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What motivates smart meter adoption? Evidence from an experimental advertising campaign in Germany

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ABSTRACT

Motivating individuals to engage in transformative behaviors aimed to mitigate the adverse effects of climate change seizes to be a large challenge of environmental social science. In particular, in remains unclear how to best promote the uptake of novel, digital technologies when it comes to efficient energy management. To contribute to this challenge, the present *Perspective* investigates factors associated with energy customers' interest in smart meters, based on an exploratory pilot field experiment in Germany (n = 4,147 clients of a German energy firm). Specifically, we set up an online field experiment and vary the arguments emphasized towards its actual customers (medium to large customers) that speak in favor of using a smart meter in an advertising campaign initiated by the firm. We find that customers are particularly interested in the technology when they learn that it may enable them to realize savings (as compared to environmental, technological or legal reasons). This result crucially adds to contrary results emphasizing moral (i.e., environmental) motives, suggesting that it may be detrimental to shift focus away from financial motives when promoting digital technologies in the energy market, particular among medium to large consumers of energy.

1. Introduction

The digitalization shapes many parts of our lives and is likely one of the most important developments for the economy of the future [1,2]. Within the energy sector, digital technologies are also seen as a promising way to mitigate climate change via the demand side as smart grids may contribute to demand management through various approaches [3–5]. Digital technologies may be especially promising in leveraging behavioral policy tools, as they – for example – enable better provision of real-time feedback or social comparison information to consumers [6–8]. Relatedly, economic innovations targeting consumer behavior such as dynamic pricing also require smart grids [9] and, finally, smart grids may facilitate the inclusion of volatile renewables into the energy mix [10].

Despite these potential advantages, many consumers remain reluctant, disinterested, or even suspicious when it comes to the adoption of digital technologies in their personal environment [11]. As a result, this reluctance may impede the dissemination and pace of technological advancement in demand-side mitigation. As managing energy via smart grids requires all end-users to be equipped with intelligent measuring and communication devices (i.e., smart meters), broad adoption is necessary. Thus, motivating individual consumers to adopt the technology is a central research challenge in an effort to reap the full scope of the current technological potential to mitigate climate change.

This *Perspective* contributes to this challenge and reports on an explorative field experiment in collaboration with a German energy supplier. The experiment was conducted to increase the evidence base about how to motivate consumers to take up digital technologies that enable smart grids. Our research builds on existing work in the domain of technology adoption and climate-friendly behaviors. Importantly, however, the existing literature on customers' interest in smart meters is overwhelmingly correlational in nature [c.f. [12]], mainly concerned with small household customers, and often based on hypothetical surveys (i.e., "stated", rather than "revealed" preferences, e.g., [13]. Additionally, causal evidence based on field experimentation is largely missing in the research on consumer interest in smart meters. This *Perspective* contributes to fill this gap.

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2. Drivers of interest in smart meters

Although causal evidence is scarce thus far, previous research has investigated consumers' interest in smart meters. On a general level, the prior literature on the acceptance of as well as the interest in smart meters is diverse. It has resulted in ambiguous and sometimes even conflicting findings [[14,15] for overviews]. For example, Ngar-yin Mah et al. [16] report strong interest in smart grid technology based on a survey conducted in Hong Kong. Similarly, Kaufmann et al. [17] observe that Swiss consumers perceive a positive value from smart metering and have a (hypothetical) willingness to pay for it. Li et al. [18], on the contrary, show that most consumers are unfamiliar with the concept of smart grids and that monetary incentives are the biggest motivation for the adoption of smart grid technologies. Gernott and Paukert [19] study the determinants of people's hypothetical willingness to pay (WTP) for smart meters and observe that a high degree of data security and people's aim to change their energy consumption behavior are positive contributors to WTP. Krishnamurti et al. [20] also report a strong interest in smart meters, but find that this interest depends on how well counter-arguments (e.g., loss of control, privacy issues, or increased cost) are addressed. In this light, Hmielowski et al. [21] observe that people's experiences with privacy violations, the perceived social norm of adopting the technology, or the individual technology-readiness are important factors associated with people's interest in smart meters. Milchram et al. [22] emphasize the importance of moral values for the acceptance of smart grid technologies. Similarly, Peters et al. [23] find that the acceptance of smart meters is in general rather low but that it increases in case environmental aspects are made salient. In an additional media analysis as well as in expert interviews, however, they find economic frames to be particularly important. Bugden and Stedman [24] show that communication towards potential customers should foster familiarity with the technology and emphasize the potential climate benefits of smart meter-related developments. Finally, Spence et al. [25] collect a UK-representative survey on people's perception regarding the transformation of the energy system. They observe that in particular those customers who are concerned about climate change are willing to engage in demand-side-management strategies. As evidenced here, the previous research findings are very diverse and mostly lacking causal manipulations to study the drivers of individual technology uptake. Thus, we contribute a field experiment to test how consumers respond to various messages (as in [26,27]).

3. Field experiment

3.1. Study context and participants

Our study involves an exploratory, natural field experiment, in which we observe behavior in energy-consumers' natural decision-making environment without their awareness. By tracking people's information acquisition decisions, we study actual behavior as was done in previous research (e.g., [26]) and thereby their "revealed preferences" rather than mere survey answers (i.e., their "stated preferences"). Thus, we can rule out social desirability and hypothetical bias in participant behavior and complement the existing research that is predominantly grounded in stated preference approaches.

In particular, our exploratory field experiment addresses the effectiveness of different promotion-framings on consumers' willingness to acquire further information regarding smart meters. In total, 4147 unique customers of a German energy supplier participated in the study, which lasted seven weeks. Per restriction from the energy supplier, the study participants were larger households and small firms with more than 6000 kWh annual consumption and those not yet equipped with smart metering technology. The study focused on this customer group as it likely has higher saving potential compared to small households. As agreed with the energy provider, the experiment did not collect any further socio-demographic data, a method that is often used in field experiments and field surveys involving sensitive customer data to preserve data protection issues (e.g., [17,28]).

The experimental manipulation itself was embedded into the platform in which customers report their annual energy use or change necessary contract details (e.g., payment information, pre-payment amounts, administrative issues, etc., see Fig. 1 for an illustration of the decision environment). Annually, all energy consumers are – at least once – required to log on the platform to report their energy use. In addition, consumers can log on at any time in case they want to adjust further elements from their contracts (e.g., bank details, other billing or administrative issues, etc.). All participants entered the experiment without being prompted to participate in a scientific study.

3.2. Implementation of experimental variation and behavioral measures

In collaboration with the energy supplier, we implemented five different study conditions, one of which was randomly presented to a participating customer. Each study condition involved a different "framing". As frames, we chose a savings framing ("Save energy") to appeal to basic savings incentives, an environmental framing ("Clever and good for the environment"), a progressive framing ("Clever and trendy") and two types of legal requirement framings (e.g., "Clever and soon compulsory"). Per guidelines from the energy supplier, the two legal requirement framings were either combined with the environmental or the technological framing on the second screen (see Fig. 1). Whereas appealing to savings follows basic economic principles, we chose the other framings to affect the psychological self-concepts regarding environmental-friendliness, technological-progressiveness, or law-obedience that are highlighted as important in the previous literature concerning technology adoption.

Our dependent variable is the observed behavior of people through the customer journey. Specifically, we recorded how customers proceeded through the web interface and whether they finally ordered an information package about smart meter use. First, customers could click directly on the advertisement, presented in the customers' log-in area (see Fig. 1). Upon clicking the advertisement, interested customers received further information in line with the respective frame and could then click on a button labeled "more information". This led them to a screen where they could enter and submit their email address in order to receive the information package. Our key dependent variable is this final submission of the email address, but the experiment also allows to track behavior through the various previous stages. As our experiment is exploratory based on heterogeneous findings in the literature, we did not test pre-registered hypothesis.

3.3. Results

The randomization of the 4147 customers was realized using the company's randomization tool and resulted in 875 observations in the savings frame, 854 in the environmental frame, 841 in the progressive frame, and 793 (or 784) in the two legal frames. As our field experiment uniquely focuses on behavioral measures without any additional demographic variables, the main experimental outcome is the behavioral heterogeneity depending on the experimentally varied "framing". Table 1 summarizes the results of the experiment.

As described above, we observed customer behavior on the homepage across several stages. The third column of Table 1 ("Ad clicks") shows the share of customers clicking on the ad in the respective experimental conditions. The fourth column shows the shares of those who also clicked on "more information" on the second page. The fifth column shows the share of consumers finally submitting their email addresses, thereby triggering the sending of the information package. The latter serves as our main variable of interest as it indicates how many customers actually received the information package regarding smart meters, depending on condition.

The experimental results show the relative importance of appealing

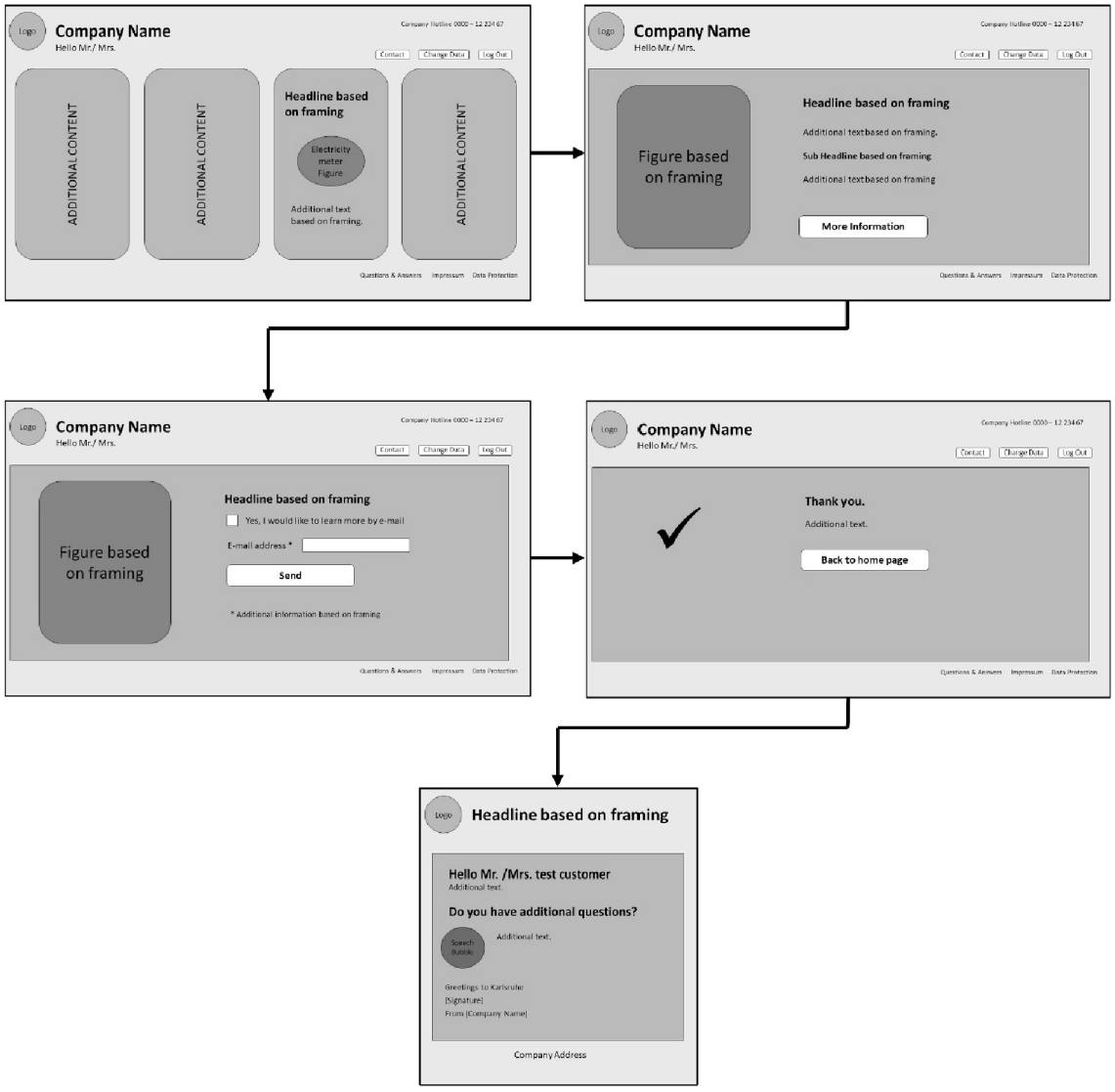

Fig. 1. Illustration of decision environment Notes: The figure shows how consumers were guided through the experiment. The experimental manipulation took place in the top-left corner, systematically varying the message (i.e., "frame") displayed. The other information was adopted accordingly. The figure resembles the actual decision environment without revealing the identity of the energy supplier, which is protected by an NDA.

Table 1
Main results, by message framing.

Framing	Ad displays	Ad clicks	Submitted "more information"	Submitted "email address"
1. Savings framing	875 (100%)	169 (19.3%)	131 (15.0%)	75 (8.6%)
2. Environmental framing	854 (100%)	84 (9.8%)	71 (8.3%)	36 (4.2%)
3. Progressive framing	841 (100%)	100 (11.9%)	76 (9.0%)	41 (4.9%)
4. Legal framing (+socio-environmental)	793 (100%)	255 (16.2%)	181 (11.5%)	83 (5.3%)
5. Legal requirement (+technological)	784 (100%)			
Total	**4147 (100%)**	**608 (14.7%)**	**459 (11.1%)**	**235 (5.6%)**

to general energy savings in our sample. The probability that customers click on the advertisement in the first place is 19.3 % and thereby larger in the savings frame than in the environmental frame (9.8 %, $p < 0.01$, two-sided test of proportions) and the progressive frame treatment (11.9 %, $p < 0.01$, two-sided test of proportions). We further observe a small difference between the financial and the combined legal frames treatment (16.2 %, $p < 0.05$, two-sided test of proportions).

In the next stage, the results are similar. The share of customers who click also on the next link is higher in the savings framing (15.0 %) than in the environmental framing (8.3 %, $p < 0.01$, two-sided test of proportions), the technological progressiveness framing (9.0 %, $p < 0.01$, two-sided test of proportions), and the combined legal framings (11.5 %, $p < 0.05$, two-sided test of proportions).

Finally and with respect to our main variable of interest, the savings framing turns out to be the most successful one. In the corresponding treatment, the uptake rate is 8.6 %. This share is a significantly larger than the shares in the other treatments (4.2 % in environmental, 4.9 % in progressive, 5.3 % in legal, at least $p < 0.05$, two-sided tests of proportions). No other two frames differ significantly from each other in the probability that customers submit their email address.

In sum, our exploratory study suggests that the savings campaign

triggered most clicks initially and consistently kept this advantage until the final submission of the email address. The environmental framing proved – by trend – least successful.

4. Discussion and conclusion

In an explorative field experiment involving about 4000 clients of a German energy supplier, this *Perspective* provides results from an exploratory field experiment and support for the efficacy of a "savings framing" when it comes to increasing uptake of smart metering. Supplementing a large body of correlational findings obtained from surveys (i.e., "stated preferences"), the present research complements existing findings with a brief explorative field experiment testing the causal effect of various advertisement frames and their efficacy to promote smart meter use. We find that the savings frame nearly doubled customers' likelihood of acquiring information regarding smart meters compared to appeals to an environmental, technological-progressiveness, or the legal requirement framing. Thereby, our results provide additional data points to the existing evidence-base, showing that medium and large customers' actual behavior may be more strongly affected by savings rather than by environmental arguments, which have also been often emphasized in prior survey studies [c.f. [26]].

Of course, our experiment should be interpreted carefully due to limitations in the research design that may affect generalizability. First, our study involves large households and small firms in a single market (i.e. Germany). Our results may therefore not be translatable to small households, large companies, or other regions. In addition, our research is essentially mute on the psychological mechanisms, as is often the case in field research. Therefore, our research is intended as a supplement to laboratory or survey research to provide further data on people's decision making in naturalistic environments. Future research can take various avenues. For example, (field) experiments could manipulate more details of the economic incentives and investigate when these materialize or extend the findings of this *Perspective* to small households. Importantly, as our research did not collect any personal information and uniquely focuses on average treatment effects of the presented framings, future confirmatory research could more carefully investigate interaction effects with demographics and thereby study how particular subsets of the population respond to various incentives. A deeper knowledge of the customer could lead to "targeted" framings that work particularly well on a specific customer.

To conclude, our explorative research on smart-meter uptake shows a behavioral impact of framings emphasizing "savings" in a natural decision-environment. When approaching medium and large energy consumers, it seems reasonable to emphasize potential savings to convince them to make use of new digital technologies. On a more general level, our research relates to existing work on households and smart meter interest [29–31] as well as a recent call for more field research on monetary versus non-monetary incentives in energy behavior [32]. Liebe et al. [32] particularly call for more covert studies that rule out experimenter demand effects and studies that aim to partial out the unique role of monetary information. And in fact, behavioral research in the domain of energy research may be best if relying on multiple methods, such as field experiment without much control over the experimental situation and surveys and laboratory studies, which are able to investigate details of the psychological mechanisms governing behavior.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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