

Domestic uptake of green energy promoted by opt-out tariffs

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Motivating individuals to choose energy from sustainable sources over conventionally produced power constitutes one of the biggest policy challenges for societies^{1,2}. Here we present the results of a randomized controlled trial in Germany that tested the impact of default rules (that is, a type of 'nudging') on voluntary purchases of 'green' energy contracts that entirely stem from renewable resources. Setting the default choice to more expensive 'green' energy (that is, where consumers have to actively opt out if they do not want it) increased purchases of such nearly tenfold. Furthermore, county-level political preference for the green party uniquely predicted behaviour in the absence of the nudge, suggesting that default setting potentially overrules motivational aspects of green energy purchases. In follow-up experiments, we provide further evidence that the effect does not seem to be driven by unawareness. Summarizing, the present research provides an example of using behavioural science³⁻⁹ for climate change mitigation and shows alternatives to the use of subsidies or other economic incentives.

As there is a broad consensus that consumer behaviour presents a viable opportunity for mitigating climate change, a core question for scientists and policymakers alike is how to effectively promote environmentally friendly behaviour on the large scale. Especially regarding climate change mitigation, scientists have tried to augment 'green' (that is, pro-environmental) behaviours of the general public by scaling up 'behavioural principles' derived from laboratory experiments¹⁻⁹. Being coined 'nudging'^{7,10}, this method has become popular among policymakers who are now capable of subtly steering individual decisions towards goals set by them without using coercion. However, even though research on 'nudges' and, in particular, non-binding defaults¹¹⁻¹³ has delivered promising results in various domains of social and economic policy, no research has thus far tested its efficacy in the case of energy-related behaviours. 'Default nudges' typically manipulate initial choice-sets without infringing liberty or autonomy but still affect a person's decision. They have been characterized as the 'choice alternative a consumer receives if he/she does not explicitly specify otherwise' (p. 592; ref. 14), a notion that is widely agreed on in the literature¹⁵⁻¹⁷. Defaults allow a pronounced change in outcomes and help to promote policy goals such as sufficient organ availability, lack of old-age poverty, or—in our case—reduction of greenhouse gases. Probably the most widely known example of nudging by default-setting stems from organ donation¹¹. A simple difference can be sufficient to provide different participation rates as shown by country-level correlations between locally set default rules and outcomes. Opt-out rules lead to high participation,

whereas actively opting in keeps participation at low levels in the respective countries¹¹.

Here, we test whether this principle can also be applied to the domain of energy choices in a large sample of German households, trying to nudge households towards purchases of 'green' energy in a randomized controlled trial (RCT). With purchasing a 'green' energy contract, the company guarantees the consumer to add their individual consumption to the energy mix in the form of energy from renewable resources. Although the impact of a single consumer's energy use on a country's total energy consumption is negligible, purchasing 'green' energy can be viewed as the consumer's decision to voice their preference regarding a country's energy mix.

Therefore, we augment previous behavioural scientific research interested in sustainable behaviour. This research has addressed, for example, social effects such as comparisons and norms^{3,9}, technical advice⁸, and public commitment² as tools to pursue energy-policy-related goals involving energy and water conservation. Besides social effects, behavioural science that aimed to increase pro-environmental behaviour has also focused on people's psychological self-concepts¹. Results suggest that biospheric framing can be sometimes more effective than economic framing as many consumers like to perceive themselves as pro-environmental.

Therefore, we attempt to use a 'nudge-based' approach to steer consumers towards the purchase of 'green' energy despite additional costs. But why are choices of 'green' energy particularly suitable for behavioural interventions using defaults? It is plausible that decisions that are highly relevant for one's moral identity¹⁸ are particularly influenced by default setting. As previous research has shown¹, individual morality is an important driver of pro-environmental behaviour. Actively negating one's moral convictions regarding the environment by opting out of a pre-selected pro-environmental option might be much more aversive compared with not opting in. Therefore, defaults could be particularly effective in the domain of environmental decision making, including energy choices.

A total of 41,952 households participated in the 4.5-week-long RCT and were randomly assigned into one of two treatments. The RCT was embedded into the webpage of a nationwide energy supplier and it uniquely targeted prospective customers of the firm. Households chose between energy contracts with a high or low service quality, and both types offer the option to uniquely use energy from renewable sources. This option was varied by letting people either actively opt into 'green' energy or passively purchase it if not opting out (see Fig. 1 and Methods for details). The corresponding box was either pre-selected (opt out) or not (opt in).

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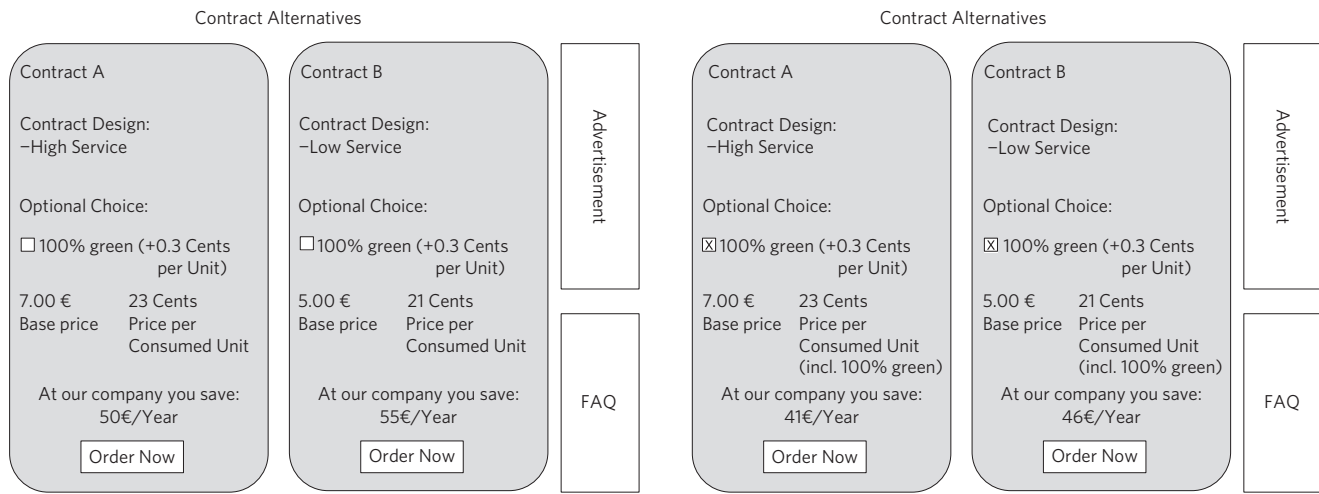


Figure 1 | Basic website layout in control (left) and experimental (right) treatments.

Our main dependent variable is the purchase of an indefinite energy contract that equips the household with energy until revoked by either party.

The impact of the default option had a substantial and statistically highly significant effect on consumers' purchase behaviour. On the level of sales per homepage visit, only 0.62% of households purchased a green contract in the opt-in treatment. In the opt-out treatment that number equals 5.58%. The difference was highly significant (χ^2 test, $p < 0.001$). Conditional on the purchase of a contract, merely 7.2% of purchased contracts in the opt-in treatment were 'green', whereas in the opt-out treatment, a majority of 69.1% of purchased contracts were 'green' (see Fig. 2, χ^2 test, $p < 0.001$).

Additional regressions support the conclusion that defaults promote 'green' energy. Including several statistical controls shows that the main effect is robust after controlling for service quality of the chosen contract, base prices of electricity, and unit prices (see Table 1). Importantly, the experimental manipulation had no effect on the choice of the service quality (χ^2 test, $p = 0.953$). In line with economic predictions, there were (marginally) negative effects of the yearly energy consumption ($p < 0.10$) as well as the unit price of energy ($p < 0.10$) on the willingness to purchase 'green' energy. The more expensive energy is, the less likely consumers opt into green energy. More importantly, the interaction terms between the treatment and these two variables were (marginally) positive ($p < 0.10$), suggesting that the treatment partially mitigated this negative relationship. The treatment variation had a small, but negative effect on the conversion rate (see Supplementary Table 1).

To explore some of the motivational underpinnings of choices, we assigned a political preference score to each data point that reflects election results of that postal code. Thus, we align individual choices to (aggregate) political preferences. As the RCT was implemented in a naturalistic decision-making context, we could not accompany observations of behaviour with subsequent questionnaires. Therefore, matching regional results from the last federal election with the postal code provided the only opportunity to estimate the effect of (aggregate) political preferences on (individual) choices, and, therefore, the efficacy of the nudge for subgroups⁶. In particular, we interpret aggregate approval for the 'green party' (that is, the political party that is most associated with environmental issues) as an indicator of pro-environmentalism in that particular region. The party is established in the national parliament and most smaller-level parliaments on the state, county, and city level and considered one of the main political parties in Germany.

Table 1 | Additional probit regressions of main effect without (1) and with (2) statistical controls.

	(1)	(2)
Treatment	1.97*** (36.31)	2.10*** (23.78)
Contract type	-	0.029 (0.31)
Base price	-	-0.008 (-0.16)
Price kWh ⁻¹	-	-0.08* (-0.169)
Online discount	-	0.04 (0.97)
Yearly consumption	-	-0.16* (-1.95)
Treatment × contract type	-	-0.14 (-1.17)
Treatment × base price	-	0.06 (1.06)
Treatment × price kWh ⁻¹	-	0.14** (2.39)
Treatment × online discount	-	0.05 (0.92)
Treatment × yearly consumption	-	0.17* (1.74)
Constant	1.46*** (-33.85)	-1.52*** (-21.23)
log likelihood	-1,485.47	-1,469.76
Observations	3,512	3,512
Pseudo R ²	0.3520	0.3575

Dependent measure: choice of green energy contract conditional on purchase taking place; *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$; numbers present regression coefficients; numbers in brackets indicate z-values. Regressions unconditional on purchase yield identical results.

Analyses revealed a significant interaction between preferences for the 'green party' and the experimental treatment (z-value: -2.73, $p = 0.006$, see Supplementary Table 2, analyses for all other parties are included and are supportive of the basic effect). We find that 'green party' approval is associated with 'green' energy choices in the absence of the default nudge, but not when the 'green' default is in place. Whereas in the lowest quintile of 'green party' approval merely 4.63% of people signing a contract opted into green energy, 9.87% of people opted into 'green' energy in the highest quintile of 'green party' approval (χ^2 test, $p = 0.005$). In cases of the opt-out nudge, this difference is smaller and not statistically different (67.06% versus 70.19%, χ^2 test, $p = 0.389$, see Fig. 3 for a non-parametric estimation of this interaction). Possibly, introducing the default for 'green' energy overruled this (intrinsic) effect, which is consistent with psychological models of choice that highlight the importance of individual motivations in weak but not in strong situations¹⁹.

Summarizing, the RCT provides evidence that default setting affects choices of energy. Importantly, the nature of the RCT does not deliver much process evidence, most importantly whether the

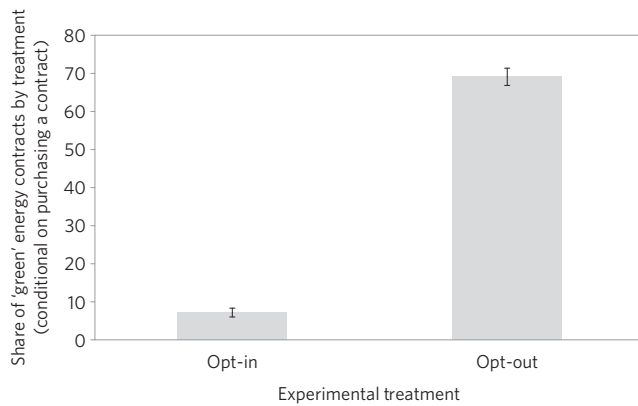


Figure 2 | The impact of the default nudge on purchases of 'green' energy. The purchase rate shows the share of 'green' energy contracts sold in each treatment as a share of the total contracts sold. Error bars indicate 95% confidence intervals.

effect is driven by unawareness, which would have important policy implications. It would be difficult to systematically execute policy interventions that merely exploit consumers' limited attention to critical aspects of the decision problem. Furthermore, we explore whether the effect reproduces in a different sample.

In supplementary studies, we aimed to answer two important questions regarding defaults that the RCT was unable to answer. First, do people simply not realize that they are choosing 'green' energy or do they make a consciously different decision? Second, does the effect generalize to a sample of consumers recruited in the United States? To this end, we conceptually replicate our findings in two additional studies using behavioural intentions in samples recruited from Amazon Mechanical Turk (AMT; ref. 20) to rely on a relatively representative US sample²¹. Framed as two consumer experience studies, we led participants (collapsed $n = 290$) through the same screens as in the RCT. The key difference is that consumers were asked to imagine that they were shopping for a contract, compared with the actual purchase of energy plans in the RCT. A subset of participants ($n = 168$) was additionally asked to recall their choice so that we could test whether choices were made within or outside conscious awareness.

Consistent with the initial results, we confirm a strong effect of the opt-out treatment on choices in favour of 'green' energy. Across all AMT data, 34.16% of people prefer the 'green' energy

option in the opt-in treatment and 93.80% of people prefer the 'green' energy option in the opt-out treatment (χ^2 test, $p = 0.001$). Furthermore, among the subset presented with the awareness check after the choice ($n = 168$), most consumers, who are 'nudged' towards green energy, are able to recall their choice correctly. In the opt-in treatment, 100% of the people actively choosing 'green' energy are able to recall their decision. In the opt-out treatment, this number equals 84.13%, which indicates that most 'green' decisions have also been made consciously.

We find strong behavioural effects of default setting on purchases of 'green' energy in a RCT and supplementary experiments. The increase is statistically highly significant and large in effect size, increasing the purchase rate of 'green' energy nearly tenfold. Thus, the application of behavioural insights can be highly effective in terms of outcomes when addressing goals related to behaviour change in energy use. The present research shows how households opt for 'green' energy without any traditional tools such as tax breaks or other monetary incentives. This is highly relevant for policymakers as we provide methods that go beyond traditional policy tools that may involve subsidies or even coercive bans of products. We have provided a simple example of how behavioural science can be used to incur large-scale behavioural changes among consumers that may help us mitigate adverse effects of climate change.

Naturally, what would have to follow is a debate about the ethical legitimacy^{17,22} of its use as well as the comparison with other, more traditional policy tools. Nudges that lead to savings for the consumer do not imply a conflict between the individual and society, but nudging consumers into 'green' energy comes at an individual cost that is traded off against future welfare of the society. However, hardly any decision comes without a default choice and, thus, policymakers need to decide which default to set. One natural candidate would be one that is in line with explicit policy goals (that is, to change the energy mix, to conserve resources, and so on).

Furthermore, it remains unclear what the effect of scaling up would exactly yield. It seems impossible to change the energy mix rapidly if consumers massively enrol in 'green' energy following a permanent change in default setting. Importantly, interdisciplinary conduct between social and other scientists can help us learn about the many ways to mitigate the effects of climate change. For example, the effective internalization of external effects caused by emissions might be affected by reference-dependent preferences²³ and ineffective if energy becomes relatively cheaper despite taxes. In these cases, nudges might work better. The goal of the present

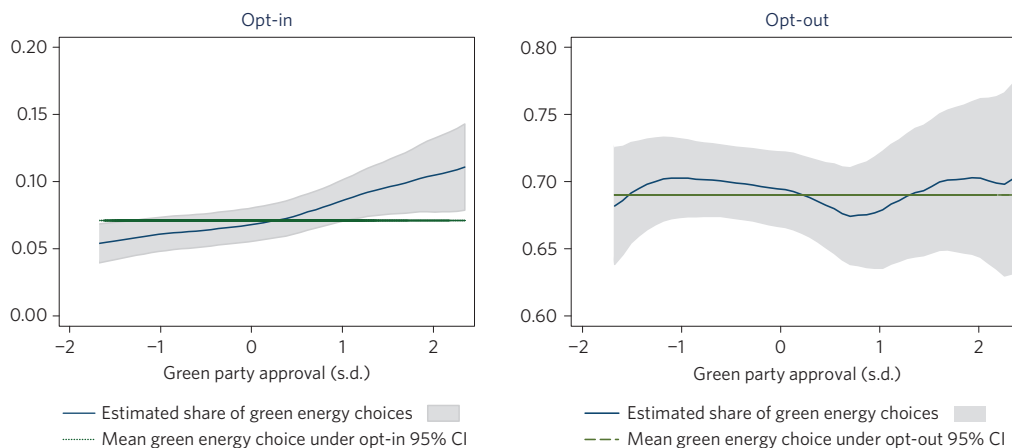


Figure 3 | Interaction of regional 'green party' approval and experimental treatment. Graphical illustration of smoothed values obtained from kernel-weighted local polynomial regression of contract choice on 'green party' approval with 95% confidence intervals. 'green party' approval is a positive predictor of contract choice under the opt-in rule (left panel), but not in the presence of the opt-out nudge (right panel).

research was to increase our knowledge and to tackle the question of whether default setting can promote enrolment into more expensive 'green' energy. The answer seems to be yes, which can be interpreted as a useful add-on to policymakers' toolboxes.

Methods

Methods and any associated references are available in the [online version of the paper](#).

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Author contributions

F.E. and S.L. designed the research question; F.E. managed data collection in collaboration with our industry partner. F.E. prepared data analysis to discuss with S.L.; S.L. drafted the manuscript; F.E. provided feedback to manuscript.

Additional information

Supplementary information is available in the [online version of the paper](#). Reprints and permissions information is available online at www.nature.com/reprints. Correspondence and requests for materials should be addressed to S.L.

Competing financial interests

The authors declare no competing financial interests.

Methods

A nationwide active German energy supplier allowed us to test our hypothesis that defaults increase green energy consumption by introducing a randomized controlled trial (RCT) on their homepage. The RCT was conducted in early summer 2012 and lasted for 4.5 weeks. The homepage is targeted towards regular consumers, that is, standard non-commercial household consumption (typically consisting of 1–6 household members). Customers who enter the homepage are asked to provide their household size, their previous yearly energy consumption, and their postal code. Postal codes are used by the company to charge different prices (that is, due to different power grid charges). The yearly energy use is used to give prospective consumers a price comparison between our supplier and the local supplier. Once prospective customers have entered this information, they can submit an enquiry using the 'show contract' button. On the subsequent page, two contracts are offered, the high-service-quality and the low-service-quality contract (see Fig. 1). The services differ mainly in the way that the low-service-quality contract is a web-only contract without extensive customer service and with online billing only. In the high-service-quality contract, the base price is, on average, €7.33 (s.d. = €1.33) and the price per unit (kWh) is, on average, €0.2386 (s.d. = €0.0081). In the low-service-quality contract, the base price is always €2 less and the price per unit is, on average, €0.0169 (s.d. = 0.0065) lower. Customers can choose which of the two contracts they prefer, by clicking one of two buttons that say 'Order now'.

The treatment variation was implemented on this page. Directly located under the price per unit, there was an option to opt into/out of green energy by checking versus unchecking the box (see Fig. 1 of the main text). In the control treatment, the option was unmarked allowing prospective customers to actively opt in. In the experimental treatment, the option was marked allowing prospective customers to opt out. Clicking versus unclicking the button dynamically led to a price change of the price per unit that was visible to the prospective customer. Across both treatments, the added price for green energy was 0.3 cents per unit, which is the actual price charged by the company independent of the RCT. On the basis of

average consumption, this yields about €9 per year additional costs for consumers, which is the actual price of energy that stems entirely out of renewable resources that the company charges. Therefore, customers change the company's energy mix with their purchase. Importantly, the green energy check box was always similarly set for the low-service-quality contract and the high-service-quality contract. Either both or none of the contracts had the box checked, depending on the treatment. Randomization was directly entered into the source code of the homepage by manipulation of the PHP script using the 'rand()' function. Furthermore, cookies were placed on prospective customers' computers to ensure that they always received the same default in case they revisited the page before making a final decision, which is a standard procedure of the supplier.

To prevent our data set from being biased, we excluded robot visits from cross-selling platforms that use automatic enquiries to update prices on price-comparison homepages that also directly sell contracts to customers without customers actively visiting the homepage of a supplier. Once a prospective customer clicked the 'Order now' button, they were directed towards a page that asked them to fill in their identifiable information (name, address, bank account, and so on). Once they submitted this information, a binding contract was set between the customer and the supplier.

The online study run on Amazon Mechanical Turk (AMT) was designed similarly to the RCT, but did not include the branding of the supplier. Colours, shapes and design were held neutral, but similar to the original design. Participants on AMT received \$0.50 flat compensation in exchange for taking the survey, a standard rate of payment on the platform at the time. All AMT data were gathered in the autumn of 2012. Participants were asked to participate in a consumer experience study and should imagine shopping for an energy contract with the simulated supplier. There were asked to make their decisions as if they were really purchasing a contract. The awareness check was a multiple-choice question involving four answering options. These were: high-service energy contract without green energy, high-service energy contract with green energy, low-service energy contract without green energy, and low-service energy contract with green energy.