



# *How Do Online Water Audits Affect Residential Demand?*

*Evidence from a 400,000-Household Field Experiment*



# How Do Online Water Audits Affect Residential Demand? Evidence from a 400,000-Household Field Experiment\*

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## Abstract

The toolkit that water companies use to reduce residential water demand is broad. Although online water audits are a popular tool promoted by water companies in the UK and globally, little is known about their effectiveness. This study addresses this gap through a natural field experiment involving approximately 400,000 smart-metered households of Thames Water, the largest water company and one of the largest utilities in England and Wales. These households were randomly allocated to six groups and received either no email (the control group) or different emails inviting them to complete the online water audit. The results suggest that emails emphasizing the potential to save on water bills are the most effective. Completion of the online water audit leads to a daily water demand reduction of 6 litres on average, which persists throughout the six-month study period. This results in an aggregate consumption reduction of approximately 4 megalitres (4 million litres) during the study period.

**Keywords:** water efficiency; field experiment; nudge; pro-environmental behaviour; scarcity; online audit.

**JEL Classifications:** C93; D12; D91; Q25; Q58; L95.

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<sup>§</sup> *Disclaimer.* The views expressed in this study are those of the authors and do not necessarily reflect the views of Thames Water. The errors are solely the authors' responsibility. During the implementation of the trial and the writing of this draft both authors were employed by Thames Water.

## 1. Introduction

Water scarcity is expected to worsen in the future both internationally<sup>5</sup> and in the United Kingdom (UK).<sup>6</sup> Given this outlook, water companies have plans for record investments in water, sewerage, and future water supply infrastructure,<sup>7</sup> and to deliver demand-side interventions that promote water conservation. The toolkit water companies use to reduce residential households' water demand includes, for example, financial instruments such as rising block tariffs (Mayol and Staropoli, 2021), technological instruments such as smart meters (Daminato et al., 2021), and behavioural instruments such as making the negative environmental implications of abundant water use salient in real-time (Tiefenbeck et al., 2016) or comparing household's water consumption to that of their neighbours (Ferraro and Price, 2013). While online water audits are one of the popular tools promoted by water companies both in the UK and internationally, there is very little evidence on their effectiveness. This study contributes to this highly scarce strand of literature. First, it aims to understand how to motivate households to conduct an online water audit, given the number of questions and stages to complete. Second, it generates evidence on the short- and long-run impacts of online water audit on residential water demand. Akesson et al. (2023) is the only paper that explores similar questions (in the UK context), though there are multiple points of divergence from the study presented in this paper, including the results (see Section 2). This clearly calls for further research.

A natural field experiment (Al-Ubaydli and List, 2013) was implemented among roughly 400,000 smart-metered households of Thames Water (TW), the largest water utility in England and Wales, serving 16 million customers and with the highest smart meter penetration. These households were randomized into a control group that received no communication and five treatment groups, each receiving a different type of email. The "Baseline" group and "Neutral" groups received a neutral email asking households to save water. The "Baseline" communication was based on current company practice, whereas the "Neutral" email modified the "Baseline" email along several dimensions, using best practices in Behavioural Science (see Section 4). The remaining emails were based on the "Neutral" template. More specifically, the "Finance" email highlighted the pecuniary benefits of reducing water demand, the "Environment" email emphasized the environmental benefits, and the "Altruism" email requested to save water for future generations. The emails were dispatched in July 2024. The two outcome variables of interest were the

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<sup>5</sup> See [UN World Water Development Report 2023](#) (retrieved on April 2, 2025).

<sup>6</sup> See [Future Water Resources](#) (retrieved on May 1, 2025).

<sup>7</sup> For example, in the UK Ofwat (the economic regulator) approved £104bn investments into water infrastructure between 2025-2030, which is twice as much as the investments made in the previous 5 years (2020-2025 price review period). See: [What are companies proposing? £104bn investment plan](#) (retrieved on April 2, 2025).

percentage of households completing the online water audit and the daily average water consumption for each month from August 2024 to January 2025.

Regarding audit completion, the average uptake across the groups that received an email is around 1.1%. The Intention-To-Treat (ITT) estimates suggest that there are substantial differences. First, all emails that include behavioural modifications are 2-3 times more effective than the “Baseline” email. Second, the “Finance” email is the most effective one, indicating that financial savings seem to be the primary reason households complete the audit. There is also substantial heterogeneity in how households act upon the emails. The higher a household’s pre-treatment water consumption, the less likely it is to complete the audit. Probably, the households with high water consumption (pre-treatment consumption above the median) either know that they cannot reduce it and, therefore, do not act upon the emails, or have little interest in reducing their consumption, and consequently, do not pay much attention to the emails.

Regarding water demand reduction, intention-to-treat estimates illustrate that the email campaign does not have any influence on households’ water demand. However, this analysis does not distinguish between different levels of household engagement: ignoring the email, reading the email without proceeding to the audit, dropping out from the audit or full completion. Evaluating the impact of completing the online audit on water demand by estimating a local average treatment effect (LATE) would be the most natural next step.<sup>8</sup> This procedure would solve the potential selection bias. Because households that complete the audit (i.e., compliers) may possess unobservable traits that differ from those who do not (non-compliers), a direct comparison of their water consumption could lead to estimates that confound the audit’s impact with pre-existing household traits. Unfortunately, the low rate of online audit completion poses a challenge for estimating the local average treatment effect (LATE). This analysis suggests that the households that completed the online water audit did not reduce their water demand, however, the confidence intervals are very large because of the low uptake.

To circumvent the above problem, the approach by Lara Ibarra et al. (2017) was followed whereby non-experimental methods were combined with the random assignment from the experiment to lead to credible estimates of audit completion on water demand reduction. More specifically, rich data on pre-treatment household consumption in the 14 months preceding the intervention, property type, and households’ financial situations (proxied by receipt of affordability support)

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<sup>8</sup> To estimate this effect, a two-stage least squares approach would be employed. In the first stage, the randomized assignment of email notifications would be used as an instrumental variable to estimate their effect on the likelihood of completing the online water audit. In the second stage, the predicted audit completion from the first stage would be used to estimate a local average treatment effect (LATE) of audit completion on water consumption.

were utilized to match those who completed the online audit in the treatment groups to households in the control group with similar characteristics. Matched difference-in-differences was then used to estimate the impact of audit completion on water demand. This methodology helps to mitigate the selection bias discussed in the previous paragraph for three main reasons. First, the rich household data used for matching (past consumption for 14 months, house type, financial situation) make pre-treatment water consumption trends in the control and matched groups near identical. Second, by matching to households in the control group only there is a plausible justification for why the control group households did not complete the online audit: they were randomly not invited to do so. This further excludes selection into the online audit completion based on unobservables. Lastly, the difference-in-differences estimation accounts for time-invariant unobservables between the two groups. The results suggest modest reduction in household water consumption of about 6 litres/day. This is in contrast to Akesson et al. (2023), that finds a sizeable short-term reduction of 43-45 litres in daily average water consumption following completion of an online water audit. Moreover, we observe that this reduction is persistent in the long run, even after 6 months of audit completion.

As far as policymakers are concerned, the study highlights the need for more evidence on the influence of online water audits on water demand reduction. Furthermore, the discrepancy in effect magnitude between two similar natural field experiments implemented in the UK illustrates the importance of rigorous testing of interventions aimed at reducing water and energy demand. This is because there are substantial heterogeneities even within the same country. For example, TW's operational area and customer base are substantially different from those in the rest of the UK, mainly due to London (please refer to Section 2), which may explain the divergence in the results.

As for the implications for TW, the current online water audit process may need improvement and further testing to increase its effectiveness. For example, once a household completes the online audit, they could be asked to set a water consumption reduction target and be regularly reminded whether they are meeting the target. Existing literature suggests that both goal setting (e.g., Nickerson and Rogers, 2010; Milkman et al., 2011) and reminders (e.g., Altmann and Traxler, 2014; Calzolari and Nardotto, 2017) can positively influence human behaviour and steer individuals in the desired direction.<sup>9</sup> Furthermore, such features introduce gamification in the context, which can further contribute to reaching the objective of water conservation (BIT, 2014). These considerations are applicable to almost all water companies in the UK and internationally.

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<sup>9</sup> Important to note that a recent study in Germany shows no impact of self-set goals on energy conservation (Loeschel et al., 2023), however there are stark differences in the UK and German contexts.

The rest of the paper is structured as follows. Section 2 outlines the study's contribution to the literature. Section 3 provides a brief snapshot of the UK water sector. Section 4 describes the experimental design. Section 5 summarizes the results, and Section 6 concludes.

## 2. Literature review

This paper contributes to the literature on the impact of demand-side interventions aimed at reducing residential households' water consumption.

First, the study relates to the strand of literature on interventions informed by Behavioural Science that aim to reduce water and energy consumption (e.g., Ferraro et al., 2011; Ferraro and Price, 2013; Allcott and Rogers, 2014; Byrne and Goette, 2022). This is because the natural field experiment dispatches emails that act as nudges to promote completion of the online water audit to conserve water. In sum, the study explores the impact of nudging on an understudied behaviour (i.e., completion of online water audit).

Second, the study relates to the literature that studies the impact of technologies on water and energy demand (Daminato et al., 2021, Ornaghi and Tonin, 2021; Ansink et al., 2021). While the existing work focuses on smart meters and efficient technologies, this paper explores a digital technology (an online water audit tool) that walks the customer through a series of questions and provides tailored advice about how to reduce consumption waste.

Third, the study relates to the literature on audits aimed at reducing water or energy consumption. There is substantial evidence on the positive impact of physical audits (e.g., Delmas et al., 2013; Alberini and Towe, 2015; Gillingham, K., & Tsvetanov, 2018; Agarwal et al., 2022),<sup>10</sup> whereas evidence on online, *do-it-yourself* water audits remains limited. To the best of our knowledge, Akesson et al. (2023) is the only study that examines how customer communication impacts the uptake of online audits and how the completion of these audits affects water consumption among Northumbrian Water Group (NWG) customers in the UK. The study in this paper diverges from Akesson et al. (2023) in multiple aspects, including the population studied, the treatments, the data, and the results.

As for the population under consideration, TW's operational area includes a large portion of the highly urbanized and densely populated Greater London and its surroundings. Compared to the rest of the UK, the London population is, for example, more demographically diverse,<sup>11</sup> more

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<sup>10</sup> A physical home water audit is an in-person assessment of how water is used throughout a household, which includes checking plumbing fixtures and appliances to identify leaks, spot inefficiencies, and provide practical recommendations for reducing water waste.

<sup>11</sup> See [London's geography and population](#) (retrieved on April 3, 2025).

transient<sup>12</sup> (i.e., people migrating between addresses), and with higher levels of poverty and inequality.<sup>13</sup> Such socio-economic and demographic differences in the population can result in differential reaction to similar treatment stimuli, which echoes the discussion on the importance of context in designing interventions (Harrison and List, 2004; Levitt and List, 2009; Glennerster and Takavarasha, 2014).

As for the treatment stimuli, while Akesson et al. (2023) incentivizes households to complete the online water audit in a few of the treatments, the experiment presented here refrains from doing so. Instead of offering financial incentives, one of the experimental treatments highlights the potential financial savings associated with implementing the personalized tips provided upon audit completion.

Regarding the timeline, this study focuses on a 6-month post-treatment time frame, which allows to estimate both short- and longer-term impacts of the interventions on water consumption. In contrast, Akesson et al. (2023) focus on a 65-day post-treatment time frame.<sup>14</sup>

### 3. Background information

The water sector in England and Wales delivers water supply, sanitation, and drainage services to over 50 million household and non-household customers.<sup>15</sup> The companies operating in the sector were privatised in 1989. There are 11 regional water and wastewater companies in England and Wales, and 5 water-only companies.<sup>16</sup> Residential households are typically served by their regional supplier, with no option to choose. Given the monopolistic position of these companies within their respective regions, a comprehensive regulatory framework is in place to ensure high service standards, environmental protection, and fair prices. The companies are regulated by the economic regulator, Ofwat; the environmental regulators, the Environment Agency (England) and Natural Resources Wales (Wales); and the drinking water quality regulator, the Drinking Water Inspectorate. Consumer Council for Water (CCW) represents consumer interests and addresses unresolved complaints.

Thames Water is among the largest utility companies in the UK. The company operates in London and the Thames Valley, with Oxford, Swindon, Reading, and Slough among the notable cities and towns it serves.

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<sup>12</sup> See [TMS 19 cost adjustment claim: transience](#) (retrieved on April 3, 2025).

<sup>13</sup> See [The latest data on London borough level poverty](#) (retrieved on April 3, 2025).

<sup>14</sup> The UI/UX of the calculators utilized is also different. This may affect how households interact with the calculator. However, this is not considered a major concern for water demand, as long as all the stages of the calculators are completed and households understand where their water waste comes from.

<sup>15</sup> See [Water Sector Overview](#) (retrieved on April 25, 2025)

<sup>16</sup> See [Constituency Information: water companies](#) (retrieved on April 16, 2025).

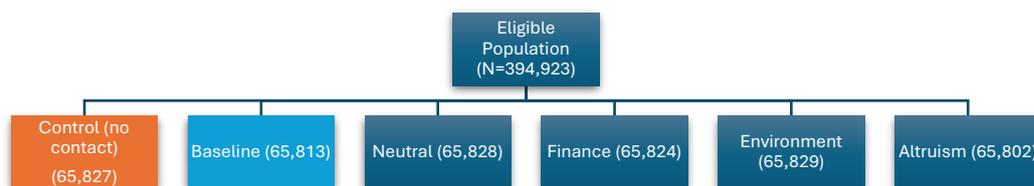
Curbing water wastage is a pressing issue for UK water companies, regulators, policymakers, public agencies, the public, and other stakeholders to secure long-term water supply and protect the environment. Climate change, infrastructure challenges, and a growing population contribute to water scarcity in the country.<sup>17</sup> The Southeast of England is expected to suffer the most severe water shortages by 2030.<sup>18</sup> To address these issues, water companies have committed to major infrastructure investments of about £104 billion in the period of 2025-2030, also aimed at reducing pollution and leakages. Reducing household water demand through various tools—online water audits being one of them—is also of utmost importance for both water companies and regulators.

#### 4. The experiment

##### 4.1. The sample

The experiment was designed to test the impact of different email nudges on the completion of the online water audit and to assess any resulting reduction in water demand. Given these objectives, the focus is on smart-metered households, whose water consumption can be observed.<sup>19</sup> Overall, 394,923 households with an ongoing contract were randomized into 6 arms. Figure 2 graphically represents the structure of the experiment.

Figure 2. The structure of the experiment



Note. The experiment randomized 394,923 smart-metered households into 6 different groups.

##### 4.2. Treatments

The control group received no communication. The “Baseline” group received TW’s standard practice email, requesting households to save water. The email template for the “Neutral” group

<sup>17</sup> See [Why is the UK facing water shortages despite record rainfall?](#) (retrieved on April 16, 2025)

<sup>18</sup> See [Seven regions in England will face severe water stress by 2030 as Brits significantly underestimate their daily usage](#) (retrieved on April 16, 2025).

<sup>19</sup> TW has the highest smart meter penetration in the UK and has surpassed one million smart meter installations. See [Thames Water surpasses 1 million smart meter installations](#) (retrieved on April 22, 2025).

was modified along several dimensions following the best practices in Behavioural Science (e.g., Harhut, 2022). First, a clear call to action was introduced, requesting households to complete the online water audit (the main objective of the email campaign). Second, template-specific benefits of completing the online water audit were emphasized. In the “Neutral” group, the benefits were centred around saving water, presented in a neutral frame and without further elaboration. Third, brief instructions about how to complete the online audit were provided, to simplify the household’s task and reduce the mental effort required to process information.

The remaining email templates were built on the “Neutral” template and mainly altered the template-specific benefits of completing the online water audit. The “Finance” group’s template highlighted the monetary benefits of reducing water demand due to the audit. The “Environment” and “Altruism” templates leveraged individuals’ other-regarding preferences for the environment and the well-being of others (e.g., Fehr and Schmidt, 2006; Cooper and Kagel, 2016; Heinz and Koessler, 2021), highlighting the benefits of saving water either for the environment or for future generations.

The email subject lines reflected the content of the templates. More specifically, the subject lines of the “Baseline” and “Neutral” emails were identical and focused on saving water through the online audit, whereas the subject lines of “Finance”, “Environment”, and “Altruism” emails emphasized saving money, protecting the environment, and supporting future generations, respectively. Appendix A contains the email templates.

### **4.3. Randomization and balance**

The study employed household-level randomization. To enhance balance, the randomization was stratified by the local authority to which the household belonged and by the income rank of the postcode to which the household belonged. The randomization was conducted on July 15, 2024. The emails were sent in two batches on July 17 (N=197,460) and July 22 (N=197,463) 2024 by TW’s communication team. Inclusion in a batch was independent of treatment allocation, with all groups equally represented within a batch. The balance tests in Appendix B illustrate that both the groups within a batch and the batches themselves were balanced with respect to observable socio-economic variables. These included: households’ average daily water consumption in a given month (in litres) and average hourly leakage in a given month (in litres) in the one-year period prior to the intervention, the fraction of households requesting affordability support, latest account balance in pounds, and the length of the contract at a given premises (in months).

#### **4.4. The water audit tool**

The original version of the online water audit tool was anonymous (see Figure A.6 in Appendix A). Under these circumstances, assessing the impact of different emails on audit completion was impossible. A second version of the calculator, which included a reference number field, was developed and made accessible only to smart-metered email recipients via the “Start Saving Now” buttons in the emails (see Figure A.7 in Appendix A). For each household a unique 9-digit random reference number was generated to assess the online audit completion.

#### **4.5. Email dispatch**

During the email dispatch two operational errors outside the control of the research team occurred.

On the first day of dispatch (July 17), the email templates for three groups (Altruism, Environment, Finance) did not load correctly and were resent on July 18 with an apology. Such a differential treatment of certain groups could indeed confound the take-up of the online audit across groups within the batch. For example, due to the error, some of the households who receive the email a second time may become disappointed and participate in the audit less compared to a situation without the error. Alternatively, the second email can serve as a reminder for some of the households and boost participation even further. In sum, the exact impact of the error and how it interacts with the email content is hard to predict. However, this error is expected to have minimal impact on water consumption, conditional on completing the audit.

On the second day of dispatch (July 22), a technical issue resulted in all email links being deactivated shortly after they were sent, preventing recipients from accessing the online audit tool through the 'Start Saving Now' button. The links were reactivated on July 23. This constituted a common shock affecting all groups at the same time. While this error may reduce the take-up across all groups within the batch, it still allows for a clean identification of the effect of email content on audit completion, due to the shock being common. This error is again expected to have minimal impact on water consumption, conditional on completing the audit.

Given the above points, the results on the take-up of the online water audit will be presented separately for each batch and the inference will be based on Batch 2 results.

### **5. Results**

The results section is organized as follows. First, the impact of email nudges on the completion of the online water audit is discussed using intention-to-treat (ITT) estimates. Second, the impact of

email nudges on water consumption is reported, again using ITT estimates. Third, the impact of online audit completion on water demand reduction is analysed using local average treatment effect (LATE) estimates. Forth, the matched difference-in-difference estimates are provided.

Three considerations are worth noting.

First, as of January 2025, a few households became inactive and are dropped from the analysis. Formal regression analysis suggests that the attrition does not depend on the treatment allocation (refer to Appendix C) and cannot invalidate the results of the experiment (Glannerster and Takavarasha, 2013). Furthermore, if a household has any missing value in the consumption data from May 2023 to January 2025, we drop this household from the analysis. This makes it possible to observe the same cohort of households each month in the post-treatment period. In sum, the final analysis is based on 302,879 households (Batch 1: N=151,549; Batch 2: N=151,330) with active contracts and non-missing consumption values. The results in Appendix C confirm the robustness of the balance checks.

Second, water consumption is winsorized at top 99% percentile, which is a common approach in natural field experiments (e.g., Pomeranz, 2015; Brockmeyer et al., 2021; Hoy et al., 2024; Antinyan and Corazzini, 2025, and others). This is to mitigate the influence of potential measurement errors in the data.<sup>20</sup>

Third, due to issues with the email dispatch and the differential treatment of groups in the first batch, priority will be given to the results of the second batch when discussing the take-up of the online water audit. The first batch results are presented for full transparency, albeit won't be discussed in detail.

### **5.1. Which email is more effective at increasing the uptake of online water audit?**

Figure 3 depicts the completion of the online water audit in each of the treatment groups separately for each batch (Panels A and B). Since the altered version of the online audit tool was accessible only to households who received an email, the control group is excluded from this analysis.

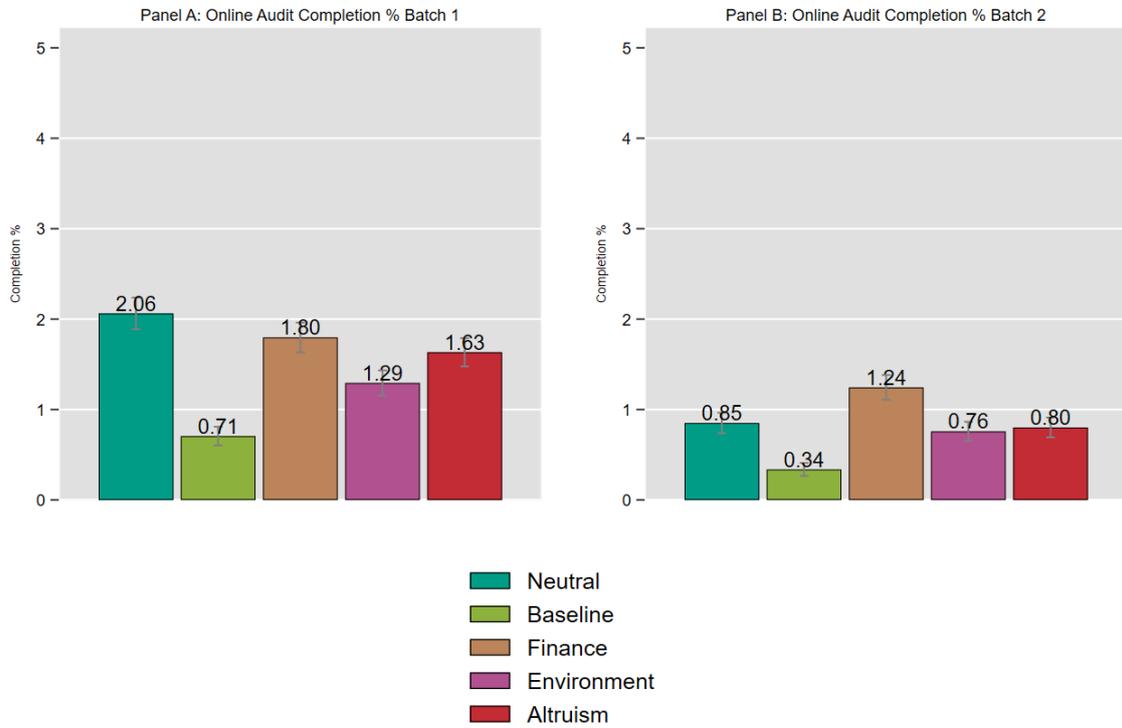
First, Panel B of Figure 2 suggests that the “Finance” email outperforms the others, closely followed by the “Neutral” template. Furthermore, any behavioural modification in the email outperforms the initial email sent by TW at least 2.2 times. Within Batch 1, “Neutral” and “Baseline” groups can be compared with each other as they both received one email without

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<sup>20</sup> The results are robust when using non-winsorized data and available upon request.

errors. As with Batch 2, this comparison suggests that “Neutral” email is about 2.9 times more effective.

**Figure 3. Online audit completion rate**



*Note.* The figure illustrates the online audit completion rate across treatment groups in Batches 1 and 2.

The above conclusions based on Figure 3 are confirmed by formal econometric analysis. The following linear probability model has been estimated:

$$y_i = \beta_0 + \sum_j \beta_j T_{ij} + \psi X_i + \varepsilon_i \quad (1),$$

where  $y_i$  is an indicator variable that equals 1 if household  $i$  completed the online audit, and 0 otherwise.  $T_{ij}$  is an indicator variable denoting whether household  $i$  belongs to treatment group  $j$ .  $X_i$  is a vector of control variables, including: a variable indicating whether the households’ pre-treatment average daily water consumption is above or below the median; a variable indicating whether the household receives affordability support; the length of the current contract in months; and postcode income rank. Specifications both with and without control variables have been estimated. The specifications with controls are reported in Appendix D. In all specifications the “Baseline” treatment group serves as the omitted category. Thus, the coefficient  $\beta_j$  identifies the

impact of treatment  $T_j$  relative to the “Baseline” group. To control for the heteroskedasticity of the residuals, Huber-White robust standard errors have been introduced.

Table 1 reports the results for batches 1 and 2. Batch 2 column suggests that, consistent with the above discussion, all behaviourally modified emails outperform the baseline template. Furthermore, the “Finance” email is superior to the remaining behaviourally modified emails. The coefficient of “Neutral” in Batch 1 column supports the greater effectiveness of the behavioural modifications over the initial TW email (the only clean comparison that can be made within Batch 1).

**Table 1. Online water audit completion**

	Batch 1	Batch 2
Neutral	1.357*** (0.104)	0.514*** (0.068)
Finance	1.091*** (0.099)	0.907*** (0.079)
Environment	0.587*** (0.088)	0.420*** (0.066)
Altruism	0.927*** (0.095)	0.465*** (0.067)
Constant	0.706*** (0.053)	0.337*** (0.036)
Treatment Comparison (Wald tests)		
Finance vs Neutral	F=4.69, p=0.03	F=18.81, p=0.000
Finance vs Environment	F=21.07, p=0.000	F=30.16, p=0.000
Finance vs Altruism	F=2.02, p=0.156	F=24.41, p=0.000
F statistics	63.279	42.152
Adj. R <sup>2</sup>	0.001	0.001
N	126,310	126,063

*Note.* Linear probability model. *Dependent variable.* Online audit completion defined as an indicator variable that equals to 1 if the audit is completed and 0 otherwise. *Independent variables.* Treatment dummies equal to 1 if the household belongs to the respective treatment and 0 otherwise. Significance levels: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

An important question to address is whether the intervention resonates with high-usage households, whose consumption is of utmost importance when designing such interventions. To answer this question, the households are divided into low-usage and high-usage types based on their pre-treatment water consumption. The pre-treatment water consumption of low-usage households is at or below the median, while the pre-treatment water consumption of high-usage households is above the median.

The analysis in model (1) is replicated by adding an interaction term between the treatment dummies and a high-usage dummy which equals 1 if the household is of high-usage type and 0 otherwise. This interaction term depicts how the behaviour of high-usage types differs from the behaviour of low-usage types. Table E.1 and E.2 in Appendix E detail the estimation results. According to the latter, high-usage households who received a given email invitation are significantly less likely to implement the online water audit compared to the low-usage households with the same email invitation. This may be a rational response. Most likely,

households of high-usage type either know that they cannot reduce their water consumption, therefore, do not act upon the emails, or have little interest in reducing their consumption, and consequently, do not engage with these emails.

## 5.2. What's the impact of email dispatch on water consumption?

This subsection reports the ITT estimates of the impact of email dispatch on water consumption. From here on the control group is included in the analysis. Households subject to email dispatch may receive the email, open it without proceeding to the audit, proceed to the audit and drop out, or complete the audit. The analysis here does not distinguish between these households and focuses on the overall impact of email dispatch on water consumption.

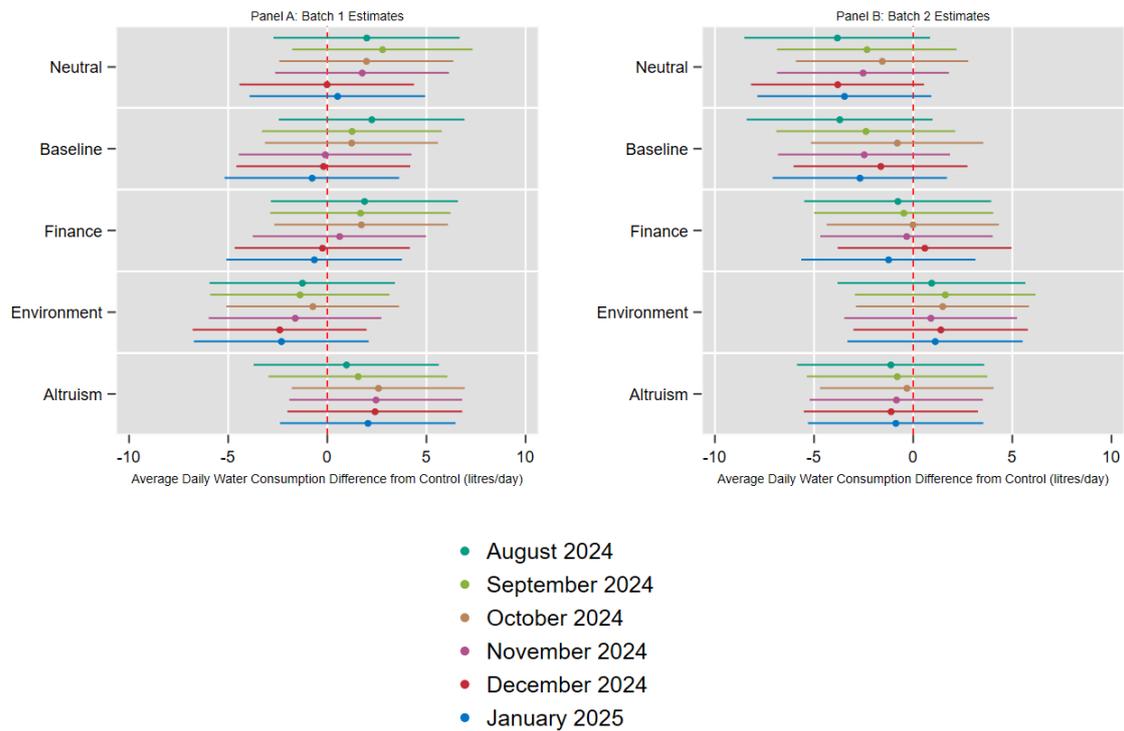
The “Baseline”, “Finance”, and “Neutral” emails will most likely have only an indirect impact on water consumption through completing the online water audit as they invite the customer to complete an audit either to save money or to save water, presented in a neutral frame and without further elaboration. The other templates may have both direct (through the email content) and indirect (through the online audit). For example, the “Environment” and “Altruism” templates may evoke pro-social preferences that can directly affect water consumption even if a household refrains implementing an online water audit (Fehr and Charness, 2023).

The following linear regression model is estimated:

$$c_i = \gamma_0 + \sum_j \gamma_j T_{ij} + \phi \mathbf{H}_i + \varepsilon_i \quad (2),$$

where  $c_i$  denotes the average daily post-treatment water consumption of household  $i$  for each month from August 2024 to January 2025.  $T_{ij}$  is an indicator variable denoting whether household  $i$  belongs to treatment group  $j$ .  $\mathbf{H}_i$  contains the same control variables as  $\mathbf{X}_i$ . The only difference is that the binary variable indicating high or low pre-treatment water consumption in  $\mathbf{X}_i$  is replaced by actual pre-treatment water consumption in  $\mathbf{H}_i$ . Specifications estimated with control variables as well as the detailed regression tables are reported in Appendix D. In all specifications, the control group serves as the omitted category. Thus,  $\gamma_j$  identifies the impact of treatment  $T_j$  relative to the control group. To account for the heteroskedasticity of the residuals, Huber-White robust standard errors have been introduced. Figure 4 reports the treatment effect estimates along with 95% confidence intervals for Batches 1 and 2. The estimates suggest no impact of email dispatch on water demand reduction.

Figure 4. ITT estimates



Note. The figure illustrates the treatment effect estimates of email dispatch on water demand reduction ( $\hat{\gamma}_j$ ). These estimates are obtained from an OLS model based on equation (2). The figure presents results from a specification estimated without control variables. Please refer to Appendix D for the specification that includes control variables and for the detailed regression tables.

Models (2) is also estimated for high-usage and low-usage households separately. Tables are omitted for brevity: only figures from the model are presented. Figures E.1 and E.2 in Appendix E illustrate that the email dispatch has no impact both on low-usage and high-usage households.

### 5.3. What's the impact of online audit completion on water consumption?

This subsection reports the impact of online audit completion on water consumption. A two-stage least square approach is employed. In the first stage, the random assignment to different email groups serves as an instrumental variable to identify their impact on the probability of completing the online water audit. In the second stage, the estimated probability of audit completion from the first stage is used to identify the local average treatment effect (LATE) of completing the audit on water consumption. This procedure identifies the impact of the interventions on the compliers. Equations (3) and (4) depict the first- and the second-stage estimations:

$$a_i = \zeta_0 + \sum_j \zeta_{1j} I_{ij} + \eta \mathbf{X}_i + v_i \quad (3)$$

$$c_i = \mu_0 + \mu_1 \hat{a}_i + \pi \mathbf{X}_i + \varepsilon_i \quad (4)$$

where  $a_i$  is an indicator variable that equals 1 if household  $i$  completed the online audit, and 0 otherwise,  $I_{ij}$  is the instrument used,  $\mathbf{X}_i$  contains the same vector of control variables as in equation (1),  $c_i$  is the average daily post-treatment water consumption of household  $i$  for each month from August 2024 to January 2025,  $v_i$  and  $\varepsilon_i$  are the error terms.

Regarding the instrument  $I_{ij}$ , it should satisfy the exclusion restriction, i.e., affect water consumption through online water audit only. This is likely the case for “Baseline”, “Neutral” and “Finance” emails as they do not refer to environmental or altruistic reasons for water demand reduction apart from asking to complete an audit to save either water or money. Thus, “Baseline”, “Neutral”, and “Finance” serve as the primary instruments. Nonetheless, the results are robust to different combinations of treatment assignment as instrumental variables

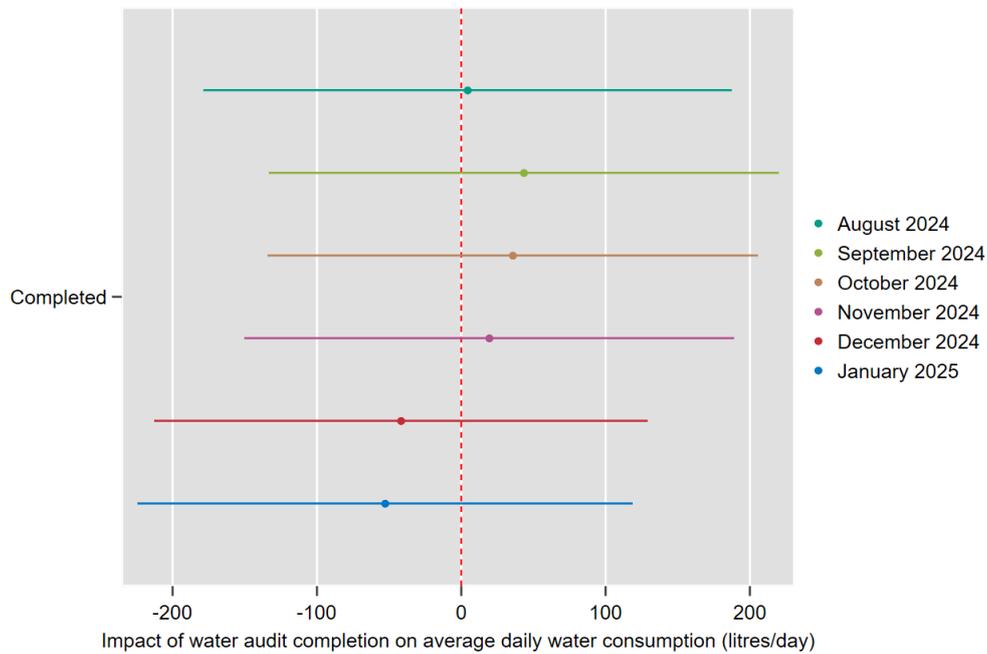
Figure 5 reports the second-stage LATE estimates for the entire sample along with 95% confidence intervals. Since the errors in the email dispatch are unlikely to impact water demand reduction—conditional on audit completion—and given the results in Figure 4, the two batches have been combined.<sup>21</sup> The figure suggests no impact of audit completion on water demand reduction. However, given the low uptake of the intervention, the confidence intervals are large. This makes the estimate less informative. Please refer to Appendix D for the robustness checks and the second stage regression outcomes in tabular form.

Models (3) and (4) are also estimated for high-usage and low-usage households separately. Tables are omitted for brevity: only figures from the model with primary instruments are presented. Figures E.3 and E.4 in Appendix E illustrate the results. The null result, along with the concern of large confidence intervals, is equally present in this heterogeneity analysis.

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<sup>21</sup> Batch-specific analysis leads to the same conclusions.

Figure 5. LATE estimates



Note. The figure illustrates the impact of water audit completion on water demand reduction. These estimates ( $\hat{\mu}_1$ ) are obtained from the second stage of a 2SLS regression model based on equation (4). “Baseline”, “Finance”, and “Neutral” serve as instruments. The figure reports a specification estimated without control variables. Please refer to Appendix D for the specification that includes control variables and for the detailed regression tables.

#### 5.4. What’s the impact of online audit completion on water consumption? Matched difference-in-differences approach

This subsection reports the impact of online audit completion on water consumption using a matched difference-in-differences approach following Lara Ibarra et al. (2017). First, propensity score matching is used to match households in the treatment group that completed the online water to similar households in the control group that did not. Second, difference-in-differences on this matched sample are employed to estimate the impact of online water audit completion on water demand. In sum, equation (5) below is estimated for the matched sample:

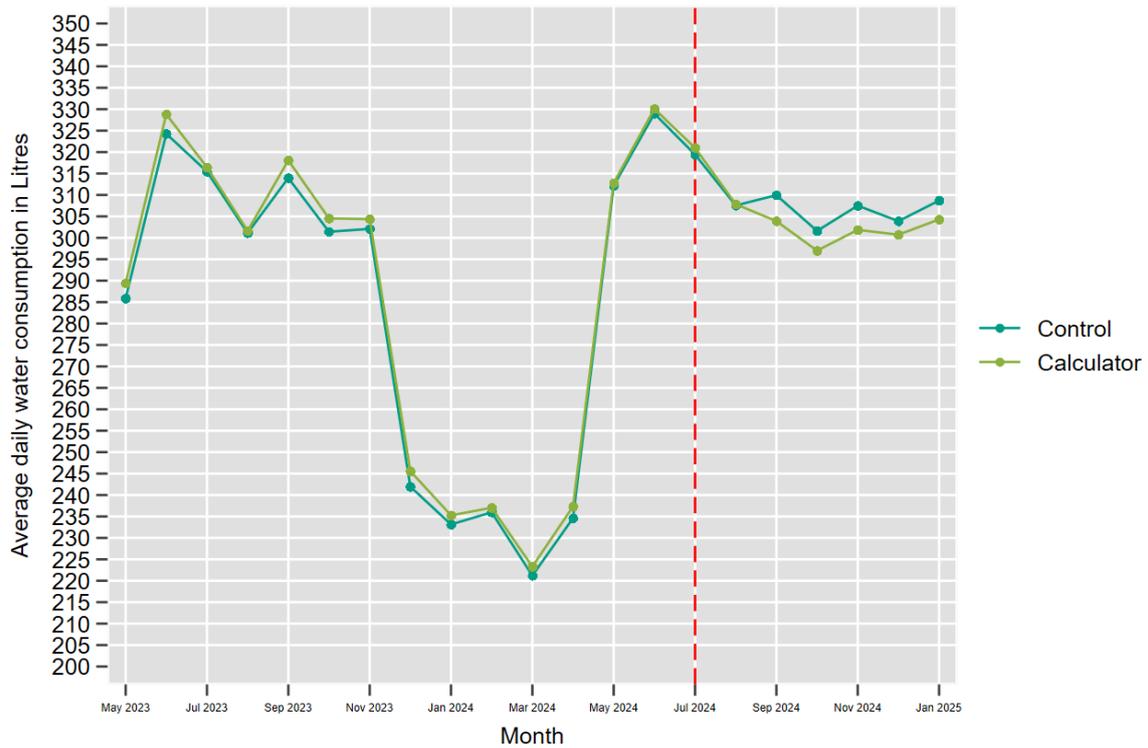
$$c_{it} = \rho Treated\&Complied_{it} + \lambda_i + o_t + \epsilon_{it} \quad (5)$$

$c_{i,t}$  is the average daily water consumption of household  $i$  in month  $t$ ,  $Treated\&Complied_{it}$  is a binary variable that equals 1 if the household had been treated and complied in the post-intervention period and 0 otherwise,  $\lambda_i$  are individual fixed effects,  $o_t$  is time fixed effects, and  $\epsilon_{it}$  is the error term. The standard errors are clustered at the individual level. The difference-in-differences estimate is  $\hat{\rho}$ .

The first step in this framework involves the choice of the control group through a matching phase. The propensity scores were estimated using a rich dataset of households’ monthly water

consumption, house type, and financial situation. Next, the nearest neighbour method was employed with a 0.01 caliper to form the matches.<sup>22</sup> Table F.1 in Appendix F indicates that this approach leads to well-balanced treatment and control groups. This comparability is further illustrated by pre-treatment consumption data presented in Figure 6, which shows closely aligned trends prior to the intervention.<sup>23</sup>

**Figure 6. Average daily water consumption each month**



*Note.* The figure illustrates the average daily water consumption per month for households that completed an online audit following an invitation in July 2024, compared to a matched group of households that did not. Groups were matched based on households' monthly water consumption, house type, and financial situation using the nearest neighbour method without replacement and with a 0.01 caliper.

We observe diverging trends in water consumption following the intervention. Specifically, households that conduct an online water audit, reduce their water consumption afterward. This reduction is persistent holding for at least 6 months after the intervention (no further analysis has been implemented). Table 2 reports the estimation results based on model (5). According to these results, a household reduces its average daily water consumption by about 6 litres, on average, in the months following the online water audit.

<sup>22</sup> Caliper is the maximum distance for which two observations are potential neighbours.

<sup>23</sup> Formal analysis suggests that the parallel trends assumption holds, as there are no significant differences in trends prior to the intervention (available upon request).

**Table 2. Difference-in-differences estimation**

	DiD
Treated & Complied	-6.314*** (2.323)
Individual fixed effects	Yes
Time fixed effects	Yes
F statistics	288.81
R <sup>2</sup>	0.024
N	127,334

*Note.* Difference-in-differences model. *Dependent variable.* The average daily water consumption of household  $i$  in month  $t$ . *Independent variables.* Treated & Complied is defined as a binary variable that equals 1 if the household was treated and complied in the post-intervention period and 0 otherwise. Time and individual fixed effects are applied. Standard errors are clustered at the individual level.

## 6. Conclusion

Given the increasing threat of water scarcity, water companies and policymakers implement both demand- and supply-side interventions to enhance water efficiency. Online water audits are one popular demand-side tool used by water companies for this purpose. However, there is limited evidence regarding the effectiveness of these audits.

This paper fills in this literature gap, by running a large-scale natural field experiment with smart-metered customers of Thames Water, one of the largest utility companies in the UK.

First, it tests which communication content motivates households the most to complete an online water audit. Emails with financial motives perform the best. The heterogeneity analysis reveals further intriguing differences. While water companies aim to engage high-usage households through their interventions, the low-usage households complete the online audit significantly more. Second, it examines the impact of the mailing campaign on water demand reduction. The ITT estimates suggest that the emails do not reduce water demand. Third, the paper estimates the impact of completing an online water audit on water demand. The low uptake of the online water audit poses challenges for this estimation. To circumvent the problem, propensity score matching is employed to match households that completed the online water audit with a comparable sample from the control group. Next, a difference-in-differences estimation is performed, which illustrates a reduction in average daily water consumption of 6 litres in the months following the audit. Although this reduction seems low, the aggregate impact is approximately 4 megalitres (4 million litres) over the 6 months following the intervention.<sup>24</sup> While the specific mechanisms are not studied here, the reduction in water demand likely takes place through either habit changes or the adoption of water efficient technology (see Brandon et al., 2025 for the mechanisms energy

<sup>24</sup> 3861 (households who completed the survey) x 6 litres (average daily reduction) x 30 (number of days in a month) x 6 (number of months under scrutiny).

demand). In follow-up survey, Akesson et al. (2023) find suggestive evidence that both channels are at work in response to the online water audit.

The study highlights the need for more evidence on the impact of online water audits on water demand reduction in particular, and the importance of rigorously testing interventions aimed at reducing water and energy demand in general. Regarding the implications for Thames Water, the current online water audit process requires modifications and further testing to enhance both online water audit uptake and water-saving effectiveness.

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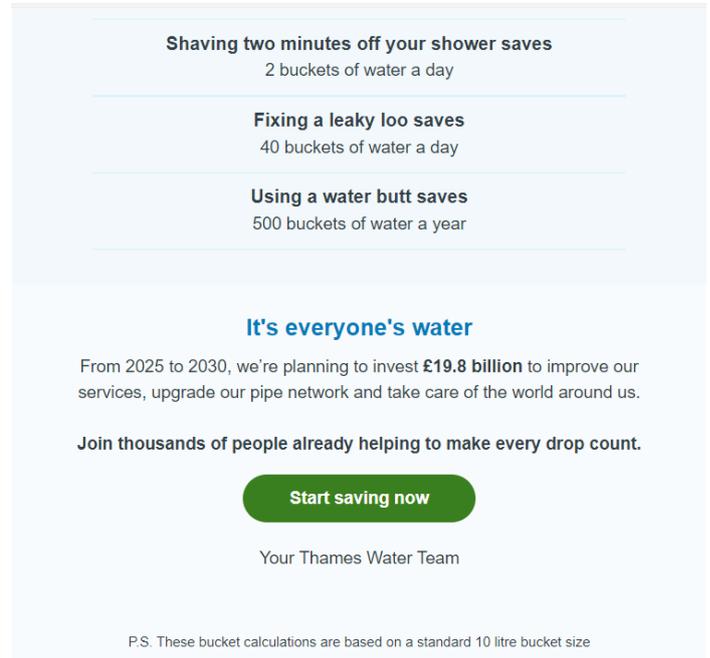
## Online Appendices

### Appendix A. Email templates and the online water audit tool<sup>25</sup>

Figure A.1 Baseline

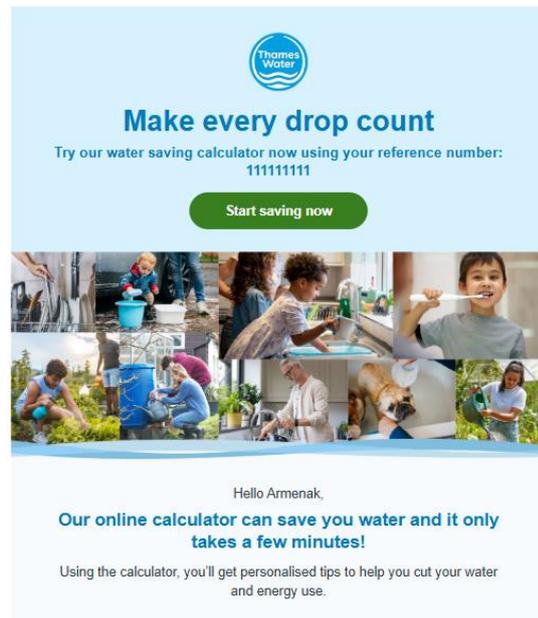


The email template for Figure A.1 Baseline features a light blue header with the Thames Water logo. The main heading is "Make every drop count, come rain or shine" in bold blue text, followed by "with our water saving calculator" in smaller blue text. A green button with white text says "Start saving now". Below this is a collage of six images showing people engaged in water-saving activities: a child watering plants, a woman washing dishes, a man brushing his teeth, a woman watering plants, a man watering plants, and a woman watering plants. The body text starts with "Hello," followed by a paragraph: "We've had plenty of rainy days recently, so our reservoir and river levels are where they should be. But it's still smart to save water for the sunny days ahead!". At the bottom, a blue button with white text says "Did you know you could be saving bucket loads?".

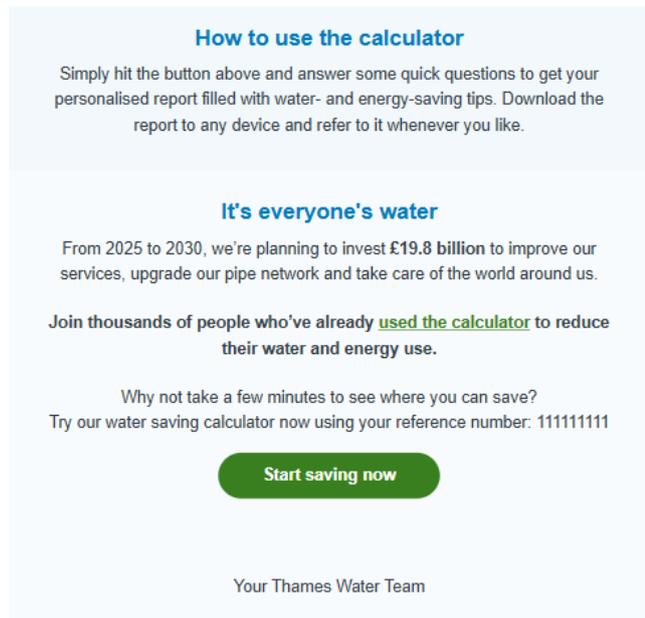


This section of the email template for Figure A.1 Baseline lists water-saving tips in a light blue box. The tips are: "Shaving two minutes off your shower saves 2 buckets of water a day", "Fixing a leaky loo saves 40 buckets of water a day", and "Using a water butt saves 500 buckets of water a year". Below this is a section titled "It's everyone's water" in bold blue text. The text reads: "From 2025 to 2030, we're planning to invest £19.8 billion to improve our services, upgrade our pipe network and take care of the world around us." followed by "Join thousands of people already helping to make every drop count." A green button with white text says "Start saving now". Below this is the text "Your Thames Water Team". At the bottom, in small grey text, it says "P.S. These bucket calculations are based on a standard 10 litre bucket size".

Figure A.2 Neutral



The email template for Figure A.2 Neutral features a light blue header with the Thames Water logo. The main heading is "Make every drop count" in bold blue text, followed by "Try our water saving calculator now using your reference number: 11111111" in smaller blue text. A green button with white text says "Start saving now". Below this is a collage of six images showing people engaged in water-saving activities: a child watering plants, a woman washing dishes, a man brushing his teeth, a woman watering plants, a man watering plants, and a woman watering plants. The body text starts with "Hello Armenak," followed by a paragraph: "Our online calculator can save you water and it only takes a few minutes!". Below this is another paragraph: "Using the calculator, you'll get personalised tips to help you cut your water and energy use."



This section of the email template for Figure A.2 Neutral is in a light blue box. It starts with the heading "How to use the calculator" in bold blue text, followed by the text: "Simply hit the button above and answer some quick questions to get your personalised report filled with water- and energy-saving tips. Download the report to any device and refer to it whenever you like." Below this is a section titled "It's everyone's water" in bold blue text. The text reads: "From 2025 to 2030, we're planning to invest £19.8 billion to improve our services, upgrade our pipe network and take care of the world around us." followed by "Join thousands of people who've already used the calculator to reduce their water and energy use." Below this is a paragraph: "Why not take a few minutes to see where you can save? Try our water saving calculator now using your reference number: 11111111". A green button with white text says "Start saving now". Below this is the text "Your Thames Water Team".

<sup>25</sup> The templates were displayed on a single screen as one complete email.

Figure A.3 Finance



## Make every drop count

Try our water saving calculator now using your reference number:  
11111111

[Start saving now](#)



Hello Armenak,

**Our online calculator can save you money – and it only takes a few minutes!**

Using the calculator, you'll get personalised tips to help you cut your water and energy bills.

### How to use the calculator

Simply hit the button above and answer some quick questions to get your personalised report filled with water- and energy-saving tips. Download the report to any device and refer to it whenever you like.

### It's everyone's water

From 2025 to 2030, we're planning to invest **£19.8 billion** to improve our services, upgrade our pipe network and take care of the world around us.

Join thousands of people who've already [used the calculator](#) to save £££ on water and energy.

Why not take a few minutes to see where you can save?  
Try our water saving calculator now using your reference number: 11111111

[Start saving now](#)

Your Thames Water Team

Figure A.4 Environment



## Make every drop count

Try our water saving calculator now using your reference number:  
11111111

[Start saving now](#)



Hello Armenak,

**Our online calculator not only saves you water but also helps the environment – and it only takes a few minutes!**

Your local area is classed as being under serious water stress. Using the calculator, you'll get personalised tips to help you cut your water and energy use and reduce your environmental impact.

### How to use the calculator

Simply hit the button above and answer some quick questions to get your personalised report filled with water- and energy-saving tips. Download the report to any device and refer to it whenever you like.

### It's everyone's water

From 2025 to 2030, we're planning to invest **£19.8 billion** to improve our services, upgrade our pipe network and take care of the world around us.

Join thousands of people who've already [used the calculator](#) to help the environment.

Why not take a few minutes to see where you can save?  
Try our water saving calculator now using your reference number: 11111111

[Start saving now](#)

Your Thames Water Team

Figure A.5 Altruism



## Make every drop count

Try our water saving calculator now using your reference number: 11111111

[Start saving now](#)



Hello Armenak,

**Our online calculator can help you save water for the future – and it only takes a few minutes!**

Your local area is classed as being under serious water stress. If nothing changes, there will be less and less water left for future generations.

Using the calculator, you'll get personalised tips to help you cut your water and energy use and save water for the future.

### How to use the calculator

Simply hit the button above and answer some quick questions to get your personalised report filled with water- and energy-saving tips. Download the report to any device and refer to it whenever you like.

### It's everyone's water

From 2025 to 2030, we're planning to invest **£19.8 billion** to improve our services, upgrade our pipe network and take care of the world around us.

Join thousands of people who've already **used the calculator** to reduce their water and energy use.

Why not take a few minutes to see where you can save?  
Try our water saving calculator now using your reference number: 11111111

[Start saving now](#)

Your Thames Water Team

Figure A.6 Original online water audit tool landing page

# Water saving calculator

## Could you squeeze more from every drop?

Answer quick and easy questions to get a personalised report on how to save water and money on your bills.

Your report will include how much water and energy your household currently uses.

**Terms and conditions**  
This tool calculates your water use based on the information you enter. The costs are estimated based on metered tariffs and may or may not reflect your actual bill.

We'll use the details you provide to help us better understand water use around our region. You can find out more about how we use your data in our [privacy notice](#).

Please accept our terms and conditions to use the water saving calculator.

[Start](#)



Figure A.7 Altered online water audit tool landing page

# Water saving calculator

Could you squeeze more from every drop?

Answer quick and easy questions to get a personalised report on how to save water.

Your report will include how much water and energy your household currently uses.

**Terms and conditions**

This tool calculates your water use based on the information you enter. The costs are estimated based on metered tariffs and may or may not reflect your actual bill.

We'll use the details you provide to help us better understand water use around our region. You can find out more about how we use your data in our [privacy notice](#).

Please accept our terms and conditions to use the water saving calculator.

Please enter your reference number in the box below

Start



## Appendix B. Balance checks

**Table B.1 Balance checks for the combined samples**

	Pre-treatment water consumption	Pre-treatment leakage	Affordability support	Latest account balance	Contract length
Neutral	-2.463 (24.911)	-0.881 (1.021)	0.001 (0.001)	-1.586 (1.421)	0.091 (0.095)
Baseline	1.921 (25.578)	-0.290 (1.151)	-0.000 (0.001)	-0.684 (1.324)	0.017 (0.095)
Finance	-3.876 (23.999)	-0.319 (1.296)	0.001 (0.001)	-2.095 (1.293)	-0.084 (0.096)
Environment	425.764 (425.595)	2.032 (2.923)	0.000 (0.001)	-1.162 (1.434)	-0.119 (0.095)
Altruism	379.292 (372.267)	-0.868 (1.051)	-0.001 (0.001)	1.022 (1.387)	0.054 (0.095)
Constant	4,494.914*** (17.218)	14.348*** (0.898)	0.059*** (0.001)	217.715*** (0.981)	48.446*** (0.068)
F-stat	0.423	0.438	0.409	1.442	1.426
Adj-R <sup>2</sup>	-0.000	-0.000	-0.000	0.000	0.000
N	394,923	394,923	394,923	393,527	394,923

Note. OLS model. *Dependent variables.* *Pre-treatment water consumption* defined as the sum of each household's average daily water consumption for each month from May 2023 to June 2024; *Pre-treatment leakage* defined as the sum of each household's average daily water leakage for each month from May 2023 to June 2024; *Affordability support* defined as an indicator variable that equals to 1 if the household receives affordability support and 0 otherwise; *Latest account balance* defined as each household's latest account balance as of June 2024; *Contract length* defined as the length of the contract (in months) in a given premise (integer). *Independent variables.* Treatment dummies equal to 1 if the household belongs to the respective treatment group and 0 otherwise. Significance levels: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

**Table B.2 Balance checks for batch 1**

	Pre-treatment water consumption	Pre-treatment leakage	Affordability support	Latest account balance	Contract length
Neutral	38.532 (35.145)	-0.224 (1.266)	-0.001 (0.002)	-0.309 (2.193)	0.147 (0.135)
Baseline	35.714 (37.084)	-0.168 (1.356)	-0.001 (0.002)	-2.655 (1.902)	0.034 (0.135)
Finance	14.581 (34.218)	1.003 (1.986)	-0.001 (0.002)	-3.857* (1.864)	-0.011 (0.135)
Environment	-12.241 (34.146)	-0.491 (1.234)	0.001 (0.002)	-2.384 (2.130)	-0.177 (0.135)
Altruism	763.184 (743.698)	-0.545 (1.344)	-0.001 (0.002)	-1.148 (1.973)	0.010 (0.135)
Constant	4,476.341*** (24.166)	13.789*** (1.051)	0.060*** (0.001)	219.192*** (1.445)	48.418*** (0.096)
F-stat	0.811	0.176	0.279	1.238	1.195
Adj-R <sup>2</sup>	0.000	-0.000	-0.000	0.000	0.000
N	197,460	197,460	197,460	196,759	197,460

Note. Remarks of Table B.1 apply.

**Table B.3 Balance checks for batch 2**

	Pre-treatment water consumption	Pre-treatment leakage	Affordability support	Latest account balance	Contract length
Neutral	-43.458 (35.314)	-1.538 (1.603)	0.002 (0.002)	-2.861 (1.806)	0.034 (0.135)
Baseline	-31.871 (35.239)	-0.412 (1.860)	0.000 (0.002)	1.286 (1.842)	0.000 (0.135)
Finance	-22.332 (33.660)	-1.641 (1.665)	0.002 (0.002)	-0.332 (1.794)	-0.157 (0.135)
Environment	863.756 (850.492)	4.556 (5.714)	0.000 (0.002)	0.060 (1.921)	-0.061 (0.135)
Altruism	-4.600 (35.307)	-1.191 (1.615)	-0.001 (0.002)	3.193 (1.948)	0.098 (0.134)
Constant	4,513.486*** (24.531)	14.906*** (1.457)	0.058*** (0.001)	216.238*** (1.328)	48.473*** (0.095)
F-stat	0.639	0.556	1.007	2.312	0.837
Adj-R <sup>2</sup>	0.000	-0.000	0.000	0.000	-0.000
N	197,463	197,463	197,463	196,768	197,463

Note. Remarks of Table B.1 apply.

**Table B.4 Balance checks across batches**

	Pre-treatment water consumption	Pre-treatment leakage	Affordability support	Latest account balance	Contract length
Batch 2	24.153 (188.664)	1.151 (1.079)	-0.000 (0.001)	-1.004 (0.787)	0.040 (0.055)
Constant	4,616.268*** (124.208)	13.718*** (0.418)	0.060*** (0.001)	217.466*** (0.577)	48.419*** (0.039)
F-stat	0.016	1.138	0.353	1.628	0.526
Adj-R <sup>2</sup>	-0.000	0.000	-0.000	0.000	-0.000
N	394,923	394,923	394,923	393,527	394,923

Note. *Independent variables.* Batch 2 defined as an indicator variable that equals to 1 if the household belongs to Batch 2 and 0 otherwise. For the rest of the table Remarks of Table B.1 apply.

## Appendix C. Further checks

**Table C.1 Attrition across treatment groups**

	Attrition
Neutral	-0.001 (0.001)
Baseline	-0.000 (0.001)
Finance	-0.000 (0.001)
Environment	-0.000 (0.001)
Altruism	-0.002 (0.001)
Constant	0.072*** (0.001)
F-stat.	0.369
Adj. R <sup>2</sup>	-0.000
N	394,923

Note. Linear probability model. *Dependent variable.* The contract status of the household defined as an indicator variable that equals to 1 if a household becomes inactive during the study, and 0 otherwise. *Independent variables.* Treatment dummies equal to 1 if the household belongs to the respective treatment group and 0 otherwise. Significance levels: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

**Table C.2 Balance checks for the combined samples**

	Pre-treatment water consumption	Pre-treatment leakage	Affordability support	Latest account balance	Contract length
Neutral	12.769 (28.121)	0.057 (1.122)	0.000 (0.002)	0.184 (1.427)	0.009 (0.103)
Baseline	6.625 (29.161)	0.715 (1.320)	-0.001 (0.002)	0.579 (1.297)	-0.035 (0.103)
Finance	5.610 (26.808)	-0.739 (1.075)	-0.000 (0.002)	-0.128 (1.239)	-0.091 (0.103)
Environment	-8.345 (26.188)	-0.969 (1.053)	0.000 (0.002)	-0.618 (1.282)	-0.154 (0.103)
Altruism	487.674 (483.703)	-0.508 (1.101)	-0.002 (0.002)	0.538 (1.291)	0.043 (0.103)
Constant	4,937.478*** (18.715)	13.749*** (0.961)	0.062*** (0.001)	223.501*** (0.942)	49.814*** (0.073)
F-stat	0.335	0.887	0.400	0.262	1.011
Adj-R <sup>2</sup>	-0.000	-0.000	-0.000	-0.000	0.000
N	302,879	302,879	302,879	301,935	302,879

Note. Remarks of Table B.1 apply.

**Table C.3 Balance checks for batch 1**

	Pre-treatment water consumption	Pre-treatment leakage	Affordability support	Latest account balance	Contract length
Neutral	59.477 (38.283)	1.718 (0.943)	-0.001 (0.002)	2.890 (2.241)	0.007 (0.146)
Baseline	61.701 (41.830)	2.111 (1.174)	-0.002 (0.002)	0.783 (1.799)	0.004 (0.146)
Finance	45.830 (37.183)	1.481 (0.873)	-0.001 (0.002)	1.267 (1.711)	0.012 (0.146)
Environment	-8.663 (35.095)	0.280 (0.714)	0.000 (0.002)	-0.793 (1.664)	-0.206 (0.146)
Altruism	996.594 (967.186)	1.267 (0.905)	-0.001 (0.002)	0.515 (1.741)	0.116 (0.146)
Constant	4,904.406*** (24.501)	11.860*** (0.474)	0.063*** (0.002)	223.282*** (1.259)	49.772*** (0.104)
F-stat	1.389	1.547	0.363	0.743	1.050
Adj-R <sup>2</sup>	-0.000	0.000	-0.000	-0.000	0.000
N	151,549	151,549	151,549	151,073	151,549

Note. Remarks of Table B.1 apply.

**Table C.4 Balance checks for batch 2**

	Pre-treatment water consumption	Pre-treatment leakage	Affordability support	Latest account balance	Contract length
Neutral	-33.959 (41.199)	-1.602 (2.035)	0.002 (0.002)	-2.532 (1.765)	0.012 (0.145)
Baseline	-48.529 (40.618)	-0.677 (2.364)	0.001 (0.002)	0.376 (1.867)	-0.075 (0.145)
Finance	-34.589 (38.623)	-2.957 (1.963)	0.001 (0.002)	-1.525 (1.791)	-0.195 (0.146)
Environment	-8.002 (38.875)	-2.216 (1.980)	-0.000 (0.002)	-0.442 (1.950)	-0.103 (0.145)
Altruism	-20.609 (40.082)	-2.281 (2.007)	-0.002 (0.002)	0.561 (1.907)	-0.030 (0.145)
Constant	4,970.514*** (28.292)	15.636*** (1.862)	0.061*** (0.002)	223.721*** (1.402)	49.855*** (0.102)
F-stat	0.415	0.901	0.635	1.089	0.560
Adj-R <sup>2</sup>	-0.000	-0.000	-0.000	-0.000	-0.000
N	151,330	151,330	151,330	150,862	151,330

Note. Remarks of Table B.1 apply.

**Table C.5 Balance checks across batches**

	Pre-treatment water consumption	Pre-treatment leakage	Affordability support	Latest account balance	Contract length
Batch 2	-150.853 (162.078)	1.011 (0.557)	-0.001 (0.001)	-0.930 (0.746)	0.028 (0.059)
Constant	5,097.104*** (161.670)	13.004*** (0.310)	0.062*** (0.001)	224.060*** (0.544)	49.761*** (0.042)
F-stat	0.866	3.300	0.353	1.554	0.227
Adj-R <sup>2</sup>	-0.000	0.000	-0.000	0.000	-0.000
N	302,879	302,879	302,879	301,935	302,879

Note. Remarks of Table B.4 apply.

## Appendix D. Additional results

**Table D.1 Online water audit completion<sup>26</sup>**

	Batch 1	Batch 2
Neutral	1.342*** (0.105)	0.529*** (0.069)
Finance	1.103*** (0.101)	0.918*** (0.080)
Environment	0.578*** (0.090)	0.443*** (0.066)
Altruism	0.933*** (0.097)	0.486*** (0.068)
High consumption	-0.759*** (0.070)	-0.370*** (0.051)
Affordability support	-0.514*** (0.117)	-0.302*** (0.082)
Contract length	0.014*** (0.002)	0.004** (0.002)
Income decile	0.050*** (0.014)	0.039*** (0.010)
Constant	0.924*** (0.167)	0.485*** (0.121)
Treatment Comparison		
Finance vs Neutral	F=3.70, p=0.054	F=17.83, p=0.000
Finance vs Environment	F=22.15, p=0.000	F=27.79, p=0.000
Finance vs Altruism	F=2.1, p=0.148	F=22.48, p=0.000
Control	Yes	Yes
F-stat.	48.702	29.423
Adj. R <sup>2</sup>	0.003	0.002
N	122,532	122,324

Note. Linear probability model. *Dependent variable.* Online audit completion defined as an indicator variable that equals to 1 if the audit is completed and 0 otherwise. *Independent variables.* Treatment dummies equal to 1 if the household belongs to the respective treatment group and 0 otherwise; *High consumption* defined as an indicator variable that equals to 1 if a household's pre-treatment water consumption is above the median and 0 otherwise; *Affordability support* defined as an indicator variable that equals to 1 if the household receives affordability support and 0 otherwise; *Contract length* defined as the length of the contract (in months) in a given premise (integer); *Income decile* defined as the income rank of the postcode (integer). Significance levels: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

**Table D.2 ITT estimates batch 1**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2024
Neutral	1.979 (2.395)	2.777 (2.322)	1.965 (2.238)	1.751 (2.236)	-0.027 (2.246)	0.506 (2.260)
Baseline	2.234 (2.389)	1.237 (2.313)	1.218 (2.225)	-0.111 (2.224)	-0.203 (2.239)	-0.777 (2.245)
Finance	1.870 (2.407)	1.666 (2.322)	1.705 (2.234)	0.612 (2.230)	-0.254 (2.253)	-0.666 (2.257)
Environment	-1.266 (2.385)	-1.387 (2.305)	-0.738 (2.224)	-1.629 (2.222)	-2.407 (2.238)	-2.324 (2.250)
Altruism	0.955 (2.383)	1.545 (2.302)	2.571 (2.225)	2.445 (2.225)	2.395 (2.249)	2.041 (2.258)
Constant	366.547*** (1.687)	373.621*** (1.633)	363.424*** (1.579)	367.076*** (1.578)	364.442*** (1.593)	368.955*** (1.597)
Controls	No	No	No	No	No	No
F-stat.	0.655	0.796	0.638	0.854	0.929	0.840
Adj. R <sup>2</sup>	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
N	151,549	151,549	151,549	151,549	151,549	151,549

Note. OLS model. *Dependent variables.* Monthly post-treatment water consumption defined as each household's average daily water consumption for a given month from August 2024 to January 2025. *Independent variables.* Treatment dummies equal to 1 if the household belongs to the respective treatment group and 0 otherwise. Significance levels: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

<sup>26</sup> The independent variable Income Decile contains missing values, that's why the number of observations in the regression drops compared to the number of observations in the same regression without controls.

**Table D.3 ITT estimates batch 2**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2024
Neutral	-3.832 (2.389)	-2.341 (2.311)	-1.568 (2.218)	-2.535 (2.212)	-3.816 (2.225)	-3.474 (2.239)
Baseline	-3.711 (2.391)	-2.392 (2.302)	-0.810 (2.218)	-2.480 (2.214)	-1.645 (2.238)	-2.691 (2.243)
Finance	-0.781 (2.405)	-0.483 (2.306)	-0.021 (2.216)	-0.336 (2.218)	0.577 (2.237)	-1.250 (2.242)
Environment	0.923 (2.417)	1.614 (2.324)	1.478 (2.227)	0.883 (2.223)	1.384 (2.244)	1.102 (2.255)
Altruism	-1.137 (2.408)	-0.816 (2.322)	-0.324 (2.233)	-0.855 (2.227)	-1.125 (2.241)	-0.886 (2.255)
Constant	368.606*** (1.704)	374.711*** (1.639)	364.519*** (1.572)	368.075*** (1.573)	365.192*** (1.588)	369.851*** (1.594)
Controls	No	No	No	No	No	No
F-stat.	1.155	1.113	0.963	1.156	1.779	1.234
Adj. R <sup>2</sup>	0.000	0.000	-0.000	0.000	0.000	0.000
N	178,327	178,184	178,267	178,848	178,829	179,039

Note. The same remarks of Table D.2 apply.

**Table D.4 ITT estimates batch 1**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2024
Neutral	0.204 (1.408)	0.957 (1.185)	0.177 (1.180)	-0.066 (1.203)	-1.792 (1.258)	-1.351 (1.285)
Baseline	1.106 (1.404)	0.163 (1.172)	0.069 (1.164)	-1.303 (1.185)	-1.208 (1.248)	-1.940 (1.272)
Finance	0.417 (1.415)	0.388 (1.174)	0.273 (1.170)	-0.768 (1.192)	-1.581 (1.264)	-1.858 (1.285)
Environment	-1.183 (1.426)	-0.972 (1.189)	-0.564 (1.178)	-1.577 (1.194)	-2.280 (1.268)	-2.361 (1.291)
Altruism	-1.594 (1.409)	-1.008 (1.176)	0.224 (1.176)	0.064 (1.206)	0.094 (1.272)	-0.133 (1.297)
Constant	44.756*** (1.952)	67.161*** (1.669)	92.438*** (1.678)	93.597*** (1.713)	70.562*** (1.798)	90.954*** (1.825)
Control	Yes	Yes	Yes	Yes	Yes	Yes
F-stat.	11,213.389	14,480.745	13,399.516	12,814.045	11,600.651	11,217.756
Adj. R <sup>2</sup>	0.657	0.746	0.729	0.720	0.691	0.683
N	146,998	146,998	146,998	146,998	146,998	146,998

Note. OLS model. *Dependent variables.* Monthly post-treatment water consumption defined as each household's average daily water consumption for a given month from August 2024 to January 2025. *Independent variables.* Treatment dummies equal to 1 if the household belongs to the respective treatment group and 0 otherwise; Pre-treatment water consumption defined as the sum of each household's average daily water consumption for each month from May 2023 to June 2024; *Affordability support* defined as an indicator variable that equals to 1 if the household receives affordability support and 0 otherwise; *Contract length* defined as the length of the contract (in months) in a given premise (integer); *Income decile* defined as the income rank of the postcode (integer). Significance levels: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

**Table D.5 ITT estimates batch 2**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2024
Neutral	-2.177 (1.448)	-0.569 (1.204)	0.148 (1.185)	-0.513 (1.202)	-1.838 (1.262)	-1.765 (1.293)
Baseline	-1.256 (1.440)	0.079 (1.194)	1.647 (1.180)	0.193 (1.201)	0.925 (1.271)	-0.177 (1.290)
Finance	0.392 (1.444)	0.671 (1.189)	1.072 (1.163)	0.906 (1.191)	1.658 (1.259)	-0.178 (1.285)
Environment	0.637 (1.449)	1.225 (1.189)	0.897 (1.171)	0.518 (1.202)	0.844 (1.271)	0.777 (1.299)
Altruism	0.852 (1.440)	0.946 (1.179)	1.543 (1.170)	1.003 (1.199)	0.713 (1.257)	0.891 (1.288)
Constant	45.158*** (1.963)	63.834*** (1.650)	89.186*** (1.645)	92.497*** (1.688)	70.120*** (1.775)	89.784*** (1.819)
Control	Yes	Yes	Yes	Yes	Yes	Yes
F-stat.	10,949.094	14,707.081	13,378.682	12,704.610	11,570.969	11,065.489
Adj. R <sup>2</sup>	0.651	0.744	0.729	0.719	0.690	0.681
N	146,842	146,842	146,842	146,842	146,842	146,842

Note. The same remarks of Table D.4 apply.

**Table D.6 LATE estimates (Instruments: Baseline, Neutral, Finance)**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2025
Completed	4.355 (93.427)	43.349 (90.173)	35.701 (86.716)	19.372 (86.605)	-41.817 (87.236)	-52.803 (87.553)
Constant	367.261*** (1.012)	373.846*** (0.977)	363.971*** (0.940)	367.019*** (0.940)	364.512*** (0.948)	368.822*** (0.951)
Control	No	No	No	No	No	No
N	201,848	201,848	201,848	201,848	201,848	201,848

Note. 2SLS model (2<sup>nd</sup> stage). *Dependent variables.* Monthly post-treatment water consumption defined as each household's average daily water consumption for a given month from August 2024 to January 2025. *Independent variables.* Completed is the predicted probability of whether a given household completed the online audit or not. Significance levels: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ .

**Table D.7 LATE estimates (Instruments: All)**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2025
Completed	7.328 (90.697)	45.645 (87.540)	46.017 (84.226)	35.972 (84.133)	-19.302 (84.778)	-23.871 (85.077)
Constant	367.278*** (0.996)	373.849*** (0.961)	363.988*** (0.925)	367.044*** (0.924)	364.576*** (0.932)	368.931*** (0.935)
Control	No	No	No	No	No	No
N	302,879	302,879	302,879	302,879	302,879	302,879

Note. The same remarks of Table D.6 apply.

**Table D.8 LATE estimates (Instruments: Finance)**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2025
Completed	35.752 (111.862)	38.902 (107.608)	55.348 (103.499)	9.024 (103.390)	10.547 (104.376)	-62.989 (104.545)
Constant	367.577*** (1.199)	374.166*** (1.157)	363.972*** (1.114)	367.575*** (1.114)	364.817*** (1.125)	369.403*** (1.128)
Control	No	No	No	No	No	No
N	100,860	100,860	100,860	100,860	100,860	100,860

Note. The same remarks of Table D.6 apply.

**Table D.9 LATE estimates (Instruments: Baseline, Neutral, Finance)**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2025
Completed	-28.883 (76.623)	10.967 (69.470)	0.349 (67.124)	-8.946 (66.897)	-72.634 (68.190)	-85.590 (68.588)
Constant	-90.956*** (2.228)	-91.347*** (2.018)	-58.706*** (1.938)	-61.321*** (1.949)	-83.631*** (1.973)	-64.492*** (2.006)
Control	Yes	Yes	Yes	Yes	Yes	Yes
N	195,842	195,842	195,842	195,842	195,842	195,842

Note. The same remarks of Table D.6 apply. For the control variables the remarks of Table D.1 apply.

**Table D.10 LATE estimates (Instruments: All)**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2025
Completed	-26.539 (74.262)	10.288 (67.341)	10.201 (65.111)	5.266 (64.898)	-51.911 (66.170)	-56.724 (66.540)
Constant	-91.009*** (1.893)	-91.817*** (1.716)	-58.557*** (1.651)	-60.655*** (1.658)	-82.519*** (1.685)	-64.299*** (1.712)
Control	Yes	Yes	Yes	Yes	Yes	Yes
N	293,840	293,840	293,840	293,840	293,840	293,840

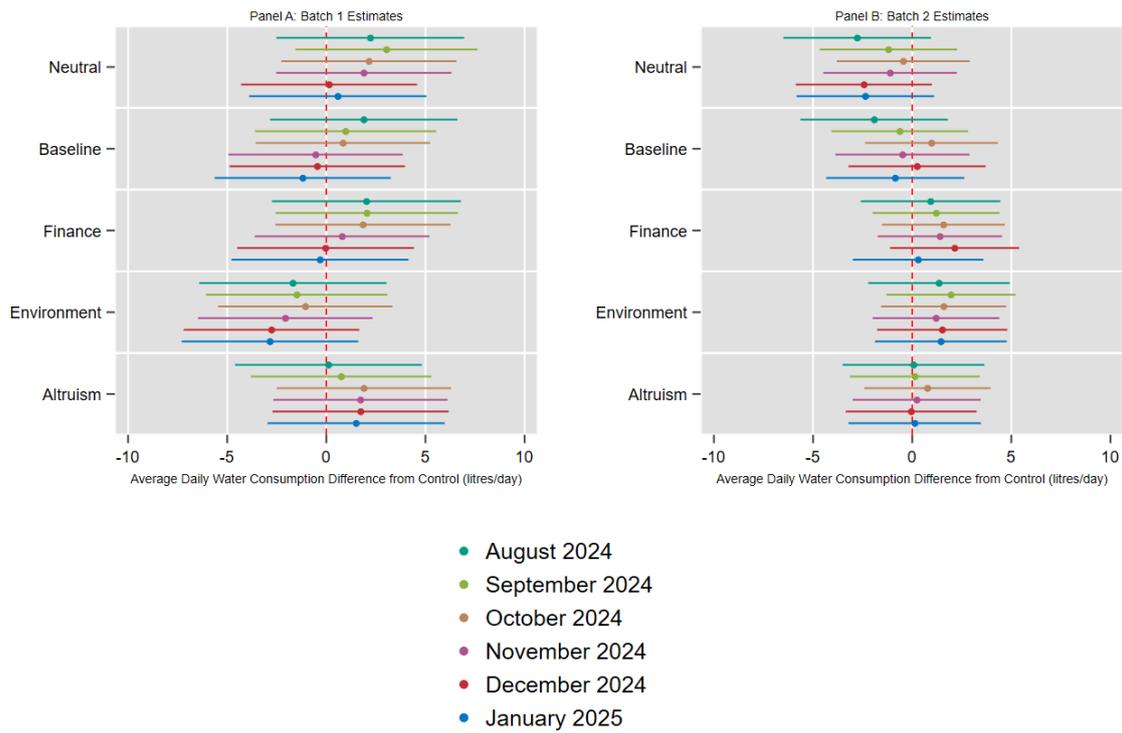
Note. The same remarks of Table D.6 apply. For the control variables the remarks of Table D.1 apply.

**Table D.11 LATE estimates (Instruments: Finance)**

	August 2024	September 2024	October 2024	November 2024	December 2024	January 2025
Completed	9.898 (91.664)	16.248 (82.789)	26.433 (79.939)	-12.989 (79.745)	-15.051 (81.476)	-83.955 (81.824)
Constant	-91.372*** (3.092)	-90.538*** (2.792)	-57.557*** (2.681)	-59.727*** (2.697)	-82.758*** (2.743)	-63.223*** (2.784)
Control	Yes	Yes	Yes	Yes	Yes	Yes
N	97,899	97,899	97,899	97,899	97,899	97,899

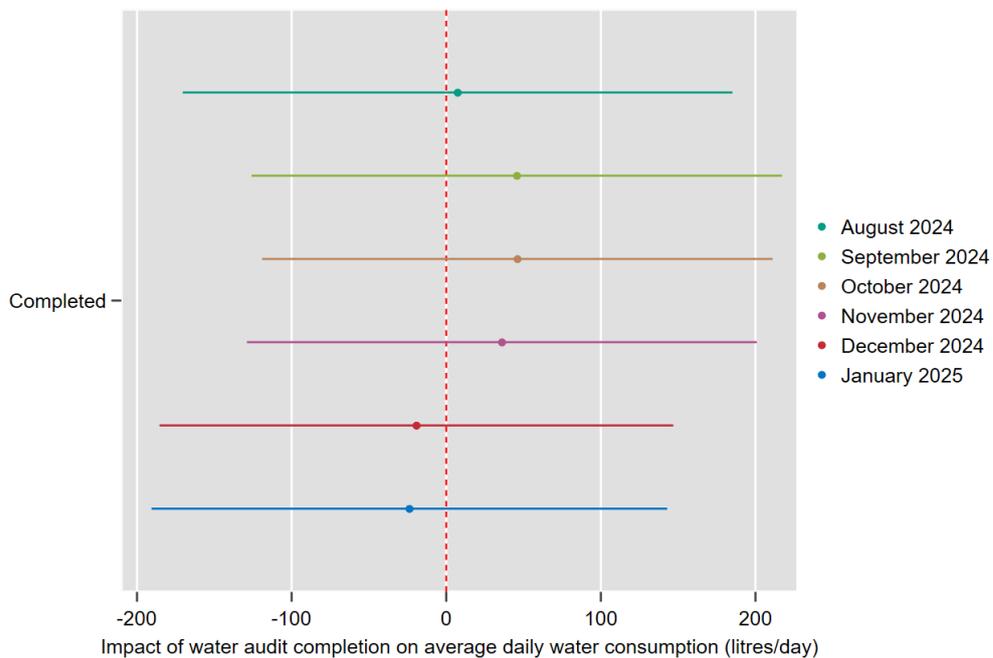
Note. The same remarks of Table D.6 apply. For the control variables the remarks of Table D.1 apply.

Figure D.1 ITT estimates (Controls: Yes)



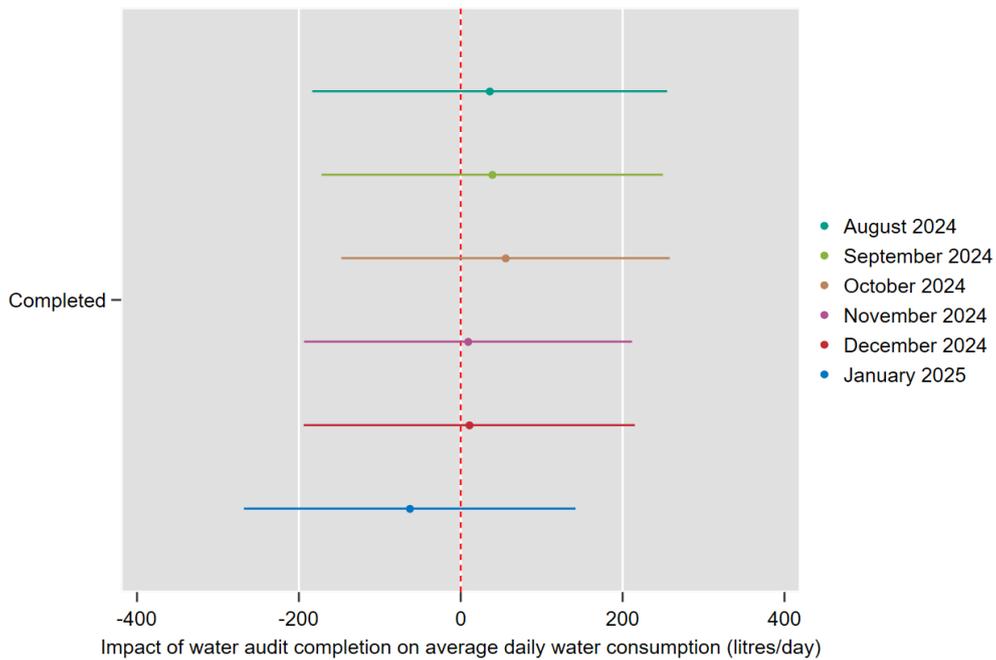
Note. The figure illustrates the treatment effect estimates of email dispatch on water demand reduction ( $\hat{\gamma}_j$ ). These estimates are obtained from an OLS regression model based on equation (2). The figure reports a specification estimated with control variables.

Figure D.2 LATE estimates (Instruments: All, Controls: None)



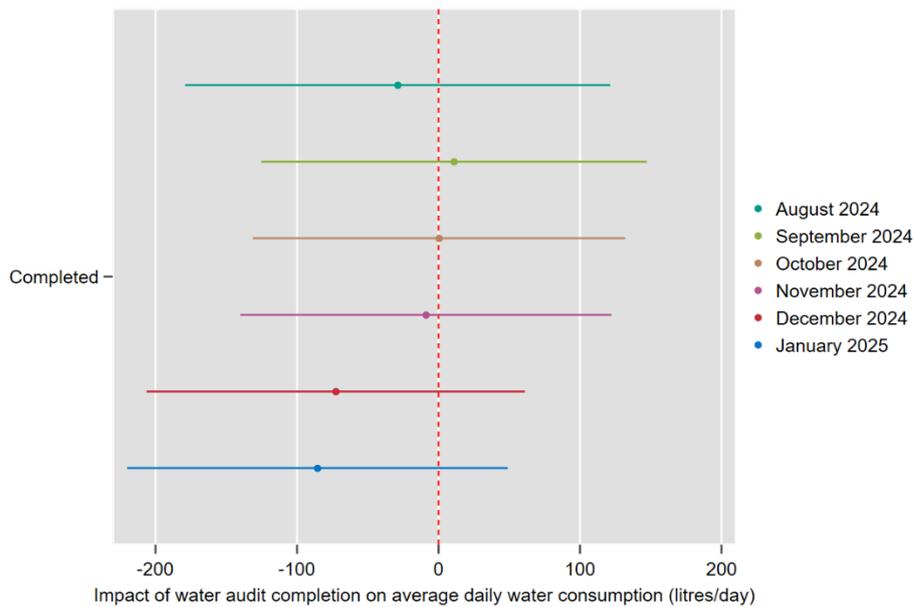
Note. The figure estimates the effect of online audit completion on water demand reduction ( $\hat{\mu}_1$ ). These estimates are obtained from the second stage of a 2SLS regression model based on equation (4). The figure reports a specification estimated without control variables.

Figure D.3 LATE estimates (Instruments: “Finance”, Controls: None)



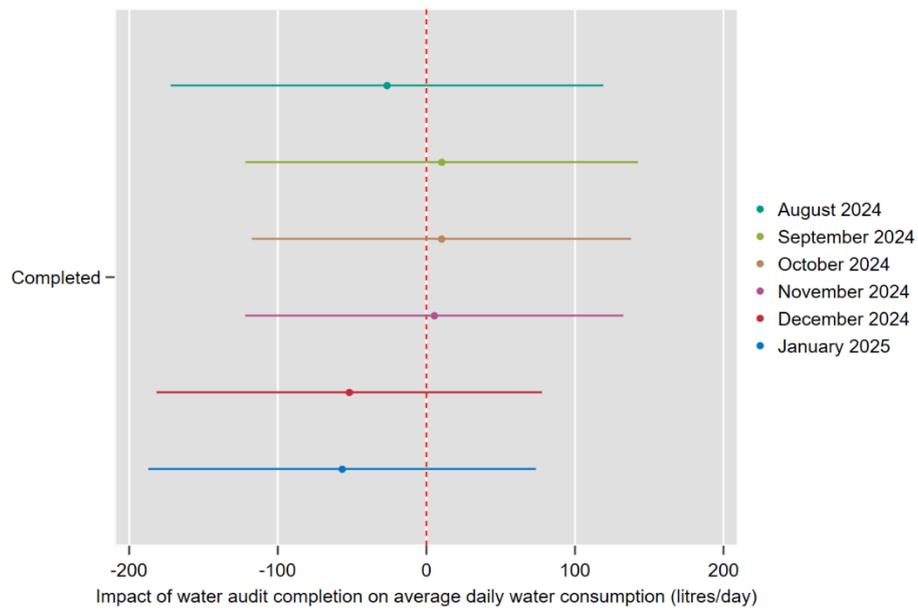
Note. The same remarks of Figure D.2 apply.

Figure D.4 LATE estimates (Instruments: “Baseline”, “Neutral”, “Finance”, Controls: Yes)



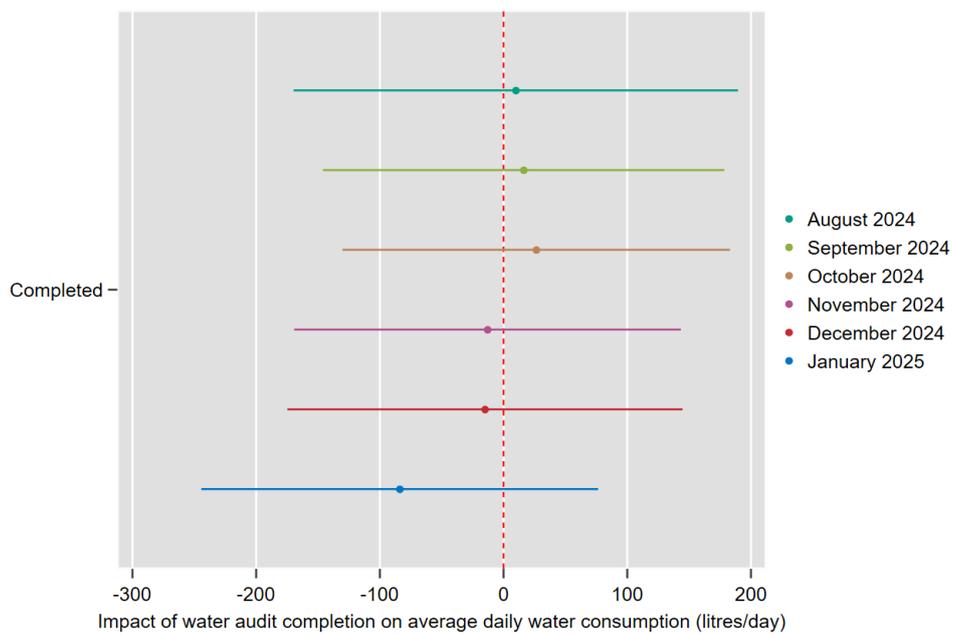
Note. The figure estimates the effect of online audit completion on water demand reduction ( $\widehat{\mu}_1$ ). These estimates are obtained from the second stage of a 2SLS regression model based on equation (4). The figure reports a specification estimated with control variables.

Figure D.5 LATE estimates (Instruments: All, Controls: Yes)



Note. The same remarks of Figure D.4 apply.

Figure D.6 LATE estimates (Instruments: "Finance", Controls: Yes)



Note. The same remarks of Figure D.4 apply.

## Appendix E. Heterogeneity analysis

**Table E.1 Online water audit completion**

	Batch 1	Batch 2
Neutral	1.615*** (0.161)	0.519*** (0.102)
Finance	1.345*** (0.155)	1.179*** (0.125)
Environment	0.829*** (0.141)	0.589*** (0.105)
Altruism	1.214*** (0.152)	0.614*** (0.105)
High Consumption	-0.320** (0.105)	-0.132 (0.073)
Neutral × High Consumption	-0.513* (0.208)	-0.010 (0.137)
Finance × High Consumption	-0.508* (0.198)	-0.539*** (0.158)
Environment × High Consumption	-0.488** (0.177)	-0.333* (0.131)
Altruism × High Consumption	-0.562** (0.191)	-0.303* (0.133)
Constant	0.866*** (0.082)	0.402*** (0.056)
Control	No	No
F statistics	39.951	23.793
Adjusted R-squared	0.002	0.002
Number of Observations	126,310	126,063

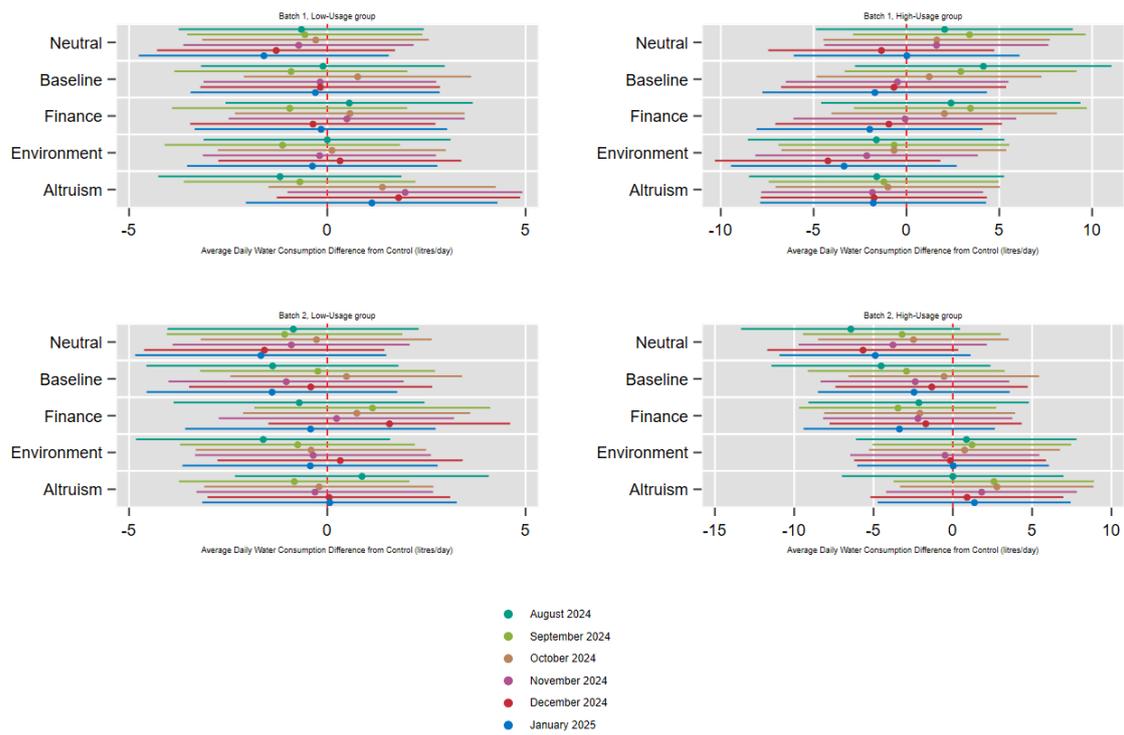
Note. The same remarks of Table 1 apply.

**Table E.2 Online water audit completion**

	Batch 1	Batch 2
Neutral	1.613*** (0.161)	0.518*** (0.102)
Finance	1.341*** (0.154)	1.180*** (0.125)
Environment	0.828*** (0.141)	0.587*** (0.105)
Altruism	1.210*** (0.152)	0.612*** (0.105)
High Consumption	-0.336** (0.105)	-0.130 (0.073)
Neutral × High Consumption	-0.508* (0.207)	-0.007 (0.137)
Finance × High Consumption	-0.499* (0.197)	-0.541*** (0.158)
Environment × High Consumption	-0.478** (0.177)	-0.330* (0.131)
Altruism × High Consumption	-0.558** (0.191)	-0.300* (0.133)
Contant	0.215 (0.126)	0.214* (0.093)
Control	Yes	Yes
F statistics	36.961	21.043
Adjusted R-squared	0.003	0.002
Number of Observations	126,310	126,063

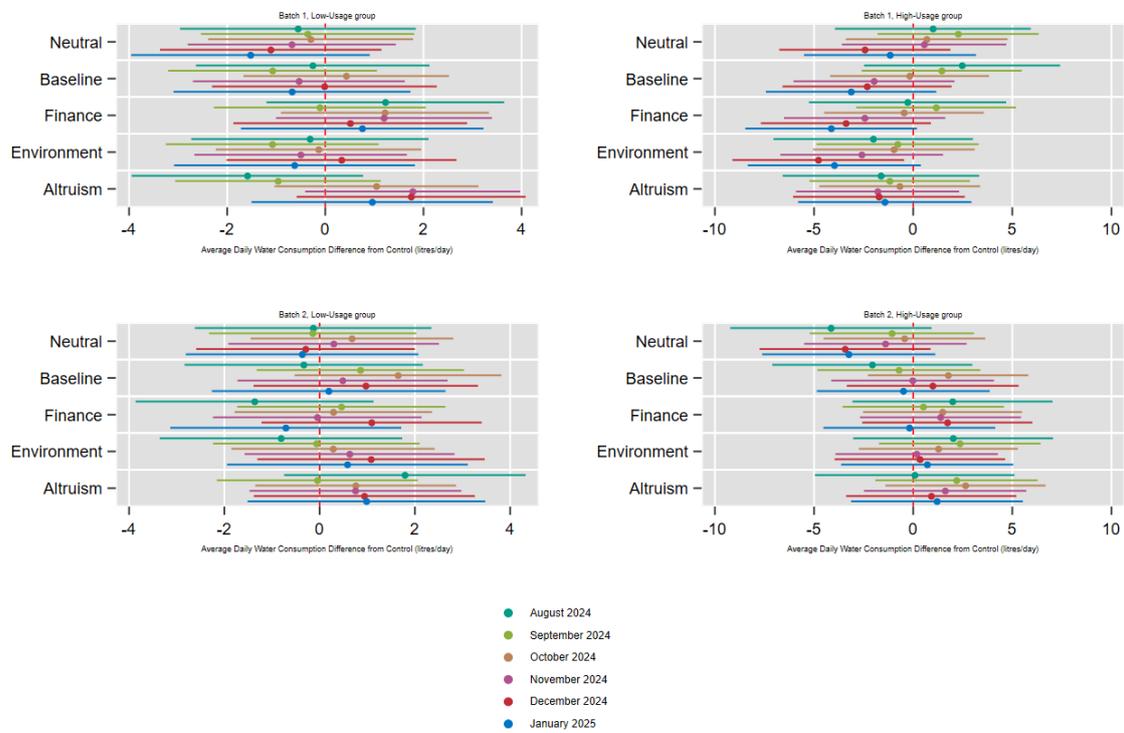
Note. The same remarks of Table D.1 apply.

Figure E.1 ITT estimates (Controls: No)



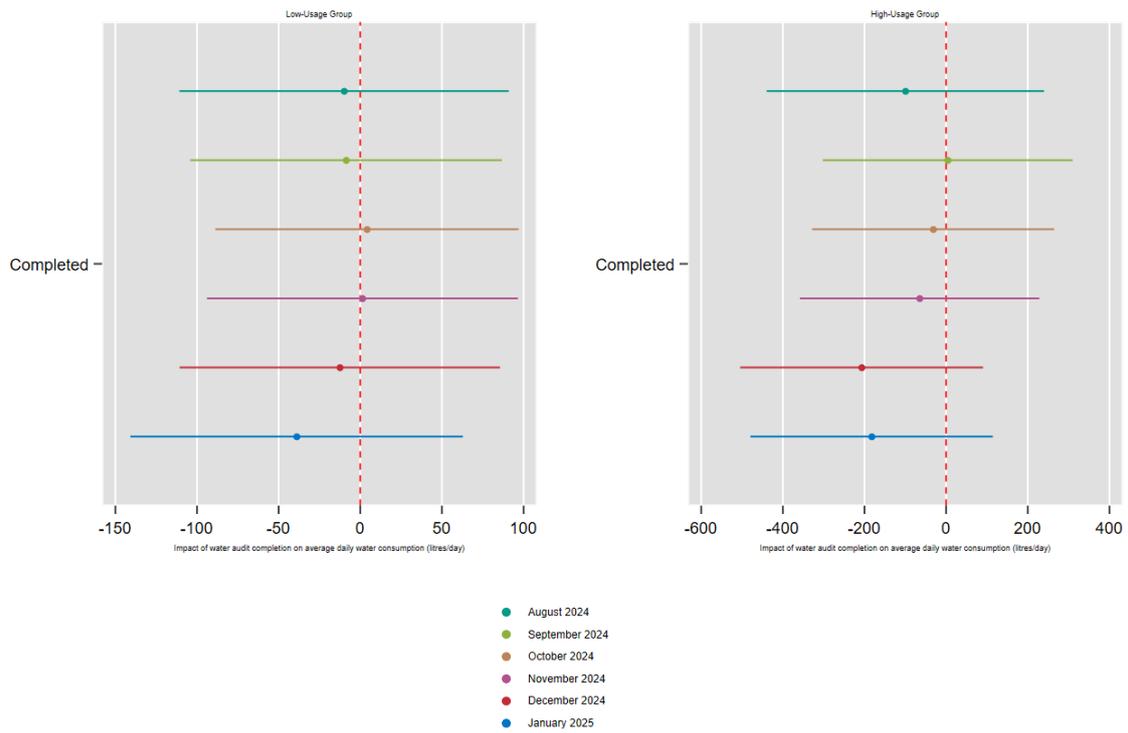
Note. The same remarks of Figure 4 apply.

Figure E.2 ITT estimates (Controls: Yes)



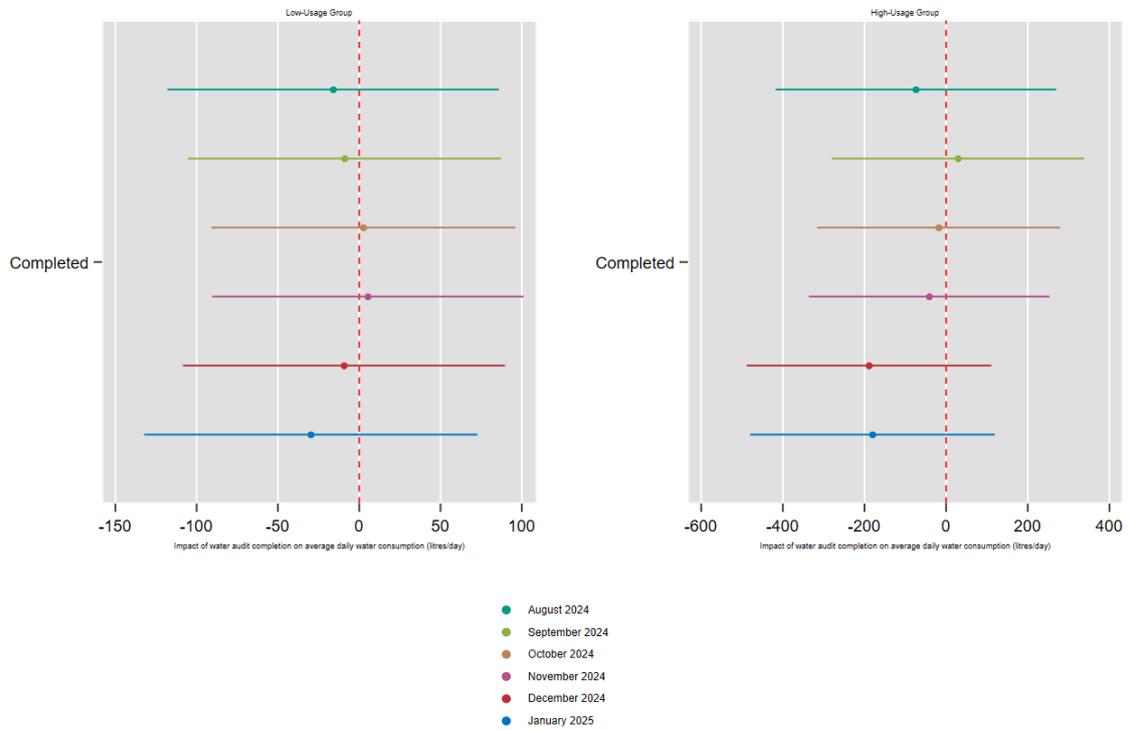
Note. The same remarks of Figure D.1 apply.

Figure E.3 LATE estimates (Instruments: “Baseline”, “Neutral”, “Finance”, Controls: No)



Note. The same remarks of Figures D.2-D.6 apply.

Figure E.4 LATE estimates (Instruments: “Baseline”, “Neutral”, “Finance”, Controls: Yes)



Note. The same remarks of Figures D.2-D.6 apply.

## Appendix F. Matched difference-in-differences

**Table F.1 Balance checks**

Variable	Mean		t-test	
	Treated	Control	t-value	p> t
<i>Daily average water consumption (litres/day)</i>				
May 2023	289.42	285.88	0.68	0.498
June 2023	328.81	324.28	0.74	0.459
July 2023	316.44	315.45	0.17	0.864
August 2023	301.63	301.13	0.09	0.929
September 2023	318.07	313.96	0.72	0.474
October 2023	304.53	301.42	0.59	0.555
November 2023	304.37	302.1	0.43	0.665
December 2023	245.57	241.96	0.69	0.492
January 2024	235.26	233.15	0.41	0.684
February 2024	237.04	235.98	0.20	0.839
March 2024	223.29	221.2	0.42	0.671
April 2024	237.32	234.61	0.54	0.587
May 2024	312.78	312.16	0.11	0.908
June 2024	330.09	328.97	0.20	0.845
<i>Affordability support</i>	0.034	0.037	-0.56	0.578
<i>Property with a garden</i>	0.294	0.279	1.31	0.192

Note. Balance checks after propensity score matching. *Property with a garden* is a binary variable that equals one if the property has a garden and zero otherwise. The same remarks of Appendix B apply.