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Perceptions and inattention in private electricity consumption

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Abstract

Households typically receive utility bills where all electricity use during a fixed period of time is lumped together. The lack of direct feedback in the form of marginal costs of using specific electric appliances reduces the attention people give to their energy consumption and potentially leads to biased cost perceptions and mistakes in households' decision making. In this paper we empirically investigate whether people who are inattentive to energy-related issues have different perceptions regarding the cost of using electricity. We conclude that many households base their decisions regarding electricity use on poor knowledge about the costs involved, that cost perceptions on average tend to be upward biased, and that cost perceptions generally are higher among inattentive respondents. This result somewhat contradicts the common notion that inattention causes *lower* price (cost) perceptions and, subsequently, too much energy use. Finally, we also find that a substantial share of the sampled households, in particular households with poor knowledge about their energy consumption, are not willing to receive customized information on their energy use and costs. This suggests that some households do not expect to benefit from such information.

JEL classification: D12, Q41, Q48

Keywords: DSM, energy efficiency, energy policy, inattention, information, nudge.

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1. Introduction

Are households and firms turning down a free lunch? If they do, how can that be? The two questions summarize a long debate in the energy economics literature concerning the potential to cost-effectively improve energy efficiency through market intervention. One suggested reason for the existence of such a potential is that consumers for various reasons do not pay attention to the energy efficiency and running costs of appliances and installations (Bull 2012). This seeming disinterest can be tentatively explained within the frameworks of both the neoclassical view of rationality and the concept of bounded rationality. Utility maximization demands a lot of information and analysis, which may be costly to gather and carry out. The typical household receives one or more utility bills monthly, or quarterly, where the electricity use of multiple electrical devices and appliances is lumped together. Thus, it is difficult for households to gather information about the marginal cost of using specific appliances and devices. As a result, households get insufficient feedback on their use of electricity, which may result in systematic inefficiencies.

Few studies empirically investigate whether or not inattention significantly affects energy use. A recent study on U.S. households finds that automatic bill payment programs cause a 4–6 percent increase in electricity consumption (Sexton 2014). In the study it is assumed that consumers underestimate electricity prices because of inattention and thereby consume too much electricity. However, we have not found any studies that empirically investigate whether inattention correlates with misperceptions (if any) of energy-related costs. In the present paper we address this issue by studying people's perceptions of the marginal cost of using common electrical appliances and how these perceptions relate to inattention to energy issues.

Biased perceptions of electricity use and costs may necessitate unconventional policy actions aimed to correct these biases. Recent research suggests that more detailed information on household electricity use and social norms can be a powerful instrument to influence people's energy-related behavior (e.g. Allcott 2011b; Delmas *et al.* 2013; Dolan and Metcalfe 2013). This opens up a promising possibility for policymakers to provide inattentive consumers with customized information. So-called social nudges change the framing of decisions without restricting actual choices, which means that they do not cause inefficiencies in terms of economic surplus (Thaler and Sunstein 2008). However, this is only true as long as people are not negatively affected and are willing to

be nudged. The willingness to be nudged is commonly ignored in empirical studies investigating the effectiveness of nudges in energy conservation. We address this issue by investigating whether households want to receive information that may help them adjust their own perceptions and beliefs about energy costs and use. We also investigate heterogeneity among households to find out whether inattentive households are more willing to receive customized information.

In the empirical analyses, we use Swedish survey data collected in 2014. The survey included questions regarding cost perceptions, behavior related to energy use, and willingness to receive customized information. As inattention is not an observable characteristic of energy consumers, a proper proxy is needed. We do not single out one specific proxy but instead investigate a spectrum of different candidates. The proxies are either based on knowledge-oriented or behavior-oriented variables. The knowledge-based proxies for inattention are based on objective information regarding energy use and energy costs. We expect attentive people to know how much they pay for electricity, how much electricity they consume, and whether they have agreed to pay a fixed or variable price. The behavior-oriented proxies are based on the idea that attentive people act differently than those who do not pay attention to energy-related information, e.g., they turn off the lights more frequently or consider energy efficiency when buying white goods or other electrical appliances.

Overall, our results show that many respondents have poor knowledge about their everyday energy costs and that cost perceptions are upward biased. They also show that inattention to energy-related information is a significant factor explaining people's perceptions about costs related to their energy use. Moreover, we find that inattentive households are less willing to receive customized information.

The outline of this paper is as follows. In Section 2 we give a brief overview of relevant research on inattention. In Section 3 we outline the empirical strategy and the hypotheses. In Section 4 we present the survey, describe the data, and discuss the main results of our econometric analysis. Finally, Section 5 concludes the paper.

2. Brief review of the literature on limited attention and energy efficiency

As mentioned above, it has long been discussed in the energy economics literature whether or not there exists a potential to cost-effectively increase energy efficiency by market interventions. Economic analyses of the so-called energy efficiency gap typically

distinguishes between market barriers to energy efficiency in general and market failures, which is the only type of market barriers that can economically justify market interventions (Jaffe and Stavins 1994). For example, the standard economic literature acknowledge that market-based policy instruments, such as an emission fee, cost-effectively can correct for externalities (e.g. pollution) but disqualifies market interventions based on low profitability in specific sectors. Relatively recently, it has been suggested that incomplete information and 'internalities' in form of behavioral anomalies may cause inefficiencies on energy markets (see e.g. Sanstad and Howarth 1994; Sanstad *et al.* 2006; Tietenberg 2009; Allcott and Greenstone 2012; Gillingham and Palmer 2014; Broberg and Kazukauskas 2015). If firms and households do not have appropriate information or cannot use information effectively due to cognitive limitations, they are prone to make mistakes and the market solution will most likely not be at the social optimum.

2.1. Rational Inattention vs. heuristics

Consumer theory builds on the idea that consumers buy goods and services with many different attributes (Lancaster 1966), some of which are more important than others. People may rationalize decisions by not paying attention to attributes that most likely will not change their final choice (Sims 2003; Sallee 2014). This is referred to as rational inattention. Sometimes energy efficiency is an important attribute that deserves great attention in decisions regarding investments and consumption. Yet other times it is deemed less important and, therefore, likely ignored. For example, the energy savings may simply be too small in relation to the costs of gathering and making use of complete information. Providing rationally inattentive people with *more* (easily accessible) information may be welfare improving if it improves their decision making related to energy use enough to compensate for the cost of providing the information.

The rational choice theory has been criticized by psychologists saying it is a bad description of human decision making. People make most choices intuitively, placing little or no analytical effort into the decision process, and simplify decision making by applying heuristics, i.e., consumers satisfy rather than optimize (Simon 1955). Empirical evidence from psychology and behavioral economics indicates that consumer choices and actions often deviate *systematically* from expected choices under the neoclassical economic assumptions. Many of these biases stem from simple heuristics or "rules-of-

thumb" that guide people in their information processing, thereby hastening the mental process of problem solving and decision making, particularly in situations characterized by high levels of choice complexity and uncertainty (Tversky and Kahneman 1974; Frederiks et al. 2015).

One example of a systematic bias discussed in the energy literature is the so-called "MPG[3] illusion," i.e., that many people for example think that an increase in fuel efficiency from 13 to 14 MPG is equivalent to increasing fuel efficiency from 33 to 34 MPG (see, for example, Larrick and Soll 2008; Allcott 2011a). Clearly, this reasoning is flawed as fuel savings do not increase linearly with changes in MPG. In general, people do not seem to put much cognitive effort into calculating fuel costs, which may be a result of rational or cognitive inattention (Allcott (2011a). Another example of an energy-related bias is given by Attari et al. (2010), who investigate the perception of energy consumption and savings for a variety of household activities using a survey approach. Their results show that survey participants tended to overestimate energy savings for low-energy activities (like turning off lights).

Psychologists argue that in a typical choice between several products, a range of attributes compete for our attention. The winning attributes are those that are perceptually salient as they are highly accessible in the mental process. Physical salience, expectations, and immediate consequences have been pointed out as important determinants of accessibility (Kahneman 2003). The empirical literature reports evidence that people are inattentive to shipping charges (Hossain and Morgan 2006), non-transparent taxes (Chetty et al. 2009), and financial news (see more detailed literature review in DellaVigna 2009). Furthermore, although standard economic theory suggests that consumers should respond to the marginal prices, it is likely that consumers are inattentive to the marginal price of electricity or water they face. Recent work on electricity (Ito 2014) and water (Wichman 2014) demand suggests that consumers respond to average price rather than marginal or expected marginal price.

2.2. The effects of providing customized information to increase awareness

Economic theory and empirical research provide some guidance for policy makers to counter the effects of inattention (Gerarden et al. 2014). Information programs could

[3] Miles per gallon.

target consumers who have biased beliefs and/or are inattentive to energy costs. Some argue that certain behavioral biases are best addressed with "nudges" that push people's behavior in a pro-social direction without restricting the choices available to them (Thaler and Sunstein 2008).[4]

Nudges may play a significant role in policies aimed to improve energy efficiency. For example, a recent large-scale field study on American households found a two percent drop in the demand for electricity in households exposed to information about their relative energy consumption (Allcott 2011b).[5] These results can be interpreted such that consumers with relatively high use of energy became aware of their relatively bad behavior and undertook what they perceived to be pro-social actions. The effect of peer comparisons has also been explored in previous small-scale studies. Delmas et al. (2013) review over 30 experimental studies on social comparisons (implemented in the last 30 years) and find an average reduction in energy use of 11 percent. Delmas and Lessem (2014) find that the effect reaches a 20 percent reduction in electricity use for heating and cooling in the U.S. when private social comparison information becomes publicly available.

3. Data collection and descriptive statistics

The empirical analysis is based on Swedish survey data collected via an internet panel consisting of approximately 90,000 randomly recruited Swedes. In June 2014, a questionnaire was sent out to about 5,900 people from the panel, and 918 of them responded within a week. In order to get a sample representative for the Swedish population the selection procedure considered a number of socio-economic factors, namely age, gender, and geographic location.

[4] Policies addressing behavioral failures are referred to as libertarian, soft, light, or asymmetric paternalism in the literature. (Loewenstein and Haisley 2008) discuss different welfare measures and conclude that "light paternalistic policies should only be put into play when welfare judgements tend to be relatively straightforward." They label this approach an "imperfect but pragmatic approach." According to this approach it is important to define what type of behavior really is pro-social, which is a difficult task.

[5] Since the households were also exposed to energy saving tips, the results must be cautiously interpreted as the tips may be confounded with the results concerning social norms. However, Dolan and Metcalfe (2013) address the problem by isolating the effect of peer comparisons from other effects. They still find a significant reduction in energy use among U.K. households that were provided comparative information.

In addition to general questions about the respondents' living conditions, age, gender, and use of energy, the questionnaire included questions relating to inattentiveness to energy issues, cost perceptions, and willingness to receive customized information. On the basis of these questions, we formulate our two main research questions (hypotheses).

The first hypothesis relates to the link between cost perceptions and limited attention. It is often assumed and/or suggested in the energy efficiency literature that inattention makes people *underestimate* the costs of using energy (e.g. Allcott 2014; Sexton 2014), which in turn may lead to excessive consumption. However, this assumption has barely been tested empirically. Thus, our first hypothesis is:

> *People who tend to be inattentive concerning energy issues have lower perceptions about costs related to the use of electricity.*

In order to study the relationship between people's cost perceptions and inattention, we asked the respondents to state how much they think it costs to use one kWh of electricity, shower 5 minutes, and run specific home appliances. The respondents were asked to state an interval. Because of the interval nature of the data, we apply an interval regression model[6] to estimate the links between inattention and cost perceptions.

Our second research question relates to the logic that individuals who tend to know or care little about their energy use and expenses should be the primary target of policy campaigns aimed to raise awareness about energy conservation. Low awareness and limited attention are the key justifications for such policy interventions (Thaler and Sunstein 2008). Of course, the promoters of energy efficiency measures presume that such information is especially useful for households that pay little attention to the potentials for energy conservation. We test this notion by asking Swedish households whether they are willing to receive information that directs their attention to their actual energy use and costs. In this part we run a probit model to explore the relationship between inattention and willingness to receive information. Thus, our second hypothesis is:

> *People who tend to be inattentive concerning energy issues are more willing to receive customized information about their energy consumption.*

[6] Interval regression model is a generalization of the Tobit model. Interval regression model can fit models for data where each observation represents interval data, left-censored data, right-censored data, or point data.

Whether or not people are the inattentive type when it comes to energy issues is not directly observable. Therefore, we need to find a proxy to approximate this characteristic. As there exist several candidate proxies in our survey data and none can be claimed to be better than the others, we investigate all of the candidates available. The proxies are based on either knowledge- or behavior (or decision)-oriented variables. The knowledge-based proxies for inattention capture whether our survey respondents know roughly how much they pay for electricity and how much electricity they consume, whether they have agreed to pay a fixed or variable price, and whether they pay for their use of electricity. We expect people who do not pay attention to energy-related information to have relatively little knowledge about their energy use and costs. The behavior-oriented proxies are based on the idea that attentive people act differently than those who do not pay attention to energy-related information. We use one inattention proxy that is based on energy conservation behavior, i.e., turning off the lights more frequently, and two that are based on investment behavior, i.e., considerations for energy efficiency when buying white goods (large appliances such as washing machines and refrigerators) and other electrical appliances. We call these two blocks of inattention indicators (knowledge- and behavior-oriented) "realized" inattention indicators. We presume that these two blocks of "realized" and observable indicators have deeper causes, i.e., transaction costs and cognitive limitations. The last block of determinants influencing the perceptions of energy use costs are socio-economic and other variables, including policies/nudges designed to increase awareness and salience about energy conservation and efficiency among households.[7]

We have identified seven different proxies in our data. The knowledge-oriented proxies consist of four dummy variables indicating (1) whether or not people answered the question about how much one kWh costs, (2) how much electricity their household uses annually, (3) what type of electricity contract they have, and (4) whether or not they are required to pay for their electricity use or whether it is included in their rent. People who answered "I don't know" to the first three questions or indicated that they do not pay for the electricity they use (the fourth question) are here treated as being the inattentive type.[8]

[7] See Figure A 1 in Appendix A for a graphic illustration of the relationships.

[8] The actual survey questions are provided in Appendix B.

The behavior-oriented variables are derived from answers to three questions in the questionnaire. We consider people the inattentive type if they gave answers indicating that they do not think about:

(1) turning off the light to save energy;
(2) energy efficiency when buying white goods;
(3) energy efficiency when buying home electronics such as TVs, stereo systems, and game consoles.

Summary statistics of all key variables and brief descriptions of each variable are presented in Table 1.

Finally, in order to investigate inattention, which is a concept that is not easily measured directly by each of our proxies, we collapse six of the inattention proxies[9] into one interpretable underlying factor ("Factor_Inattention"). The relationship of each inattention proxy to the underlying factor is expressed by the so-called factor loading (see Table A1 in Appendix A).[10]

[9] In the factor analysis the sample is restricted to households that pay electricity bills, and thus it does not include inattention proxy No. 4.

[10] The correlation matrix of all key variables is shown in Table A2 of Appendix A.

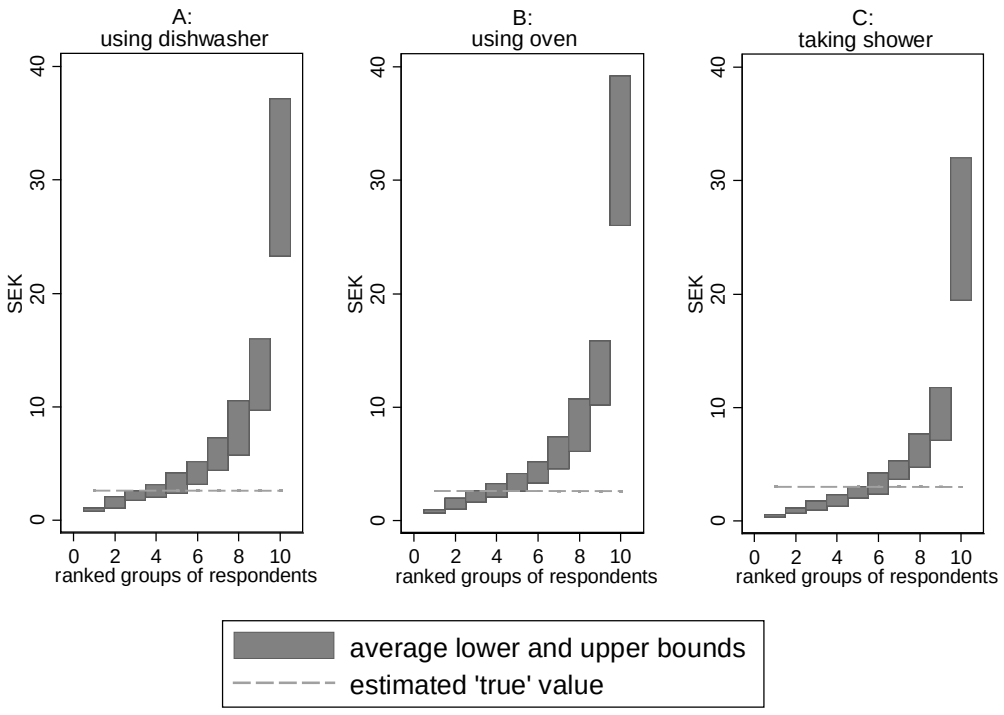
Table 1. Descriptive statistics of the variables of interest

Variable		Obs.	Mean	Std. Dev.	Min	Max
inattention_1	respondent NOT knowing the price of electricity per kWh	918	0.557	0.497	0	1
inattention_2	respondent NOT knowing their household annual energy use quantities in kWh	918	0.377	0.485	0	1
inattention_3	respondent NOT knowing the nature of their electricity contract	918	0.107	0.309	0	1
inattention_4	electricity bill is included in rent payment	918	0.059	0.235	0	1
inattention_5	usually keeps lights on in several rooms, even when nobody is there, and it is common that devices are left turned on or in standby mode, even when not in use	918	0.096	0.295	0	1
inattention_6	does not consider energy efficiency when buying home electronics	918	0.378	0.485	0	1
inattention_7	does not consider energy efficiency when buying white goods	918	0.167	0.373	0	1
L_bound_dish	lower bound of perceived cost of running dishwasher for 2 hours, in SEK	842	6.199	10.906	0.01	100
U_bound_dish	upper bound of perceived cost of running dishwasher for 2 hours, in SEK	836	9.633	14.186	0.01	100
average_dish	average perceived cost of running dishwasher for 2 hours, in SEK	828	7.825	11.670	0.01	100
L_bound_oven	lower bound of perceived cost of using oven at 200ºC for 1 hour, in SEK	856	6.279	10.602	0.01	100
U_bound_oven	upper bound of perceived cost of using oven at 200ºC for 1 hour, in SEK	853	9.347	13.465	0.02	100
average_oven	average perceived cost of using oven at 200ºC for 1 hour, in SEK	842	7.654	11.069	0.02	100
L_bound_shower	lower bound of perceived total cost of taking a hot shower for 5 min., in SEK	858	5.009	10.558	0.01	100
U_bound_shower	upper bound of perceived total cost of taking a hot shower for 5 min., in SEK	856	7.473	12.723	0.02	100
average_shower	average perceived cost of taking a hot shower for 5 min., in SEK	845	6.049	10.390	0.02	100
Age	age	918	54.793	16.788	18	85
woman	gender of respondent	918	0.452	0.498	0	1
hh_size	self-reported household size	914	2.177	1.099	1	8
direct_el_heat	direct electric heating	906	0.146	0.353	0	1
income_hh	household income index based on self-reported income intervals	855	8.227	3.705	1	16
higher_edu	university education or equivalent of more than 3 years	918	0.321	0.467	0	1
comparison	respondents willing to receive information on similar peers' use of electricity	918	0.423	0.494	0	1
past consumption	respondents willing to receive more detailed information on their own past use of electricity	918	0.662	0.473	0	1
appliance use	respondents willing to receive information on the electricity cost of running their appliances	918	0.597	0.491	0	1

4. The results

To get an idea of the respondents' perceptions concerning energy costs, we asked them to estimate the cost of using specific home appliances and taking a shower. Figure 1 shows the distribution of perceived costs. To illustrate the variation, the respondents are divided into 10 groups of equal size. The groups have then been ranked by average perceived costs (the group with the lowest average perceived cost to the left and the group with the highest average perceived cost to the right).

Figure 1: Average cost perceptions of using common home appliances and taking a shower ordered by equal sized groups of respondents: (a) the cost of running a common dishwasher for two hours, (b) the cost of using a typical electric oven for one hour, and (c) the cost of taking a shower for 5 minutes.



Note: Some respondents were removed from this illustrative graph as they provided incredibly high estimates or their responses were missing. The respondents were divided into 10 same-size groups and ranked by their average perceived costs of energy, starting with the lowest and ending with the highest average perceived cost. The groups consist of 82, 84, and 84 respondents, respectively. The suggested "true" costs of energy use (our benchmark) are mainly based on Vattenfall's "Stora Elräknaren" online energy cost calculator.

First, we asked the respondents to estimate the costs of using a dishwasher (two hours) and an electric oven (one hour). The answers to these questions show high variation. The mean of the reported costs differs by a factor of more than 35 between the group with the lowest estimates

and the group with the highest estimates (ranging from SEK 0.86 to 30.18 and SEK 0.77 to 32.55 for dishwasher and electric oven, respectively). A considerable number of respondents gave seemingly unrealistic estimates, increasing the average for the group to the far right in the graph. It should be pointed out that we deleted the most obvious outliers before calculating the averages.[11] On average, the estimated costs are higher than our conservative but realistic benchmarks, meaning that people tend to overestimate the costs.

Second, we asked the respondents to estimate the cost of taking a hot shower for 5 minutes. As shown in Figure 1, the range of estimated costs of taking a shower is similar to the range of estimated costs of using appliances. This suggests that the issue of poor knowledge about relatively small and discreet costs is not confined to the electricity domain. As in the case of electrical appliances, we find somewhat upward-biased beliefs about the costs of taking a shower.

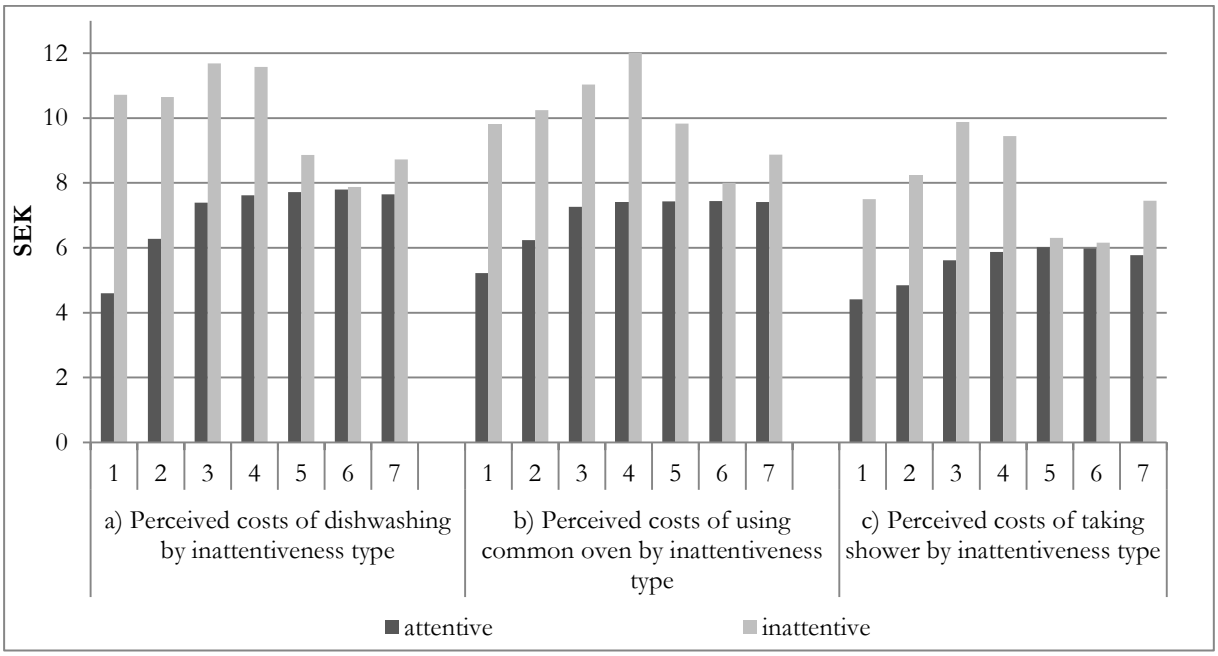
In general, the results of the survey suggest that many households base their decisions regarding energy use on poor knowledge and that people on average perceive energy-related activities as more expensive than they really are.[12]

In our analysis of the relationship between inattention and perceived electricity-related costs, we categorize respondents as being (1) attentive or (2) inattentive. Figure 2 illustrates how average cost perceptions differ between attentive and inattentive people. A consistent pattern emerges for the seven inattention proxies showing that inattentive persons estimate higher costs of using electrical appliances and taking a shower. One can also observe that the differences between inattentive respondents and others are larger for the knowledge-oriented than the behavior-oriented inattentiveness proxy variables. To see if this pattern holds when controlling for socio-economic factors, we employ an interval regression model. The results from the estimation are presented in Table 2.

[11] Note that the "outlier" numbers indicate the observations of the upper bound higher than 100 SEK per use of dishwasher/oven/shower. More details on the breakdown of outliers and other missing observations for perception variables are presented in Table A3 of Appendix A.

[12] There is empirical evidence that people's perceptions are sometimes systematically biased not only in an energy use-related context but also in other common everyday activities. For example, people tend to overestimate the calories in drinks and underestimate the calories in food (Bollinger et al. 2011), or investors tend to have biased perceptions on financial risks and returns (Kaplanski *et al.* 2016).

Figure 2: Average perceptions about the costs of running common electrical appliances and taking a shower. Results presented for seven different inattention proxies.



Note: Each inattention proxy or type (1 to 7) is described in Table 1.

The results confirm the initial descriptive analysis that inattentive respondents generally estimate *higher* costs. However, only the knowledge-oriented proxies are significantly different from zero.[13] These result remain, by and large, insensitive to a number of robustness checks[14], e.g., (1) different model specifications, (2) whether we use lower bound instead of intervals as dependent variable,[15] and (3) different assumptions about the distribution of the error term.[16]

The general pattern of the results somewhat contradicts the notion that inattention causes *lower* price perceptions and, subsequently, too much energy use. On average, the perceived costs are

[13] Also, we considered an additional proxy for inattentiveness to water costs that is based on whether a respondent resides in an apartment or not. In Sweden, most people residing in multi-dwelling buildings do not pay for their individual hot and cold water consumption, meaning that they have little incentive to seek information about the actual costs of their water consumption. The results show no difference between people living in apartments and others in terms of perceived cost of taking a 5 minutes shower.

[14] All the results of our robustness checks can be provided upon request.

[15] One may argue that the lower bound is a better measure of perceptions than a midpoint in the range provided by respondents as the midpoint may be significantly influenced by an extreme upper bound.

[16] Interval regression assumes that the data come from a normal distribution. In our case this is a fairly reasonable assumption, but we still did a robustness check for this assumption by using a range of other distributional assumptions (log-logistic, log-normal, and gamma type of distributions). The results remained consistent with our base models. The robustness check results can be provided by the authors upon request.

50% higher for inattentive than for attentive respondents. We do not have a credible explanation for this finding, but one can speculate that active information (awareness) campaigns stressing the importance of energy and water conservation could have contributed to higher cost perceptions among people with poor knowledge about the costs. Our findings open new theoretical and empirical research questions, i.e., whether these results hold for other goods and services, and what the potential driving forces behind the results are.

Table 2. The effects of each inattention variable (only one inattention variable enters each regression model) on respondents' perception of (1) the cost of running a common dishwasher for two hours, (2) the cost of using ordinary oven for one hour, and (3) the costs of taking a hot shower for 5 minutes (*24 interval regression models, 8 for each dependent variable*)

Variable	dishwasher	oven	shower
	(1-8)	(9-16)	(17-24)
Factor_Inattention	5.7294***	4.9557***	3.0060***
	(1.3530)	(1.2978)	(1.0595)
inattention_1[a]	4.9819***	3.5626***	2.2925***
	(0.8117)	(0.7646)	(0.7529)
inattention_2[a]	2.6940***	2.9970***	1.1757
	(1.0385)	(0.8740)	(0.8671)
inattention_3[a]	1.3654	1.3380	1.7195
	(1.5134)	(1.5578)	(1.5182)
inattention_4[ab]	1.9544	5.4966	4.6281
	(2.6971)	(3.5869)	(3.2989)
inattention_5[a]	0.3249	1.8413	0.7901
	(1.4194)	(1.7681)	(1.6601)
inattention_6[a]	0.3013	0.3251	-0.1844
	(0.8851)	(0.8188)	(0.7815)
inattention_7[a]	2.4568	1.6862	2.1476*
	(1.5070)	(1.2317)	(1.1786)
Age	y	Y	y
woman[a]	y	Y	y
household size	y	Y	y
dir_el_varm[a]	Y	y	y
Observations	792	810	811

*Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*

[a] *Indicates dummy variable*

[b] *We used an unrestricted sample for the regressions with this variable*

The cost perceptions can also be influenced by not only inattention but also other factors. [17] In the analysis we consider the following variables: age, household size, gender, and an indicator of whether the household's heating system manly consist of electric radiators. As expected, we find

[17] More detailed information about the relationship between perceptions and other variables are given in Table A4 of Appendix A. Detailed results of all 24 models can be provided upon request.

that age, which correlates with better knowledge about the energy issues (see Table A2 in Appendix A), is associated with lower perceived costs that are closer to our estimated benchmarks for "correct" costs. Females and larger households generally state higher perceived costs of running appliances. Again, it is difficult to point to a solid reason for this finding, but, as for the gender effect, one can speculate that it might be that females generally know less or are more uncertain about energy issues (see Table A2 in the Appendix A). In addition, it has been found in previous research that females on average are more risk averse than men (see e.g. Borghans *et al.* 2009). It seems like a reasonable hypothesis that a risk averse consumer as a mean to handle uncertainty and avoid high electricity bills presume that the costs of using appliances are high.[18]

As mentioned, only the knowledge-oriented inattention proxies are significant. One tentative explanation for this is that these proxies are to a higher degree associated with heuristics and lesser with calculated decisions and rational inattention. These findings are consistent with the expectation that rationally inattentive consumers know that the use of home appliances are relatively low and do not bother to calculate precise costs, but should in the end largely have the same perceptions as attentive consumers (Gilbert and Graff Zivin 2014).[19]

To test the hypothesis that rational inattentive respondents share the same perceptions as attentive energy consumers, we attempt to create a proxy for *rationally* inattentive respondents. We assume that being rationally inattentive is the result of a calculated decision, i.e., a deliberate decision by a respondent to ignore some information. To construct a proxy for rational inattention, we follow the reasoning by Sallee (2014) by arguing that rational inattention is quite likely for home appliances as inattention is a function of price variation, variation in the differentiation of products in other dimensions than energy efficiency, and the effort cost of paying attention.

[18] We also used other socio-economic variables, such as income and education. We find that high-income respondents and those with university education do not have significantly different cost perceptions than others. This finding is in line with the results in Attari et al. (2010), who find that income and education are not reliable predictors of perceptions of energy saving activities. In order to have parsimonious models and because we have no solid theoretical reason to believe that income or education would be a significant factor in shaping the cost perceptions, we have excluded these variables from our final models.

[19] The expectations of the cost perceptions associated with rational inattention are even more relevant in our case, where the costs occur repeatedly almost every day.

We use two mutually exclusive binary variables to distinguish between the properties of different consumers described in Table 3.[20] First, as a proxy for attentiveness we use a binary variable where the value 1 represents households stating that they pay attention to energy efficiency when shopping for both electricity-consuming white goods, such as refrigerators, AND other electricity-consuming products, such as stereo systems and TVs, for which energy efficiency is expected to play a minor role in the consumers' decisions. Second, as a proxy for rational inattentiveness, we use a binary variable where the value 1 represents households stating that they pay attention to energy efficiency when shopping for electricity-consuming white goods but NOT when buying other electricity-consuming products, such as stereo systems and TVs, for which energy efficiency is expected to play a minor role in the consumer decision making.

Table 3. The construction of indicators for two cases, rational inattention and attentiveness, and respondents' perceptions of (1) the cost of running a common dishwasher for two hours, (2) the cost of using an ordinary oven for one hour (at 200ºC), and (3) the cost of taking hot shower for 5 minutes.

	Cases to consider	
	Rational inattention	Attentiveness
Inattention_7	1	0
Inattention_6	0	0
Obs.	206	559
Dishwasher	7,748	7,612
Oven	7,691	7,312
Shower	5,551	5,854

Table 4. Comparison between attentive and rationally inattentive respondents regarding their perception of (1) the cost of running a common dishwasher for two hours, (2) the cost of using an ordinary oven for one hour (at 200ºC), and (3) the cost of taking hot shower for 5 minutes.

Variable	dishwasher	oven	Shower
	(1)	(2)	(3)

[20] The two groups of interest do not cover all respondents. The remaining respondents are inattentive to energy costs in both cases or only attentive to energy efficiency when buying stereos, TVs, etc. For clarity reasons we do not consider this group here. However, the inclusion inattentive people and others as a third binary variable would not affect the results in Table 4 in any significant way.

inatt_rational	-0.3982	0.0059	-1.0764
	(0.8702)	(0.9555)	(0.8526)
age	-0.0660**	-0.0486**	-0.0810***
	(0.0262)	(0.0226)	(0.0262)
woman[a]	1.8540**	1.2309	1.3686*
	(0.7830)	(0.7786)	(0.7394)
household size	0.5515	0.5946	1.3076**
	(0.4282)	(0.5142)	(0.5193)
dir_el_varm[a]	0.4679	1.5992	0.2274
	(1.0459)	(1.1966)	(0.8471)
Constant	8.7403***	7.5635***	6.7188***
	(2.0163)	(2.0437)	(2.2067)
Observations	664	682	683
log	-2065	-2166	-2336

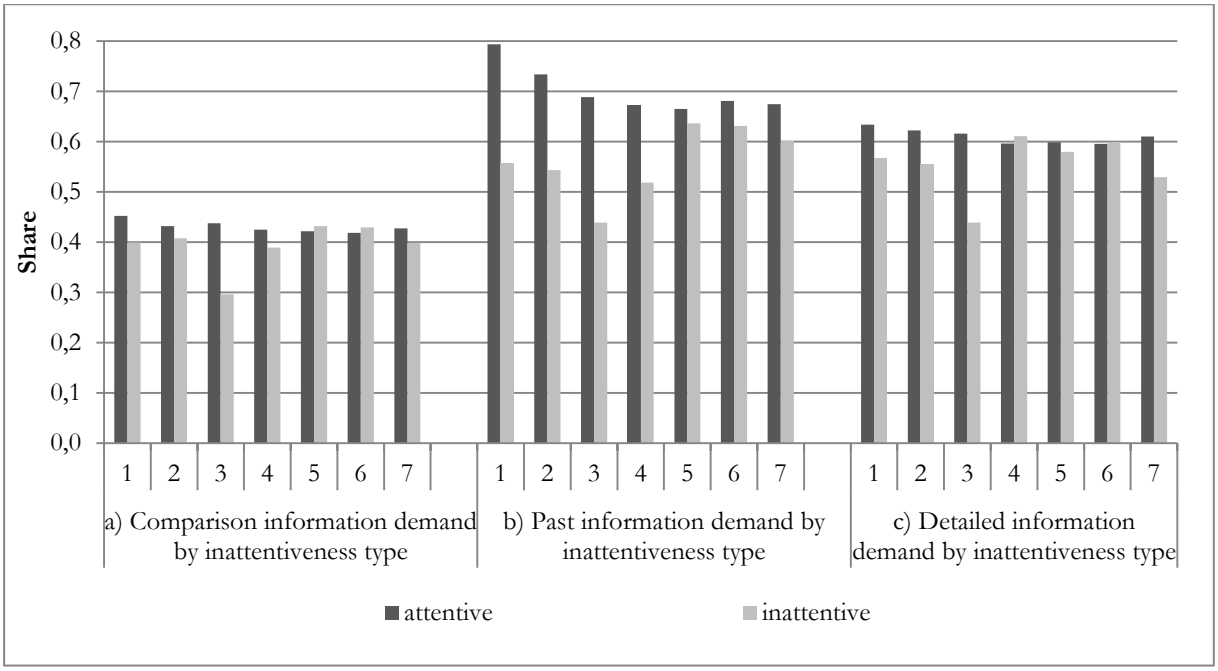
*Note: robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*
[a] indicates dummy variable

The results in Table 4 show that rationally inattentive respondents are not significantly different from attentive ones. As noted above, we do not claim that we can identify rational inattention well enough to draw any strong conclusions here. However, our results indicate that, as one would expect, rationally inattentive people have similar perceptions of the costs of using common electricity appliances and taking a shower as attentive respondents. We can speculate that the strong positive relationship we find between inattention and the cost perceptions (see Table 2) is less likely related with rational inattention and more with "heuristics."

Our finding that many respondents, in particular inattentive ones, have poor and biased knowledge about energy-related costs raises the question of whether customized information campaigns would be beneficial to them. We address this question by directly asking people whether they wish to receive information that (i) compares their energy use with other similar households, (ii) compares their energy use with their own past consumption, and/or (iii) highlights the operating cost of electric appliances.

The data show that the respondents are in favor of receiving more detailed information about their energy use, but also that they are not as enthusiastic about getting information on the energy use of similar households. Almost half of the survey participants expressed a negative opinion about the possibility of being compared with peers. Figure 3 shows that there are differences between inattentive and more attentive respondents regarding the willingness to receive information. Again, as with cost perceptions, the differences are more profound for inattentive people in terms of their knowledge about electricity price, use, and contracts. To understand better how inattention and other factors can possibly be associated with the (un)willingness to receive information on private energy use, an econometric analysis based on probit models is performed.

Figure 3: The share of respondents willing to receive information on: (a) comparison of their neighbor electricity use, (b) their past electricity use, and (c) cost details for using electric home appliances. Results presented for seven different inattention proxies.



Note: Each inattention proxy or type (1 to 7) is described in Table 1.

The results are presented in Table 5 and show that inattentive respondents are less willing to receive additional information about their actual and relative use of electricity and the costs of running appliances. This result is in line with the recent findings of Palmer and Walls (2015), which focus on homeowners' willingness to receive information in the form of home energy audits. Based on responses from U.S. homeowners, the study finds that marginal effects of going from fully attentive to fully inattentive lowers the probability of getting an audit by roughly 11 percent.[21]

[21] We also find that other socio-economic variables, such as age and education, are significant factors explaining the willingness to receive customized information. More information of the relationship between willingness to receive customized information and other variables are shown in Table A4 of Appendix A. Detailed results of all 24 models can be provided upon request.

Table 5. Marginal effects of inattention indicators (only one inattention variable enters each regression model) explaining willingness to *receive certain* information (24 probit models, 8 for each dependent variable)

VARIABLES	Willing to *receive* information on		
	comparison	past consumption	appliance use
	(1-8)	(9-16)	(17-24)
Factor_Inattention	-0.1360**	-0.3362***	-0.1848***
	(0.0543)	(0.0507)	(0.0536)
inattention_1[a]	-0.0714**	-0.2043***	-0.0925***
	(0.0363)	(0.0326)	(0.0353)
inattention_2[a]	-0.0609	-0.1781***	-0.0992**
	(0.0389)	(0.0379)	(0.0390)
inattention_3[a]	-0.2230***	-0.2482***	-0.2227***
	(0.0520)	(0.0619)	(0.0609)
inattention_4[a]	-0.0522	-0.1254*	-0.0120
	(0.0720)	(0.0739)	(0.0729)
inattention_5[a]	-0.0010	-0.0557	-0.0474
	(0.066)	(0.0568)	(0.0573)
inattention_6[a]	-0.0108	-0.0690**	-0.0010
	(0.0358)	(0.0342)	(0.0354)
inattention_7[a]	-0.0410	-0.0870*	-0.0945**
	(0.0457)	(0.0457)	(0.0467)
higher_education[a]	y	y	y
age	y	y	y
woman[a]	y	y	y
household size	y	y	y
dir_el_varm[a]	y	y	y
income_hh	y	y	y
Observations	847	847	847

*Note: robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*
[a] indicates dummy variable

It is somewhat worrying that inattentive types tend to be less eager to receive customized information. It indicates that information campaigns targeting inattentive energy users might not be as welfare enhancing as previous policy evaluations have suggested on the basis of their effects on energy savings, not social welfare. Our finding regarding households' widespread unwillingness to be part of the information campaign, as we define it, complements the recent finding by (Allcott and Kessler 2015), who carry out a comprehensive welfare evaluation of sending home energy conservation reports. They conclude that such information campaigns can have even detrimental effects on overall welfare gains of such policies, in particular for the households who state negative willingness to pay for free customized information.

5. Conclusions

Households typically receive utility bills lumping together all electricity use during a fixed period of time. The lack of direct feedback in the form of marginal costs of using specific electrical

appliances reduces the attention people give to their energy consumption and potentially leads to mistakes in households' decision making. In this paper we study people's perceptions about the marginal cost of using common household appliances and taking showers and how these perceptions relate to inattention to energy issues.

In the empirical analyses, we use Swedish survey data collected in 2014. The survey included questions regarding cost perceptions, behavior related to energy use, and willingness to receive customized information. We find a wide range of perceptions and that many people use energy under imperfect knowledge about costs. We also find that people on average have relatively high cost perceptions compared with our (realistic) benchmark values. However, despite poor knowledge about the costs of running common household appliances or taking a shower, a large proportion of households are not willing to receive customized information to help them improve their knowledge. In the context of these findings, we formulate and address two main questions in this paper. First, do cost perceptions differ between attentive and inattentive households? Yes, the results show that inattentive respondents generally have *higher* cost perceptions. This result somewhat contradicts the general presumption that inattention causes *lower* price (cost) perceptions and, subsequently, too much energy use. Second, do households, in particular inattentive ones, who have poor knowledge about energy demands and costs, want to receive customized information? No, many households with poor knowledge about energy demands and costs (inattentive) are less willing to receive information about their own and others' energy use and about the cost of using specific appliances. As for future research in this area, it would be interesting to investigate whether the unwillingness to receive information translates into disutility if information is forced on them. Any findings to this effect would signal that the welfare effect of social nudges may be lower than suggested in previous literature.

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Appendix A

Figure A 1: The illustration of relationships among perceptions, inattention, and other factors

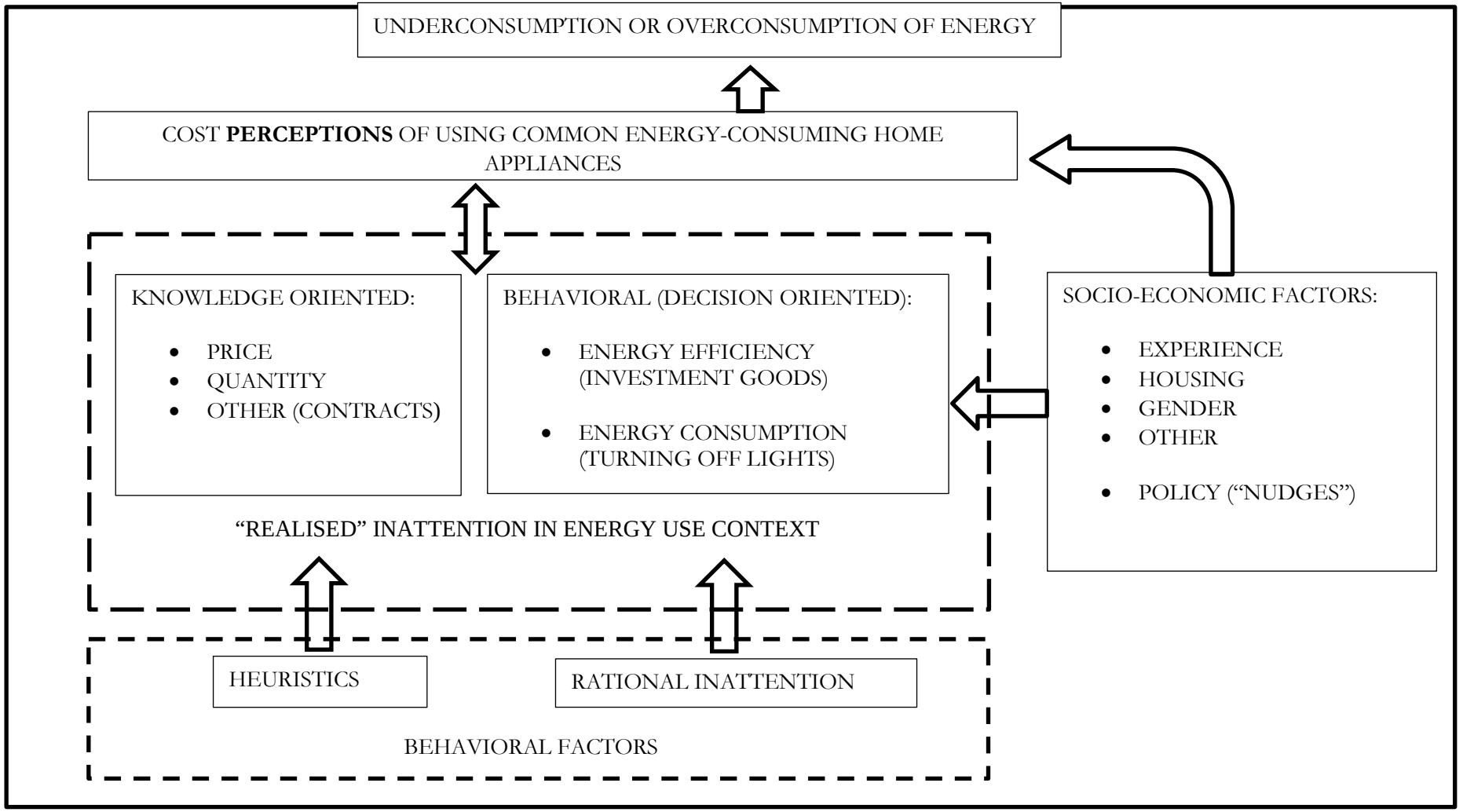

Table A1. Scoring coefficients for the factor of inattention

Variable	Factor_inattention
inattention_1	0.243
inattention_2	0.350
inattention_3	0.199
inattention_5	0.049
inattention_6	0.242
inattention_7	0.273

Table A2. Correlation matrix of the selected variables

	av_dish	av_oven	av_shower	factor_inat	inatt_1	inatt_2	inatt_3	inatt_4	inatt_5	inatt_6	inatt_7	age	woman	hh_size	el_heat
av_dish	1.00														
av_oven	0.78	1.00													
av_shower	0.73	0.77	1.00												
factor_inat	0.21	0.19	0.16	1.00											
inatt_1	0.43	0.30	0.23	0.76	1.00										
inatt_2	0.22	0.22	0.21	0.86	0.67	1.00									
inatt_3	0.13	0.12	0.15	0.69	0.52	0.66	1.00								
inatt_4	0.13	0.14	0.10	0.28	0.21	0.44	-	1.00							
inatt_5	0.06	0.10	0.03	0.31	0.14	0.11	0.15	-0.27	1.00						
inatt_6	0.02	0.02	-0.03	0.65	0.01	0.09	0.10	0.18	0.31	1.00					
inatt_7	0.07	0.06	0.06	0.70	0.07	0.11	0.19	0.20	0.34	0.83	1.00				
age	-0.17	-0.16	-0.21	-0.31	-0.23	-0.36	-0.32	-0.20	-0.10	-0.15	-0.13	1.00			
woman	0.13	0.09	0.12	0.17	0.38	0.30	0.09	0.13	-0.04	-0.15	-0.11	0.00	1.00		
hh_size	0.11	0.10	0.18	-0.04	-0.05	-0.07	0.09	-0.20	0.05	-0.01	-0.04	-0.30	-0.13	1.00	
el_heat	0.00	0.07	0.03	-0.21	-0.12	-0.34	-0.21	-0.39	-0.05	-0.07	-0.01	0.20	-0.02	0.14	1.00

Table A3. A breakdown of missing observations for perception variables

	dishwasher	oven	shower
both bounds are zeros	28	12	16
lower bound is missing or zero	18	18	17
upper bound is missing	7	11	10
No-answer[a]	23	25	24
Outliers[b]	12	8	6
upper bound is smaller than lower bound	2	2	0
Total	90	76	73

[a] *Note that respondents had no option to state that they did not want to answer the question, i.e., they had to enter a response in order to proceed to the next question. "No-answer" numbers indicate how many respondents wrote "Do not know," "-", "??" etc. in order to avoid providing their estimates.*

[b] *Note that the "outlier" numbers indicate the observations of the upper or lower bound with higher than 100 SEK per use of dishwasher/oven/shower.*

Table A3. Relationship between perceptions and selected control variables

	dishwasher		**oven**		**shower**	
Variable	**sign**	**significant?**	**Sign**	**significant?**	**sign**	**significant?**
age	negative	y	negative	y	negative	y
woman[a]	positive	y	positive	y	positive	y
household size	positive	y	positive	y	positive	y
dir_el_varm[a]	positive	no	positive	no	positive	no

[a] *indicates dummy variable*

Table A4. Relationship between willingness to receive customized information and selected control variables

	comparison		**past information**		**appliance use**	
Variable	**sign**	**significant?**	**sign**	**significant?**	**sign**	**significant?**
higher_education[a]	positive	yes	positive	yes	positive	no
age	negative	yes	negative	yes/no	negative	yes
woman[a]	positive	no	negative	y	positive	yes
household size	positive	no	negative	no	positive	no
dir_el_varm[a]	positive	yes	positive	yes	positive	no
income_hh	positive	no	positive	no	positive	no

[a] *indicates dummy variable*

Appendix B

Inattention to price (No. 1): To get an idea of people's awareness of electricity prices, we asked people about the perceived price of using one kWh electricity. The respondents were asked to state intervals. About half of the respondents declined to provide their perceptions by stating that they have no idea (in Swedish "ingen uppfattning") about the cost of electricity. Among the respondents stating an interval, a majority were quite close to a reasonable price of using one kWh of electricity. However, a considerable number of respondents gave quite unrealistic numbers. These respondents were indicated as inattentive to price. [22] The actual question was:

> *Hur mycket skulle du spontant säga att det kostar er att idag förbruka en kilowattimme el i er bostad?*
>
> *Om hushållet inte har ett eget elavtal, utgå då ifrån vad du tror att det kostar er hyresvärd eller er bostadsrättsförening. Vi vill att du svarar på frågan utan att söka efter rätt svar (t.ex. via internet eller gamla elräkningar).*
>
> *Circa från _ _ , _ _ kronor till _ _ , _ _ kronor*

Inattention to quantity (No. 2): To get an idea of people's general awareness of their household's annual energy use in kWh, we asked how much electricity they used in 2013 and gave them eight options with the broad ranges of their annual electricity use:

> *Hur många kWh el förbrukade ditt hushåll totalt under 2013?*
>
> *Titta gärna på en tidigare elräkning innan du svarar.*
>
> ❍ *0 – 3000 (1)*
> ❍ *3000 – 6000 (2)*
> ❍ *6000 – 10 000 (3)*
> ❍ *10 000 – 14 000 (4)*
> ❍ *14 000 – 20 000 (5)*
> ❍ *20 000 – 26 000 (6)*
> ❍ *26 001- (7)*
> ❍ *Vet ej (8)*

We classified respondents who chose the last option (No. 8, "I do not know") as inattentive to the quantities of electricity they use.

Inattention to contract type or cases of electricity bills included in rent (No. 3 and No. 4): For this, we asked what type of contract they currently have (variable rate, fixed rate or default rate):

> *Vilken typ av elavtal har ni för närvarande (avseende bindningstid)?*
>
> ❍ *Elavtal med rörligt pris (per timme eller månad) (1)*
> ❍ *Elavtal med bundet pris (1-5 år) (2)*
> ❍ *Har det elavtal som erbjöds vid inflyttning (tillsvidareavtal/anvisningsavtal) (3)*
> ❍ *El ingår i hyra/avgift (hushållet har inget enskilt elavtal) (4)*
> ❍ *Annat (5)*_____

[22] If the upper bound of the provided electricity price was higher than SEK 2.5 we classified the respondent as price inattentive. We also considered a number of sensitivity analyses by defining the price inattentiveness with higher thresholds (SEK 50 and SEK 100 for the upper bound), but our key analysis results remained virtually unchanged.

❍ *Vet ej (6)*

We classified the respondents who chose the last option (No. 6, "I do not know") as inattentive to their electricity contract and the respondents who chose option No. 4 ("electricity is included my rent") as households not paying for their electricity use.

Inattention to energy conservation (No. 5): To identify the respondents who typically keep lights on in several rooms and keep their devices in standby mode, we asked the following question and provide 3 options to choose:

Vilket av följande alternativ överensstämmer bäst med ditt hushåll när det gäller elanvändning?

❍ *Vi tänker på att släcka lampor i rum där vi inte är och stänger av apparater som vi inte använder. (1)*
❍ *Det står tänt i många rum - även de vi inte befinner oss i och det är vanligt att apparater står på, eller i standbyläge, även då ingen avser att använda dem. (2)*
❍ *Inget av ovanstående. Vi upplever oss vara mitt emellan de ovanstående alternativen. (3)*

We classified the respondents who chose the last option (No. 2) as inattentive to their electricity conservation.

Inattention to small energy efficiency savings (No. 6): To identify the respondents who do not consider energy efficiency when buying home electronics (relatively less energy-consuming goods), we asked the following question:

Hur resonerar ni i ert hushåll när det gäller inköp av hemelektronik (t.ex. stereo, TV, datorer och spelkonsoller)?

❍ *Vi väljer bara bland produkter som är energisnåla även om de kan ha ett högre pris. (1)*
❍ *Vi väljer energisnåla produkter även om de kan ha ett högre pris så länge det inte innebär uppoffringar i fråga om andra egenskaper (t.ex. utseende och prestanda). (2)*
❍ *Vi beaktar inte energieffektivitet vid inköp. Vi styrs av inköpspris och andra egenskaper. (3)*
❍ *Vet ej (4)*

We classified respondents who chose option No. 3 as inattentive to energy efficiency characteristics.

Inattention to larger energy efficiency savings (No. 7): To identify the respondents who do not consider energy efficiency when buying white goods (generally more energy-consuming goods), we asked the following question:

Hur resonerar ni i ert hushåll när det gäller inköp av vitvaror?

❍ *Vi väljer bara bland produkter som är energisnåla även om de kan ha ett högre pris. (1)*
❍ *Vi väljer energisnåla produkter även om de kan ha ett högre pris så länge det inte innebär uppoffringar i fråga om andra egenskaper (t.ex. utseende och prestanda). (2)*
❍ *Vi beaktar inte energieffektivitet vid inköp. Vi styrs av inköpspris och andra egenskaper. (3)*
❍ *Vet ej (4)*

Again, we classified respondents who chose option No. 3 as inattentive to energy efficiency characteristics.