Electricity savings in households with everyday IT, report from at field experiment

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Abstract:

This paper analyzes the effect of supplying online feedback by SMS-text messages and email about electricity consumption on the level of total household electricity consumption. An experiment was conducted where 1,452 households were randomly allocated to three experimental groups and two control groups. Feedback was supplied throughout 2007 to members of the experiment groups who accepted the invitation, and data on consumption of electricity for 2006 and 2007 collected for all participants and control group members. 30% of the households invited to receive feedback accepted the invitation. The estimated effects of the feedback on consumption of electricity are estimated to be in the range of 2-3%. The feedback technology is cheap to implement and therefore likely to be cost-effective

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1. Introduction

There is a long tradition for providing consumers with feedback information about their energy consumption, for example by printing last period's consumption level of the energy bill, Wilhite (1999). The purpose of feedback information is to increase the awareness among consumers of their energy consumption. Consumption of electricity is characterized by being indirect in nature, i.e. consumers consume services derived from electricity, for example by using a dishwasher. Understanding the exact marginal costs of using a dishwasher requires reading of the meter before and after the use of the dishwasher while holding constant the use of other appliances, calculating the use of electricity and transforming it in to money terms. This is usually much too complicated compared to the potential gain from understanding the exact marginal costs of consuming a service derived from electricity. Consumers can handle this by applying routine based decision making. Such behavior is sometimes labelled inattentiveness, Reis (2006). Feedback provides consumers with more information, so that consumption decisions can be made at smaller costs. Supplying feedback information about electricity consumption at an increased frequency should enable consumers to make more precise consumption decisions by relying less on routine based decision making. In this sense supplying feedback at an increased frequency could in principle affect the level of consumption both upwards and downwards, since a costumer may realize upon having received more information that her level of consumption was actually lower than what is optimal. Policy makers, however, tend to focus on the ability of such measures to reduce consumption.

Advanced meters with automated meter reading are being distributed in many countries. In Denmark 45% of all Danish costumers will be equipped with an advanced meter within few years. This development takes place without special regulation from the authorities. In Sweden advanced meters are required by authorities, and in other countries like Norway, and the Netherlands a similar development is under way. The distribution of advanced meters together with the rapid development and proliferation of new information technologies provide new possibilities for giving feedback information.

The objective of this paper is to investigate the effect of supplying feedback by text messages and /or email on the level of total household electricity consumption. Feedback by text messages and /or email is being used already in other sectors. In the banking and portable telephone sector, for example, account statements are being supplied to consumers by SMS-text messages and email. For the present purpose this technology is adapted to generate feedback on household electricity consumption, and a randomized field experiment is performed where a group of costumers of a Danish electricity supplier are randomly allocated to two control groups and three experimental groups that are invited to receive feedback. For all the households who accept the invitation and all control households electricity consumption is recorded

from 1 January 2006 to 31 December 2007. The experimental groups receive feedback via SMS-text messages or emails from 1 January 2007 to 31 December 2007.

The choice of feedback technology is made based on a tradeoff between the type of feedback that is known to have the largest impact and the costs of implementing the technology that supplies it. It is know that feedback information works best if it is given frequently, over a long period and at an appliance specific level, see Fischer (2008). The effect of online feedback by SMS-text message and email has never previously been explored. As applied in this experiment it meets the first two requirements. It is sent out at a daily frequency, and the experiment runs for an entire year. There is thus plenty of opportunity for participants to adjust and get used to the type of feedback given. The third requirement is not met in our setup. Appliance specific feedback is usually relatively costly as it requires meters to be installed at all the appliances targeted. Unless the savings are very large the benefits are unlikely to be large enough to finance the technology required. Our feedback technology, on the other hand, operates on total household electricity consumption. The majority of the population have access to receiving either email or text messages. This implies that the type of feedback information tested here is cheap to implement, and therefore likely to be cost-effective even if the impact is small. This is important since effects of feedback are likely to be small. For example, Matsukawa (2004) finds that 113 Japanese households, who had feedback provided by a continuous display installed in the residence and giving information about consumption, were observed with a level of electricity consumption that was 1.5 % lower than that of a control group.

The results of the present experiment indicate moderate interest in the type of feedback tested. 30% of the households invited to participate in the experimental groups accepted the invitation. The majority of the participating households preferred to receive feedback by email. The results based on a differences-in-differences analysis, where the growth rate of consumption from 2006 to 2007 is compared for participants and control group members, suggest that among the households that received feedback electricity consumption was reduced by 2-3%. Results are, however, not significant across all econometric specifications investigated, and this is likely due to the fact that the experiment includes a limited number of households, compared to the natural variation in demand.

The paper is organized as follows. In the next section the feedback technology is described. After that, the experimental design is outlined and the data described. Then results are presented and finally the analysis is summarized and conclusions are made.

2. Experimental design

The experiment is conducted by randomly allocating a group of costumers of a Danish electricity supplier, SYD ENERGI, on two control groups and three experimental groups

that will have different degrees of choice between various types of feedback via SMS text messages or emails. For all the households involved in the experiment electricity consumption is recorded from 1 January 2006 to 31 December 2007.

2.1 Types of feedback

Three types of feedback are given to the experimental groups. Frequency, deviation, and limit based feedback. Frequency based feedback provides the consumer with information about the development of her consumption level at a regular frequency. Deviation based feedback provides the consumer with feedback when current consumption deviates significantly from the consumption level of the previous period. Limit based feedback provides feedback when current consumption is extreme relative to the distribution of consumption levels in several earlier periods. The types of feedback are summarized in table 1 below.

Table 1: Types of feedback

Types of feedback	**Description**
Frequency based	The feedback is sent out every day, week or month
Deviation based	The feedback is sent out, if the electricity consumption during this period (day, week or month) deviates with a certain percentage compared to the consumption in the previous period
Limit based	The feedback is sent out, if the current electricity consumption is very low or very high compared to the consumption in previous periods

For the experiment we select 1,452 households that we include/invite to participate in the experiment. They are allocated randomly on two control groups and three experimental groups. One of the control groups is blind, but the members of the second control group are informed that they are part of an experiment testing the effect of feedback information. This second control group is introduced as an attempt to frame any experimental effect that may be present.

The three experimental groups are given different degrees of choice with respect to the type of feedback that they will receive. Group 1 is given no choice of feedback and receive only frequency based feedback at a weekly frequency. Group 2 has more choice. Group 2 members can choose frequency and/or deviation based feedback at three different frequencies, daily, weekly, or monthly. Experimental group 3 is not restricted in their choice.

This allocation of choices between the three experimental groups reflects a weighting of a design, where the effect of information on consumption can be measured without complications, group 1, and a design that reflects the available

technological possibilities, but where the isolated effect of information on consumption is more difficult to measure, because the participating households must make choices concerning both consumption and type of information they wish to receive, group 2 and 3. The types of feedback available to members of the three experimental groups are summarised in table 2.

In connection with the experiment a home page is established where all households in control group 2 and all three experimental groups can get access to graphical presentations of historical consumption data[1]. All households in the experimental group have to choose whether to receive feedback via SMS-text messages and/or email. SMS-text messages contain only text whereas emails also contain a graphical presentation of the consumption data. Participants in group 2 and 3 also have to choose the type of feedback they wish to receive. For these households a default feedback setup was established, but households in group 2 and 3 could adjust the setup, i.e. the type and frequency of the feedback, at the homepage at any point during the experimental period.

Table 2: The types of feedback available to the three experiment groups. Participants in group 2 and 3 can choose two types of feedback.

Types of feedback	Experiment group 1	Experiment group 2	Experiment group 3
Monthly frequency based		X	X
Weekly frequency based	X	X	X
Daily frequency based			X
Monthly deviation based			X
Weekly deviation based		X	X
Daily deviation based		X	X
Monthly limit based			X
Weekly limit based			X
Daily limit based			X

2.2 Implementation

[1] In this sense control group 2 did get feedback, but it required logging on the home page of SYD ENERGI.

The experiment was conducted among a set of costumers of SYD ENERGI. This supplier was targeted because it is the first company in Denmark to install advanced meters enabling automated read meter reading at a massive scale to their customers. The pool of participants for the experiment was selected among the costumers who had an on-line meter installed and in operation by 1 January 2006. 15,847 households satisfied this criterion. For these costumers we obtained information about dwelling characteristics from the official building registers that enabled us to deselect costumers that are not likely to benefit from this type of feedback or would not be relevant to the experiment. From the pool of costumers we selected households living in a detached, terrace or town house that did not use electricity as the main energy source for heating the house. Denmark is a relatively cold country, and energy consumption for heating purposes is the dominating part of total household energy consumption. We exclude households using electricity as the main source for heating since their consumption co-varies strongly with outdoor temperature, and electricity consumption is therefore very volatile for this group. We also deselect costumers that use the house for commercial purposes or use the house as non-permanent residence. Finally, we required the costumer to have been living in the house at least since 1 January 2006. Imposing these restrictions left us with 1,452 costumers. These households were then randomly allocated to the two control groups and the three experiment groups, approximately 200 to each of the control groups and approximately 350 to each of the experiment groups. More households were assigned to the experiment groups than to the control groups. This is because households in the experiment groups can choose not to accept the invitation to participate in the experiment, and drop-outs are expected. The control groups, on the other hand, will only suffer from attrition to the extent that some households move during the experiment period.

Invitations were sent out to the experimental groups and information about the experiment sent out to control group 2 in mid-November 2006. Members of control group 1 were not informed that they were part of the experiment. Members of experimental group 1-3 were asked to sign up via the homepage or by returning a reply-form included in the letters. Members of the experimental groups who had not answered by the beginning of December received a second letter reminding to sign up to the experiment.

For implementing the experiment a technical platform has been developed[2]. The purpose of the platform is to facilitate communication between the electronic on-line meters located at the costumers, the billing server located at energy supplier, and a feedback server that for the purposes of this experiment is placed at a third location.

[2] The technical platform is designed and developed by ZONITH A/S (http://www.zonith.com/). A detailed description of the platform (in Danish) can be downloaded at http://feedback.noe.dk/Publicering/PDF/FeedbackTeknologiPlatformAfslutningsRapport%20(v12).pdf

As mentioned previously the feedback technology applied in this experiment is based on an idea known from other sectors. For example, some banks offer feedback to their customers about movements in their account. In that case the bank already has all the necessary information available in their data base. In the present context the consumption data, from which the feedback is to be calculated, is initially collected at the costumers. Therefore, consumption data needs to be transferred from the costumers to the billing server of the electricity supplier and then to the feedback server before feedback is generated and sent back to the costumers[3]. Consumption data are transferred from the customers to the billing server by Power Line Communication and from the billing server to the feedback server by an internet connection.

The technical platform also facilitates communication between the feedback server and the costumers through a web interface, where customers can get access to a graphical presentation of their consumption data. The web interface enable customers to update their own profile with e-mail addresses, GSM phone numbers (experimental group 1-3), and choice of feedback (experimental group 2 and 3). Each household can enter more phone numbers and more email addresses. The webpage is secured so that access requires user name and password. The website offers a possibility for the participating households who have forgotten their password to type their address and then via text message or e-mail receive their password.

4. Data and Summary Statistics

The data used in the analysis come from different sources. Consumption was recorded for all participants and all control group members for the period 1 January 2006 to 31 December 2007. The number, the timing and type of messages were also recorded. As mentioned earlier we also had access to data from the public building register with information about the type of house, the size and the main heating source. These data are publicly available and were used to select the households entering the sample that we invited to participate or included in the control groups. Next, historical data on annual consumption was obtained from the electricity supplier, SYD ENERGI, for 2004, and 2005. These data were collected for billing purposes by SYD ENERGI before electronic on-line metres were installed. Finally, using the address code of the house we merged background characteristics of the individuals living at the addresses were electricity was supplied and measured during the experiment. These background characteristics are measured in 2006 and include information about income, education, age, marital/cohabitation status of the adult members, and household size. The background characteristics are obtained from administrative registers. These

[3] The type of online-meters installed at the costumers do not allow for feedback to be generated directly at the costumer. This would require "intelligent" meters that can store and make calculations on location.

registers are not publicly available and can only be used by researchers under strict confidentiality conditions. Because of the confidentiality restrictions this information could only be obtained after the experiment had finished.

Next, we describe the participation rate and summary statistics characterising the participants in the experiment. Also a description of the amount of feedback sent out and the level of electricity consumption across the different groups in the experiment is presented.

In table 1 an overview of the participation rate is given. The first column gives the number of households invited to participate in the experiment. The second column gives the number of households who accepted the invitation, and the third column the number of households who completed the experiment. Not all households who accepted to participate actually completed because they moved during the experiment period. The final column gives the sample sizes actually used in the analysis of the effect of the experiment. Some observations were lost when merging characteristics of the household members. Linking to the administrative register data by matching addresses with the people recorded as inhabitants at the address implies a loss of observations because in some cases the match is not exact.

The acceptance rate for the experimental groups was 31%. This indicates that the households included in the experiment were only moderately interested in the type of feedback tested. The limited participation also opens for the possibility that households deciding to participate in the experiment are on average different types of consumers than the average consumer in the control groups

The experimental groups tend to have a higher level of consumption than the control groups whether measured by the mean or the median. Participating families on average have higher income, are slightly more educated, slightly younger, and are more likely to be living in couples, i.e. married or cohabiting. They also live in larger houses, which is the likely reason for the higher level of consumption. Summary statistics are presented in table A1 in the appendix.

Table 1. Participation in the experiment.

	Invited	Accepted	Completed	Completed and with register data
Control group one	214	213	205	193
Control group two	203	203	189	177
Treatment group one	341	107	105	104
Treatment group two	340	99	94	91
Treatment group three	354	111	108	103
Total	**1,452**	**733**	**701**	**668**

Source: Register, meter and participation data

Table 2 shows the distribution of feedback media chosen by the households participating in the experimental groups. Most households prefer to use email rather than SMS-text messages as the feedback medium.

Table 2. Choice of feedback media

	Number of households			
	Only SMS	Only E-mail	SMS and E-mail	Total
Treatment group one	33	59	13	105
Treatment group two	20	62	12	94
Treatment group three	35	60	13	108

Source: Meter data and own calculations

A lot of feedback information was sent out during 2007, but unfortunately the feedback server suffered from some technical problems in the beginning of the experimental period. Two problems occurred. Initially, many uninformative messages were sent out. From February this traffic was blocked, so that only informative messages were passed on to the consumers. Also, in the beginning the feedback server was unable to handle missing information on daily electricity consumption. This reduced the number of valid feedback messages that were sent out in the period January to April 2007. This shows very clearly for group 1, the group that did not face any choice and could only receive weekly based frequency feedback, whose feedback volume is graphed in figure 1. If feedback was sent out according to the plan about 400 messages should have been sent out per month. Figure 1 clearly shows that this is not the case. In January 2007 a lot

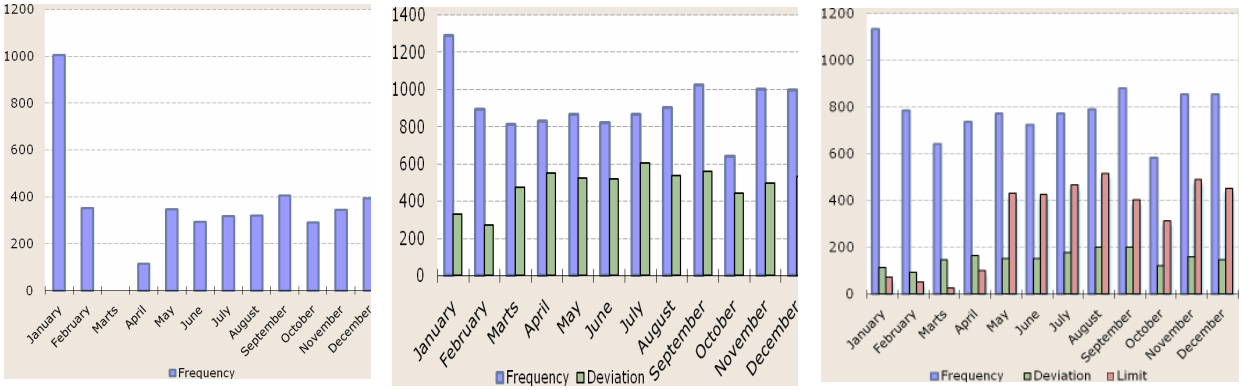
of messages were sent out, including many uninformative messages, and the number of feedback messages was clearly below the intended level up to and including April.

Experimental group 2, who received both frequency and deviation based feedback, was not influenced as much by the technical problems. Deviation based feedback was initially low. The number of frequency based feedback messages is much higher than for treatment group one. This is because a fraction of the households in experimental group 2 chose to receive daily frequency based feedback and this type of feedback was not affected by the problems described for experimental group 1.

The distribution of feedback messages sent to experimental group3 is graphed in the right-most panel of figure 3. This group was also affected by the technical problems in the period January to April, but this mainly affected the limit based feedback.

Figure 1. Feedback messages sent to experimental group 1, 2 and 3.

Experimental group 1 Experimental group 2 Experimental group 3



5. Results

The primary objective of the study is to analyze the effect of the feedback on consumption of electricity. For doing this we compare the growth rate of annual electricity consumption from 2006 to 2007 for the experimental groups with that of the control groups. One important feature of the data is the fact that only 30% of the households invited to take part in the experiment decided to participate. This potentially implies that the effect of the feedback cannot be revealed by simply comparing the unconditional growth rate of consumption for the experimental groups with the growth rate of the control groups. This is because participants in the experimental groups for example could have been recruited from the sub group of invited households with the largest potential for benefitting from the feedback. In order to understand if participation is related to certain characteristics we first analyze the

participation decision, and then turn to the analysis of the effect of the feedback on the level of consumption.

5.1 Participation

For analyzing the participation decision we estimate a discrete choice model of participation. For doing this we make use of different data sources. First, we use the experimental data indicating if the costumers participate in the experiment. Next, we use historical billing data obtained from the electricity supplier, and finally we make use of the data characterizing the inhabitants of the dwelling that we measure consumption for. This information is, as mentioned previously, obtained from various public administrative registers and merged on to the experimental data by matching address codes. For some address codes we find no match, and the sample that we use for estimation is therefore slightly reduced. 1035 costumers are invited to participate in the experiment, but we only have background information for 980 of them. The number of non-matched households is equally distributed across the three experimental groups.

The participation decision is modeled as a probit model giving the probability of participating as a function of a vector of covariates. In the covariate vector we include the level of log electricity consumption in 2005 and the growth rate of consumption from 2004 to 2005. The lagged level of consumption is intended to control for effects related to the size of the stock of appliances that the household owns, and which we have no direct information about. The idea is that participating households may on average have a stock of electrical appliances that is different from that of all the invited households. The lagged change in log consumption is included because households may have selected in to the experiment because they had recently experienced an increase in their electricity consumption and was therefore more interested in gaining additional information about their consumption behavior. Besides historical consumption information we also include the level of income, age of the oldest household member, an indicator for whether the household is an immigrant household, the level of education for the person with the longest education in the household, an indicator for whether the adult members of the household were living together as a couple, indicators for the presence of children in the household, a variable giving the size of the house, and the number of rooms.

Results are presented in table 3. They indicate that the participation decision is significantly correlated with the level of income and the historical level of consumption. The higher the income level the more likely are households to participate, and the higher the level of consumption in 2005 the larger is the probability that households participate. Note that this is the case even when size of the dwelling and number of household members has been controlled for. Only one of the other covariates is

significantly related to the probability of participating. The chance of participating increases with the level of education.

Table 3. Estimates from a probit model of participation on characteristics.

Dependent variable = 1 if Participation = Yes, otherwise 0		
Parameter	Estimate	st. err.
Intercept	-10.8262**	1.7856
Ln(kWh) 2005	0.2244*	0.1216
ΔLn(kWh), 2004-2005	-0.1533	0.1429
Ln(income)	0.4757**	0.1194
Age of oldest in household	0.0058	0.0039
Immigrant in household	-0.1002	0.1701
Highest education in household (years)	0.0347*	0.0185
Cohabiting	0.0368	0.1258
Number of children age 0-2	-0.0286	0.1407
Number of children age 3-12	0.0176	0.0710
Number of children age 13 – 17	0.0479	0.1075
ln(m2), Size of house	0.3870	0.2373
Number of rooms	-0.0618	0.0449
Number of observations	980	
Note: Reference for number of families in the household is one family. ** indicate significance at the 5% level of significance. * indicate significance at the 5% level of significance.		

5.2. The Effect of Feedback on the Level of Consumption

We now turn to the analysis of the effect of feedback on the level of consumption. The impact of feedback on the level of consumption is estimated by regressing the growth rate of electricity consumption on a set of dummy variables indicating if the household belongs to an experimental group or to one of the control groups. This regression effectively compares the growth rate of consumption for the experiment groups with

that of the control groups[4]. This types of estimator is known as a differences-in-differences estimator in the economics program evaluation literature, see for example Heckman et al (1999). The participation analysis presented in the previous section indicated that participation in the experiment groups is likely not by random selection. In particular, participation is related to the level of income, the historical level of consumption, and to the level of education. Comparing growth rates of consumption alleviates some of the self-selection problem to the extent that it is related to an unobserved factor that is roughly constant across the measurement period, 2006-2007; such a factor is often referred to as a "fixed effect". This would, for example, be the case if the decision to participate is based on an unobserved positive attitude towards energy savings. To further control for any self selection in to the experiment group we also condition on the set of household characteristics included in the participation analysis[5]. Formally, the regression function that we estimate is

$$\Delta\left(\ln kWh_i\right) = \beta_0 + \beta_1 D_i + \beta_2 X_i + u_i \quad (1)$$

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[4] Alternatively we could have compared the level of consumption in 2007 for the experimental groups and the control groups or by just considering the change in consumption for the experimental group. These alternative estimators are dominated by the differences-in-differences estimator. The latter is insufficient since other factors than the feedback could have influenced the change in consumption from 2006 to 2007. For example, it is found that the level of consumption is lower in 2007 than in 2006. Exploiting that consumption is measured daily it is found that some of the drop in consumption from 2006 to 2007 is explained by fluctuations in the weather measured by number of degree days. This analysis is not reported. Comparing levels of consumption in 2007 between experiment and control groups is also likely to give an inconsistent estimate of the effect of the feedback. To the extent that participation in the experiment is related to unobserved factors that are approximately constant across 2006-2007, for example a positive attitude to energy savings, regressing the level of consumption on a set of dummies indicating allocation to experiment/control groups will give a biased estimate of the parameter of interest.

[5] This assumes that any self-selection over and above what is caused by the fixed effect is related to these observed factors. Alternatively, one could assume that self-selection introduced on top of what is controlled for by the fixed effect, is also related to unobserved factors. The appropriate estimator would then allow for the dummy variables indicating allocation to experiment/control groups to be endogenous. Econometric models allowing for this is the dummy-endogenous model of Heckman (1978) or the well-known heckit model, heckman (1979). Application of such estimators requires a valid instrumental variable. We have no behavioral model of participation that can inform us about how a valid instrumental variable is characterized in this context, and we therefore simply assume that any self-selection induced over and above what is controlled for by the fixed effect is corrected for by the set of covariates that we include in the regression. For an overview of estimators used in program evaluation problems of the type analyzed here, see Wooldridge (2002, chapter 18).

Where $\Delta \ln(kWh_i)$ is the change in log annual electricity consumption from 2006 to 2007. D_i is a dummy vector taking the value one if the household belongs to one of the experimental groups. In practice we estimate a coefficient for each of the experimental groups. X_i is a vector of covariates measured in 2006 or earlier. Specifically, X_i includes the same set of variables that were included in the participation analysis in the previous section.

Results from two estimations are presented in table 4. In column (1) the results from an OLS regression are shown, and in column (2) the results from a median regression are shown. In both regressions control group 1, the blind control group, is the omitted group. The estimates of the parameters on the dummy variables indicating control group 2 and experimental group 1-3 are insignificant in the OLS regression. Note, however, that the estimated parameters for group 2 and 3 are negative. Group 2 and 3 are the groups that had access to choose which type of feedback they wanted. Also, as mentioned in section 4, the feedback server did not send out feedback regularly in the beginning of the experiment, and group 1 was affected the most by these problems. The pattern of the estimated parameters is consistent with this.

Ordinary least squares is sensitive to extreme observations, and meter data are well-known to be volatile. We therefore also estimated a median (quantile) regression. A median regression minimizes the absolute deviations of the residuals rather than the square of them and is therefore less sensitive to noise in the data. Results from this regression show the same qualitative pattern, i.e. the largest effects are found for group 2 and 3, but now the estimated parameters are significant for these two groups. The parameters for group 1 and experimental group 2 are both smaller and are estimated insignificantly. Again, this is consistent with the notion that feedback did have a small and significant effect for group 2 and 3 while not for group 1.

Table 4. Differences-in-Differences estimates. Mean and median regressions.

Dependent variable: Δln(kWh), 2006-2007	Mean (1)		Median (2)	
Parameter	Estimate	st. err.	Estimate	st. err.
Control group two	-.01607	0.0184	-0.0123	0.0111
Treatment group one	0.0129	0.0215	-0.0134	0.0130
Treatment group two	-0.0128	0.0228	-0.0253*	0.0138
Treatment group three	-0.0170	0.0218	-0.0284**	0.0131
Note: Sample size is 668. ** indicates significance at 5% level. * indicates significance at 10% level. Also covariates are included in the this regression. The full set of parameter estimates are presented in the Appendix.				

The parameters are generally estimated imprecisely. This could either be because the feedback did not have any effect on the level of consumption or because the number of costumers involved in the experiment is too small to estimate the effect precisely. To address this we have performed regressions corresponding to those presented in table 4, but where only one parameter is estimated jointly for group 1-3. Results were qualitatively similar to what is presented in table 4.

6. Summary and Conclusions

The paper present an analysis of an experiment designed to test the effect of on-line feedback supplied by SMS-text messages and email on total household electricity consumption. 1,452 households were randomly allocated to two control groups and three experiment groups. Households allocated to the experiment group were invited to receive feedback. 30% of the invited households accepted the invitation. The analysis suggests that among the participating households online feedback had an effect in the range of 2-3% on total household electricity consumption.

Lessons from previous studies of feedback have shown that feedback is most likely to have an effect if it is given frequently, over a long period and at an appliance specific level. The type of feedback investigated here satisfies the first two requirements, but compromise the third. This is because appliance specific feedback is likely to be costly to implement and effects are likely to be small. Our feedback technology operates on total household electricity consumption. It is cheap to implement, and even small reductions in consumption are likely to make the feedback cost effective. The company who has supplied the technology for this experiment estimates that the costs of the scheme per consumer are 6 USD (4.4 EUR). In the experiment the median participating household in group 2 and 3 reduced consumption by 3% corresponding to 135 kWh.

References

Fischer, C. (2008); Feedback on household electricity consumption: a tool for saving energy? ; Energy Efficiency, 1, pp. 79-104.

Matsukawa, I. (2004); The Effects of Information on Residential Demand for Electricity; The Energy journal; Volume 25; Number 1.

Heckman, J. (1978); Dummy Endogenous Variables in a Simultaneous Equation System; Econometrica, vol. 46, no. 4, July 1978, pp. 931-59.

Heckman (1979); Sample-selection Bias as a Specification Error; Econometrica, vol. 47, no. 1, January 1979, pp. 153-61.

Heckman, J.; Lalonde, R.; Smith, J. (1999): The Economics and Econometrics of Active Labor Market Programs. In Ashenfelter and Card: *Handbook of Labor Economics, Volume 3A*.

Reis, R. (2006); Inattentive Consumers; Journal of Monetary Economics; Volume 53, 8, pp. 1761-1800.

Wooldridge, J. (2002); Econometric Analysis of Cross Section and Panel Data; MIT Press, Cambridge Massachusetts.

Wilhite, H.; Høivik, A. ; Olsen, J.-G. (2002); Advances in the use of consumption feedback information in energy billing: the experiences of a Norwegian energy utility; Proceedings of the 1999 ECEEE Summer Study, 1999.

Appendix: Summary statistics and complete estimation results.

Table A1. Summary statistics of the characteristics of participants and controls

	Exp. 1	Exp. 2	Exp 3	Control 1	Control 2
kWh, 2005	4,831	4,908	4,591	4,437	4,590
kWh, 2004	4,801	4,784	4,673	4,270	4,352
Income, 1000 DKK	472	510	540	428	441
Age of oldest in household	53	54	55	56	55
Immigrant in household	0.05	0.08	0.08	0.05	0.09
Highest education in household (years)	12.49	12.79	12.52	12.25	11.95
Cohabiting	0.74	0.84	0.83	0.64	0.73
Number of children age 0-2	0.10	0.15	0.08	0.05	0.11
Number of children age 3-12	0.40	0.33	0.36	0.35	0.38
Number of children age 13 – 17	0.16	0.21	0.17	0.16	0.19
m2, size of house	144	150	149	134	138
Number of rooms	4.93	4.85	4.90	4.63	4.67

Table A2. Differences-in-Differences estimates. Mean and median regressions. Dependent variable = growth in ln(kWh), 2006-2007

	Mean (1)		Median (2)	
Parameter	Estimate	st. err.	Estimate	st. err.
Control group two	-.01607	0.0184	-0.0123	0.0111
Treatment group one	0.0129	0.0215	-0.0134	0.0130
Treatment group two	-0.0128	0.0228	-0.0253*	0.0138
Treatment group three	-0.0170	0.0218	-0.0284**	0.0131
Ln(kWh) 2005	-0.0618**	0.0196	-0.0466**	0.0116
ΔLn(kWh), 2004-2005	0.0222	0.0228	0.0098	0.0130
Ln(income)	-0.0031	0.0208	-0.0037	0.0126
Age of oldest in household	-0.0004	0.0006	0.0001	0.0004
Immigrant in household	0.0036	0.0274	-0.0002	0.0164
Highest education in household (years)	0.0050*	0.0029	0.0031*	0.0017
Cohabiting	0.0411*	0.0217	0.0311**	0.0131
Number of children age 0-2	-0.0440**	0.0222	-0.0095	0.0124
Number of children age 3-12	0.0114	0.0105	0.0157**	0.0062
Number of children age 13 – 17	-0.0168	0.0156	-0.0003	0.0092
ln(m2), Size of house	0.0252	0.0373	0.0059	0.0226
Number of rooms	-0.0060	0.0074	-0.0086*	0.0045
Intercept	0.3531	0.2973	0.3534	0.1797

Note: Sample size is 668. ** indicates significance at 5% level. * indicates significance at 10% level.