and Zeckhauser (1988), that even though the status-quo bias is considered an implication of loss aversion, there may be other causes for the status-quo bias even in the absence of loss aversion.

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

As to our knowledge, there is no validated measure for the status-quo bias yet. In the following, we will therefore discuss several measures for loss aversion and the endowment effect, which are considered as underlying causes of status-quo bias (Samuelson and Zeckhauser, 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, separately in the time and money dimension.

In the context of risky choices, incentivized lotteries are usually used to measure loss aversion. 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 task 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. 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. Hjorth and Fosgerau (2011) find that loss aversion in terms of loss in travel time is stronger than in terms of travel cost and, consistent with Gächter et al. (2010), that it increases in age but decreases in 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 two sets of 18 and 7 items that constitute a Loss Aversion Questionnaire (LAQ). Testing the 18-items LAQ with a sample of 479 students in management and economics classes, they observe a relatively high internal consistency of the 18-items scale (Cronbach's $\alpha = 0.82$) and the 7-items scale (Cronbach's $\alpha = 0.72$). As the LAQ of De Baets and Buelens (2012) does not capture the relative nature of loss aversion which, according to prospect theory, manifests when comparing an individual's valuation of losses to the valuation of equal-sized gains, it rather allows to rank individuals according to their sensitivity to losses.

Finally, a survey-based indicator for status-quo bias is used by Martin-Bonnel de Longchamp et al. (2018) who study the impact of status-quo bias on the energy performance of low-energy buildings. Yet, their measure of status-quo bias is not a general, context-free measure of status-quo bias, but reflects self-reported changes in habits related to manual ventilation behavior (comparison of behavior before and after the energy-efficient renovation). This measure is thus not suitable for comparison with the above mentioned more general measures for loss aversion.

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

As mentioned before, we are not aware of any empirical study that has investigated the influence of status-quo bias on the energy efficiency of households' electric appliances. However,

a range of studies has investigated the role of risk and 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. For appliances, Qiu et al. (2014) test in a laboratory experiment the influence of risk and time preferences on energy-efficient investments. 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 negatively impacts the likelihood for energy-efficient renovations.

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. Both Heutel (2017) and Schleich et al. (2018) test whether prospect theory parameters (Kahneman and Tversky, 1979) can explain the energy efficiency gap. Heutel (2017) analyzes the role of prospect theory for 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.

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

According to Samuelson and Zeckhauser (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 another implication of loss aversion.

Frederiks et al. (2015) 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.

2.5 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). As the conceptual framework in Figure 1 visualizes, status-quo bias can be explained by the endowment effect and the sunk-cost fallacy (Samuelson and Zeckhauser, 1988), which both are considered consequences of loss aversion (Thaler, 1980; Kahneman et al., 1991). Eventually, keeping appliances longer and using appliances more intensely should be reflected in the total electricity consumption of a household.

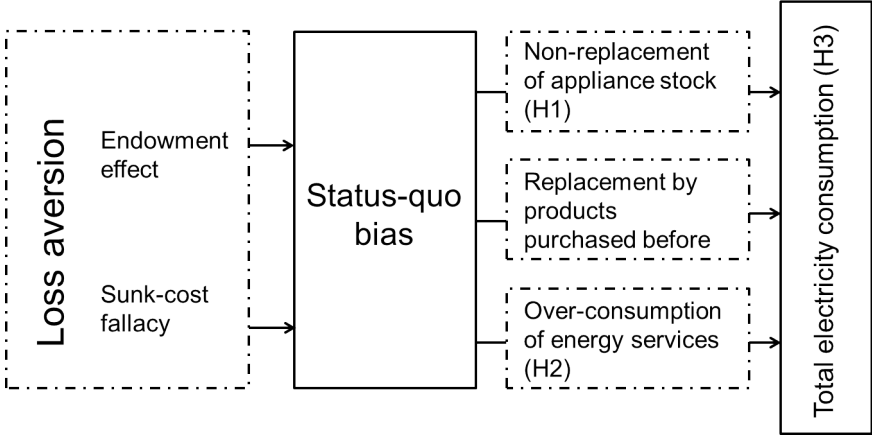


Figure 1: Conceptual framework for our analysis.

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:

- 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.

3. Data and measurement of status-quo bias

3.1 *The data*

The empirical analysis is based on data from a household survey conducted in 2017 in three European countries (Italy, Netherlands, Switzerland).² The survey has been implemented in collaboration with electric utilities in the three countries (Italy: ENI, the Netherlands: Qurrent, Switzerland: Stadtwerk Winterthur and Aziende Industriali Lugano). Customers of each utility were invited with a letter accompanying the electricity bill to take the online survey. A total of 4,899 households took the survey. Details about the recruitment process and the implementation of the survey are reported in Appendix A.1.

The data contain detailed information on households' socio-economic characteristics, dwelling characteristics and the respondent's energy-related knowledge. Most importantly, the survey jointly collects unique information on the age of the major home appliances, the intensity of their usage (e.g., the number of times per week the washing machine is typically utilized) and asks questions to elicit the respondents' degree of bias towards the status quo. Finally, the data that we use also include yearly electricity consumption provided by the utilities. In Appendix A.1, we report descriptive statistics about selected socio-economic characteristics, and a comparison with the corresponding figures in the national statistics.

Age of appliances and consumption of energy services As laid out in Section 2, a bias towards the status quo 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 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.³

²The household survey has been carried out in the context of the EU H2020 Project PENNY (Psychological social & financial barriers to energy efficiency).

³The 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 1: 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	0.43	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	0.43	0.54
Age: 6-10	0.26	0.27	0.30	0.27
Age: > 10	0.14	0.16	0.24	0.16
Clothes dryer				
Ownership rate	0.23	0.62	0.71	0.52
Age: ≤ 5	0.72	0.48	0.42	0.50
Age: 6-10	0.20	0.30	0.30	0.28
Age: > 10	0.07	0.20	0.24	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 2: Presence of old appliances (> 10 years) in the household.

	Italy	Netherlands	Switzerland	Total
At least one appliance > 10 years	0.368	0.434	0.527	0.434
Number of appliances older than 10 years	1 0.200	0.199	0.184	0.196
	2 0.089	0.128	0.143	0.118
	3 0.043	0.037	0.084	0.050
	4 0.082	0.017	0.062	0.025
	5 0.001	0.005	0.022	0.008

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.

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 1. 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 24 percent in Switzerland.

As shown in Table 2, around 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 53 percent in Switzerland. 20 percent of the households own at least two appliances older than 10 years, and in around 1 percent of the households all the appliances considered in this study were older than 10 years.

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 certain types of appliances as dishwashers, washing machines and clothes dryers. In the 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 3 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 use their home appliances less often on average than Italian and Dutch households.

Table 3: Energy services

	Italy	Netherlands	Switzerland	Total
Average number of cycles				
Dishwasher	4.11	4.49	3.85	4.2
Washing machine	4.21	3.89	3.69	3.96
Clothes dryer	2.88	3.02	1.96	2.63
Total (washing and drying cycles)	12.42	12.64	9.82	11.57

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.

3.2 Measure of the status-quo bias

As 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 is based on six survey items, taken from the Loss Aversion

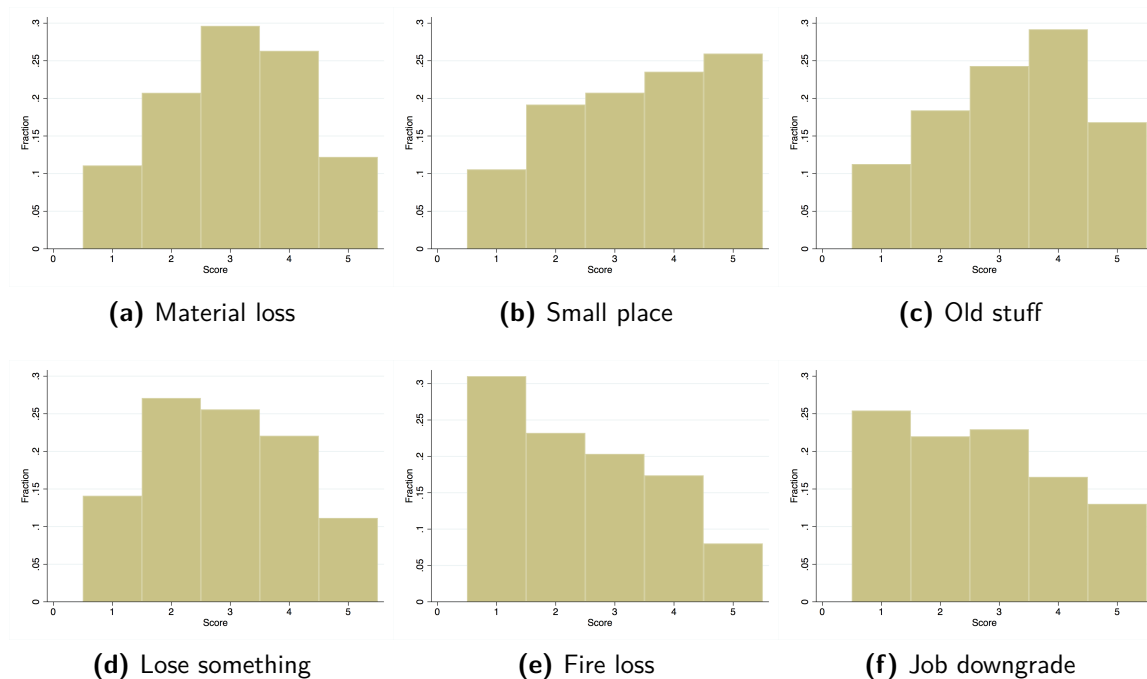


Figure 2: Qualitative measures of status-quo bias

Questionnaire (LAQ) developed by De Baets and Buelens (2012). From their questionnaire, which includes a total of 18 items, we selected six items which specifically capture an individual's tendency to stick to the status quo, combined with 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 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. 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.

The survey items we consider refer to different contexts with different implications for ones' well-being. Also, as shown in Table 4, the observed scores associated to the different survey items exhibit a certain degree of correlation. For these reasons, to address the question of

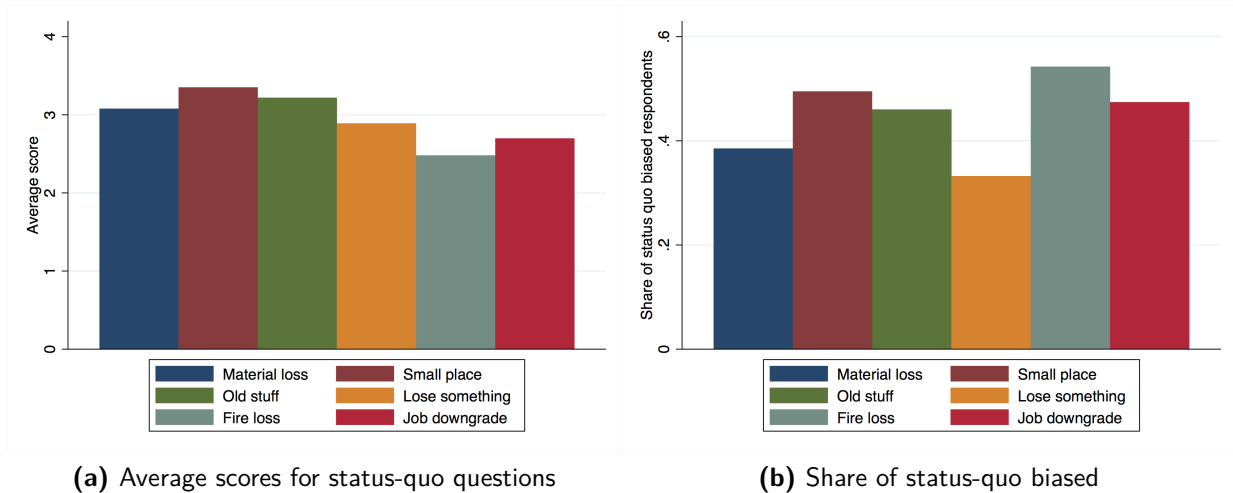


Figure 3: Status-quo bias in the sample

Table 4: 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.

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.

We start by creating binary indicators for whether a respondent exhibits bias towards the status quo in each of the survey items (i) to (vi). This avoids that high scores obtained in certain survey items compensate for low scores obtained in other survey items when adding up scores. We define a respondent to exhibit bias towards the status quo for each 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 items in which a respondent expresses bias towards the status quo.⁴ 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

⁴The status quo bias index is simply generated adding up the values taken by each binary indicator corresponding to survey items (i) and (vi).

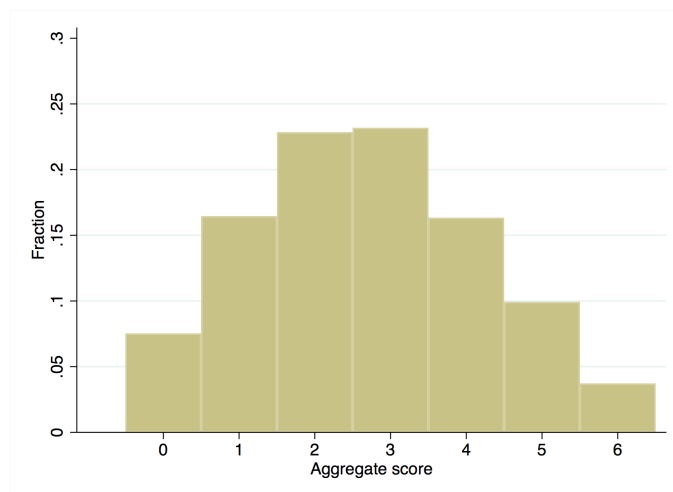


Figure 4: Distribution of the status-quo bias index

the *status-quo bias index*.

Finally, we construct a *binary indicator for the status-quo bias* that takes the 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 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 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. 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.

3.3 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 tasks (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 probability to be status-quo biased between working respondents and respondents out of the labor force.

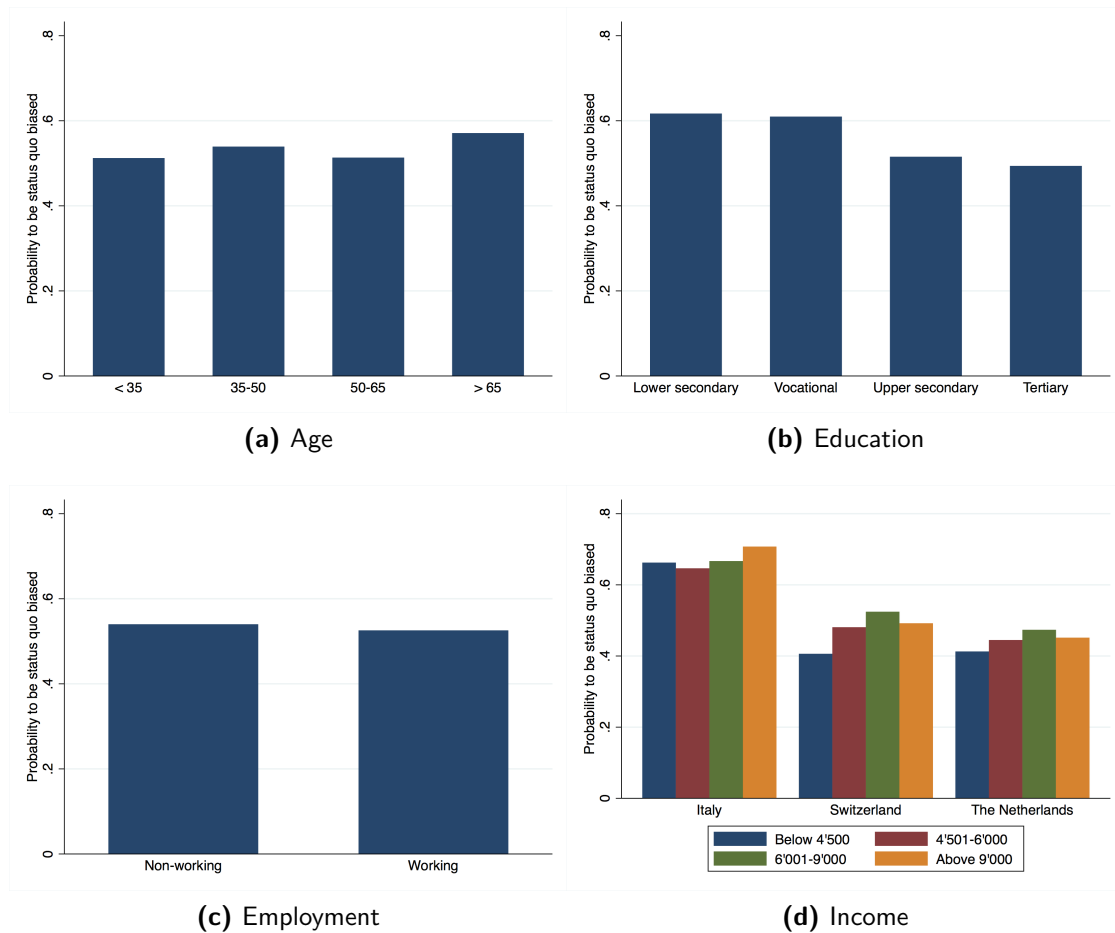


Figure 5: Share of status-quo biased respondents by individual characteristics

Finally, higher degrees of bias towards the status quo are associated with higher income levels, in all the three countries. It is worth noting the large heterogeneity in our measure 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 (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 5).

Table 5: Status-quo bias and respondents' characteristics

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

4. 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 and 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 5, 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 associated with our measure of status-quo bias. In addition, we include a large number of factors that are typically considered as determinants of energy-related choices.

4.1 *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.⁵ 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 6: Status-quo bias and ownership of old appliances

	(1)	(2)					
	Binary indicator	Number of 10+ old appliances					
		0	1	2	3	4	5
Status-quo bias indicator	0.0372** (0.0157)	-0.0413*** (0.0145)	0.0105*** (0.0037)	0.0139*** (0.0049)	0.0088*** (0.0031)	0.0057*** (0.0021)	0.0022** (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 6 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.⁶ 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 6.⁷ 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.

⁵While 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).

⁶The 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).

⁷The 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).

4.2 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 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 7.⁸ We find that our indicator of bias towards the status quo is associated with an 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 7: Status-quo bias and consumption of energy services

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

4.3 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 on the positive association between the indicator of status-quo bias and both the probability for the household to use old appliances and the intensity of their usage suggest that a bias towards the status quo might predict

⁸The complete estimation results are reported in Table 13.

higher electricity consumption. We test this hypothesis using a direct measure of electricity consumption provided by the respondents' energy utility.⁹ 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 7 show that households in which the head exhibits bias towards the status quo consume about 5.7 percent more electricity.

4.4 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 (8) confirm our main findings about the predictive power of the status-quo bias on energy-related choices.

Table 8: 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 (0.0227)	0.0882*** (0.0326)	0.0516 (0.0353)
Third quartile of status quo bias index	0.0523** (0.0226)	0.0938*** (0.0348)	0.0840** (0.0344)
Fourth quartile of status quo bias index	0.0456** (0.0218)	0.1058*** (0.0316)	0.0825** (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.

⁹To reduce the effect of extreme values in the electricity consumption data, we winsorize the distribution of electricity consumption at 5%.

5. Discussion

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 bias is substantial. Moreover, our results suggest that the role of the status-quo bias becomes more important when explaining the presence of more than one old energy-consuming durable per household. Indeed, given the share of households owning such a number of old appliances, as reported in Table 2, 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 points into this direction (see Table 6).

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 in our sample seem to replace their appliances only when they are defective.¹⁰

These findings about the predictive power of the status-quo bias on the probability for households to keep old appliances 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 national and 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 2, 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.¹¹ 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

¹⁰In the Swiss panel of the survey, we ask the question about the reason for the replacement of the last major appliance. Around 67% of the households in the Swiss sample replaced the last appliance because it was defective.

¹¹A direct, qualitative, measure of risk aversion is available only for Swiss sample.

that empirical research interested in the impact of risk or loss aversion can focus on single preference measures individually. Still, 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 causal effects as we believe that an experimental setting that exploits some exogenous variation in status-quo bias would be better suited to unpack the causal chain from the presence of the status-quo bias to economic decision making.

Finally, it can be debated whether the qualitative index used to measure the status-quo bias is an appropriate measure to capture this individual trait. 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 individual's WTA and WTP (Gächter et al., 2010; Hjorth and Fosgerau, 2011). While the measures derived from (incentivized) lottery tasks are clearly 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. One downside of the loss aversion questionnaire of De Baets and Buelens (2012) is that it cannot capture the relative nature of loss aversion. Rather, their survey-based instrument can be considered as an indicator of an individual's sensitivity to losses. The derived measure of status-quo bias used in this study, however, includes items that aim at measuring an individual's tendency to stick to the current situation, rather than loss aversion per se, which makes this drawback less relevant. Furthermore, by using a binary measure that classifies individuals as status-quo biased relative to the sample median emphasizes that we rank individuals regarding the degree to which they express a preference for staying with the status quo rather than providing an absolute measure for status-quo bias. At the same time, the qualitative index used in this analysis shows similar associations with socio-demographic characteristics as the incentivized measures for loss aversion of Gächter et al. (2010) and Tanaka et al. (2010), which suggests that our indicator measures a behavioral trait that is at least to some extent correlated with loss aversion. While this is supporting our approach, a further validation of the six survey items used in this study in future research is desirable.

6. Conclusions

Our study presents results from a household survey among customers of European energy utilities. It empirically explores the role of the status-quo bias for the persistence of the energy-efficiency gap as well as for the over-consumption of energy services in residential households. We find that our measure of status-quo bias is an important predictor of both the age of home appliances and the level of consumption of energy services of a household. 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. 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 by 5.7 percent when the household head is status-quo biased. 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 thus provide evidence that the status-quo bias is an important determinant of the level of energy consumption of European households. They inform behavioral models of consumer behavior about the channels through which the status-quo bias operates 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 anomalies. It may hence constitute a severe limit to policy-makers' opportunities to narrow the energy efficiency gap.

Yet, our findings offer guidance to policy makers about what range of policy measures might be more effective in overcoming the consequences of individuals' tendency to remain with the status quo and prompt to the importance of tailoring alternative policies for individuals with different characteristics. First, the introduction of so-called scrapping incentives for old electric appliances, i.e. monetary premiums for replacing an old appliance by a newer and more efficient one, would explicitly target households that are biased towards the status quo. 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 (Young, 2008). Second, the over-consumption of energy services due to the status-quo bias could be limited by the introduction of a carbon price. Alternatively, providing households with social-comparison feedback (Allcott, 2011) 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. Clearly, more research is needed on the extent to which such policy measures would limit the consequences of the status quo-bias on individual choices. For instance, the effectiveness of the introduction of a carbon price might be mitigated in case the elasticity of energy services to changes in energy prices was a decreasing function of the degree of bias towards the status quo.

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

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A. Appendix

A.1 *PENNY data*

In this Appendix we provide details about the collection of data and report descriptive statistics about selected socio-economic characteristics of the respondents in the sample.

Data collection The household 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 Lugano is a regional utility serving a district in the Italian part of Switzerland. In Switzerland, the electricity market has not been open to competition for residential customers. Thus, the partner utilities in Winterthur and Lugano serve the whole population in the respective service area.

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 utilities both in Winterthur and in the district of Lugano. 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 bill. Both the letters and the emails contained a link to access an online questionnaire. Table 9 reports details and statistics about the recruitment process.

In addition, Table 10 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 10).

Table 9: 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.	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 based on the place of residence, contract characteristics, and historical consumption.

Table 10: 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%

Descriptive statistics 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. In Table 11 we report descriptive statistics about selected socio-economic characteristics and a comparison with the corresponding value in the national statistics, by country of residence. Descriptive statistics of other selected socio-economic variables are reported in Table 12. The average age in the sample varies between countries, with Italian respondents being almost five years older, on average, than 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% in the Netherlands. 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.

The median household income 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, consistent with the national statistics on household income as reported by the OECD. 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. 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. The majority of households in the sample own the dwelling they live in. The home ownership rate ranges from around 59% in Switzerland to around 85% in Italy. Although this heterogeneity reflects differences in the home ownership rates across countries as indicated in the national statistics, home-owners are slightly overrepresented in the sample in all three countries.

Table 11: Selected household characteristics in the sample and in the national statistics

	Italy		Netherlands		Switzerland	
	Sample (share)	Statistic	Sample (share)	Statistic	Sample (share)	Statistic
Residence characteristic						
Single-family house	0.44	0.47	0.73	0.76	0.52	0.37
Home ownership status						
Owned	0.85	0.73	0.73	0.68	0.59	0.44
Household type						
Couple with/without children	0.76	0.47	0.69	0.53	0.71	0.56
Single with/without children	0.22	0.36	0.29	0.41	0.24	0.41
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		0.13	
6'001 to 9'000	0.06		0.14		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 disposable income		4417.95		4614.34		6993.87
Education of respondent						
Lower secondary education and less	0.11	0.42	0.06	0.28	0.02	0.18
Upper secondary/Vocational	0.54	0.43	0.24	0.41	0.40	0.46
Tertiary	0.35	0.16	0.70	0.31	0.57	0.35

Note: The table reports the average value for some selected socio-economic characteristics used in the empirical analysis and a comparison with the corresponding value in the national statistics, by respondents' country of residence.

Table 12: Other selected household characteristics by country of residence

	Italy	Netherlands	Switzerland
Respondent characteristic			
Age	53.20	48.86	52.11
Female	0.31	0.38	0.37
Working	0.61	0.71	0.69

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

A.2 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** (0.0453)	0.120*** (0.0423)	0.0567** (0.0225)	0.0567** (0.0248)
Energy-related financial literacy	0.0258* (0.0152)	0.00931 (0.0143)	-0.00340 (0.00798)	-0.0176** (0.00830)
Age	0.0460*** (0.0125)	0.0472*** (0.0120)	-0.00144 (0.00710)	0.0116* (0.00656)
Age squared	-0.000359*** (0.000121)	-0.000379*** (0.000115)	-0.0000189 (0.0000694)	-0.0000950 (0.0000634)
Female	0.149*** (0.0512)	0.0992** (0.0477)	-0.00904 (0.0314)	-0.0768*** (0.0277)
Education: vocational	-0.259** (0.103)	-0.194** (0.0971)	-0.0615 (0.0635)	-0.110** (0.0509)
Education: upper secondary	-0.363*** (0.110)	-0.254** (0.102)	-0.0135 (0.0633)	-0.00952 (0.0567)
Education: tertiary	-0.234** (0.101)	-0.157* (0.0947)	-0.0538 (0.0627)	-0.0856* (0.0511)
Household size: 2	-0.0782 (0.0888)	-0.134 (0.0834)	0.420*** (0.0645)	0.161*** (0.0509)
Household size: 3	-0.154 (0.0972)	-0.215** (0.0919)	0.676*** (0.0676)	0.328*** (0.0554)
Household size: 4	-0.156 (0.106)	-0.183* (0.0989)	0.781*** (0.0729)	0.393*** (0.0589)
Household size: 5	-0.0958 (0.124)	-0.230** (0.116)	0.915*** (0.0751)	0.387*** (0.0713)
Household type: couple	-0.0893 (0.0752)	-0.0792 (0.0709)	0.151*** (0.0412)	0.0756* (0.0433)
Non-working	0.000554 (0.0624)	-0.000846 (0.0580)	-0.0128 (0.0335)	-0.0155 (0.0348)
Income: 4501-6000	-0.0504 (0.0777)	-0.0555 (0.0731)	0.0432 (0.0345)	-0.00512 (0.0516)
Income: 6001-9000	-0.0415 (0.0792)	0.0109 (0.0734)	0.0282 (0.0356)	0.111** (0.0447)
Income: above 9000	-0.120 (0.0748)	-0.0760 (0.0695)	0.0889** (0.0373)	0.103** (0.0420)
Income: not reported	-0.103 (0.0685)	-0.0474 (0.0646)	0.0621 (0.0389)	0.128*** (0.0382)
Saving rate: 0 percent	0.141* (0.0795)	0.118 (0.0746)	0.0991** (0.0434)	0.168*** (0.0433)
Saving rate: 1-5 percent	-0.0363 (0.0726)	-0.0184 (0.0677)	0.108*** (0.0381)	0.0657 (0.0409)
Saving rate: 6-20 percent	0.0157 (0.0702)	0.0307 (0.0652)	0.0620* (0.0347)	-0.0314 (0.0403)
Saving rate: above 20 percent	0.0807 (0.0857)	0.0591 (0.0794)	-0.0148 (0.0431)	-0.0716 (0.0482)
Tenant	-0.00128 (0.0641)	-0.0523 (0.0611)	-0.0447 (0.0444)	-0.131*** (0.0322)
Dwelling size (log)	0.133** (0.0613)	0.181*** (0.0573)	0.116*** (0.0325)	0.300*** (0.0375)
Weeks off: 2	0.178*** (0.0526)	0.203*** (0.0494)	-0.0908*** (0.0299)	-0.0624** (0.0292)
Weeks off: 3	0.231** (0.101)	0.212** (0.0940)	-0.163*** (0.0550)	-0.123** (0.0577)
Weeks off: 4	0.150 (0.106)	0.148 (0.100)	-0.119** (0.0530)	-0.172*** (0.0603)
Days off: 2	-0.0909 (0.0674)	-0.0715 (0.0638)	-0.0247 (0.0385)	-0.130*** (0.0390)
Days off: 3	0.0662 (0.112)	0.0721 (0.106)	-0.0352 (0.0500)	-0.0679 (0.0688)
Multi-family house	-0.0702 (0.0699)	-0.0616 (0.0662)	0.0451 (0.0481)	-0.230*** (0.0394)
Moved in recently	-0.758*** (0.0589)	-0.703*** (0.0570)	-0.0466 (0.0284)	-0.118*** (0.0307)
Period dwelling built: 1970-2000	0.126* (0.0719)	0.0826 (0.0664)	0.0242 (0.0342)	-0.0473 (0.0426)
Period dwelling built: before 1970	-0.0113 (0.0634)	-0.0914 (0.0601)	0.0148 (0.0320)	-0.0730** (0.0370)
IT	-0.261*** (0.0680)	-0.227*** (0.0643)	-0.144*** (0.0369)	-0.0805** (0.0402)
CH	0.207*** (0.0685)	0.333*** (0.0627)	-0.325*** (0.0358)	0.330*** (0.0396)
Constant	-1.785*** (0.440)		5.299*** (0.231)	6.030*** (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.