Knowing me, knowing you: the role of trust, locus of control and privacy concern in acceptance of domestic electricity demand-side response

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Abstract

Choosing to take part in a demand-side response (DSR) programme entails accepting external influence over one's energy consumption patterns, such as through price or direct load control (DLC) signals. If participation is low, the programme will be ineffective. How might people's perceptions of their relationship with the influencing entity affect the likelihood of participation? This study used a representative survey of Great Britain (N=2002) to explore the importance of trust, privacy concern and locus of control for acceptance of different approaches to influencing electricity consumption.

Survey respondents were randomly shown a description of one of five DSR products (static time of use [TOU] tariff, static TOU with automated response to price changes, dynamic TOU, dynamic TOU with automated response, and DLC), framed as being offered by their electricity supplier. They then responded to a number of scales including those intended to measure trust in their supplier, privacy concern and locus of control.

Controlling for demographic variables, trust in electricity supplier was significantly positively associated with acceptance of all tariffs, although the effect size was smaller for the automated TOU tariffs. The specific measure of trust in the supplier to ensure a reliable electricity supply was significantly negatively associated with acceptance of the dynamic TOU tariff. Privacy concern was significantly negatively associated with acceptance of all tariffs, with the strongest effect for the automated dynamic TOU tariff. Locus of control was a significant factor only in the case of DLC, where external locus was related to higher acceptance.

These results suggest the existing low levels of trust in energy companies in the UK may present a challenge in securing uptake of DSR, and an opportunity to trusted entrants from other sectors. Automation within the home may mitigate trust concerns, but people must have sufficient confidence in the privacy of this arrangement. DLC may be viewed especially positively by people who currently perceive themselves to have little control over their energy use, but protections should be in place to ensure they are not exploited.

Introduction

Faced with the 'trilemma' of ensuring affordability, security and sustainability of electricity, European countries are increasingly exploring the potential of demand-side response (DSR) programmes. Simply defined as 'change in electricity consumption patterns in response to a signal' (Element Energy 2012, 9), DSR offers the ability to sculpt demand for electricity to fit the available supply. For example, this may entail attempting to reduce demand during peak periods (such as the evening in winter in northern Europe), or to increase it when wind generation is high.

The benefits of DSR accrue to electricity systems in the form of congestion management, portfolio optimization and balancing (He et al., 2013). While users should collectively benefit from the overall cost savings, system stability and sustainability improvement this facilitates, individually they must agree to receive and respond to signals which aim to influence their electricity consumption patterns if they are to benefit directly. Since for the majority of people in the UK there is no special incentive beyond personal convenience to use electricity at one time rather than another, participating in DSR constitutes

a significant change in the relationship between supplier and consumer.

Our study used a nationally representative online survey experiment to investigate how consumers' perceptions of aspects of this relationship relate to their stated intention to participate in a range of DSR offerings. In this paper, we focus on the trust they have in their electricity supplier, their level of concern about privacy and their locus of control in relation to energy. These issues are important because they all affect how DSR offerings are designed, who offers them, and to whom they are offered. The next section outlines the constructs of trust, privacy concern and locus of control and discusses previous work connecting them with energy and DSR. We then present the survey method and results, followed by a discussion of the implications for future DSR product offerings.

Trust, privacy concern and locus of control

To take part in a DSR programme, a user will usually be required to adopt a product or service which facilitates this. For example, this could take the form of switching to a time of use (TOU) electricity tariff or purchasing an appliance which can respond to price or direct load control (DLC) signals. Many factors could be expected to influence this switching/purchasing choice, including expected savings, existing household schedules, perceived usability of the product/service, etc. Here we focus on three constructs which may be viewed as characteristics of the relationship the user has with the wider energy system: trust, privacy and locus of control. The rest of this section gives a brief overview of each of these constructs, along with hypotheses as to their possible association with acceptance of DSR. Specific hypotheses are not proposed for the effects of varying tariff design (e.g. different types of TOU, or DLC), although such effects are considered in the Discussion section below. In this study, 'acceptance' refers to people's stated intention to switch to a given DSR tariff if it were available today.

TRUST

Trust is important in facilitating relationships of all kinds. For example, where trust exists, in many circumstances parties are less obliged to depend on repeated legal and other formal agreements which are costly in money, time and other resources to administrate. It enables dependence on the abilities and resources of others, rather than having to directly acquire them oneself. However, it involves accepting an element of vulnerability, as the following (widely-used) definition describes: '[trust is] the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party' (Mayer et al. 1995, 712).

In the case of electricity, people may choose to buy it from a centralized electricity system rather than generating it themselves, but in return they (often tacitly) accept vulnerability to being cut off, or to rising prices. Regarding DSR, the vulnerability may be perceived to increase and involves accepting higher electricity prices at certain times, or even direct control of appliances in the home. In return, there is some expectation of benefit, perhaps in the form of the ability to capitalize on lower electricity prices at certain times, rebates on bills or appliance functionality improvements, and more widely of greater system stability.

There is abundant evidence of a positive association between trust and product/service/innovation acceptance across sectors (e.g. see Bhattacherjee 2002 for e-commerce, Ortega Egea & Román González 2011 for healthcare records and Terwel et al. 2011 for carbon capture and storage). In the UK there is a high level of distrust of gas and electricity companies. According to the consumer organization Which?, 40 % of the population distrust their supplier compared to figures for other "essential" services such as 25 % for mobile phone services and 15 % for water companies (Which?, 2014). Just 28 % of people say they trust energy companies to act in their best interests (Which?, 2013b). This is a problematic starting point for DSR. Based on the evidence of a link between trust and acceptance cited above, it suggests that products or services offered by (distrusted) energy companies are at risk of being rejected.

There is also a risk that perceived misalignment of interests between energy companies and consumers may have ramifications for trust in smart technologies such as those required for direct load control. Work by Verberne et al. (2012) into automated (smart) driving systems found that where the system shares the goal of the user it is more likely to be trusted. If consumers perceive the system to have goals contrary to their own – or to not be acting in their best interests – this could have negative ramifications for acceptance. Indeed, Fell et al. (2014) identified that concerns around energy companies not acting in consumers' best interests were associated with expectations of loss of control in DSR.

Based on this brief consideration of the role of trust in product/service acceptance, this study tests the hypothesis:

H_1: Trust in electricity supplier is positively associated with DSR tariff acceptance.

PRIVACY CONCERN

Privacy has featured prominently in discussions around the transition to a smart energy system. The principal concerns are around the additional information which technologies such as smart meters allow to be shared and around the security of the infrastructure which permits this sharing (McDaniel and McLaughlin, 2009). Such concerns were exemplified in long delays to the smart meter roll-out in the Netherlands, which were driven largely by the widespread fear of electricity suppliers and network operators keeping track of citizens' electricity use (Hoenkamp et al., 2011). In the case of DSR, privacy issues are at stake not only in the energy data which may be shared but around control signals and consumers' responses to them. For example, consumers' financial rationality could be deduced from their response to TOU price changes (Li et al., 2014).

It is useful to draw a distinction between different conceptions of privacy. In the sense that it is used above, we may more precisely refer to 'information privacy' – that is, 'the concept of privacy in terms of conditions having to do with access to and control over personal information' (Tavani 2007, 7). While this is relevant to a discussion of DSR, similarly salient is the concept of 'non-intrusion' – the breach of which may be analogous to 'unwarranted intrusion into one's personal space through someone physically accessing one's personal papers, home, and so forth' (Tavani 2007, 6). This is because the intention of

domestic DSR is to exact some change in a home's electricity use patterns, whether this has perceptible effects in the physical world or not, or is induced directly (as in direct load control) or through price incentives (as in time of use pricing).

Privacy is also bound up with trust. As the previous section described, trust involves the acceptance of vulnerability by the trustor. In the case of DSR, this vulnerability is likely to involve some compromise in one's previous expectations of privacy. And similarly to trust, privacy concern has also been shown to be associated with product/service acceptance, although in this case negatively (for example in adoption of location-based services [Tao Zhou 2011] and social networking [Fogel & Nehmad 2009]). On the basis of this and the above evidence, this study tests the following hypothesis:

H_2: Privacy concern is negatively associated with DSR tariff acceptance.

LOCUS OF CONTROL

The concept of locus of control refers to people's perceptions as to who or what controls events which affect them (i.e. themselves or external entities and circumstances). Early work on the construct outlines it as follows:

> When a reinforcement is perceived by the subject as following some action of his own but not being entirely contingent upon his action, then in our culture, it is typically perceived as the result of luck, chance, fate, as under the control of powerful others, or as unpredictable because of the great complexity of forces surrounding him. When the event is interpreted in this way by an individual, we have labeled this a belief in external control. If the person perceives that the event is contingent upon his own behaviour or relatively permanent characteristics, we have termed this a belief in internal control. (Rotter, 1966, 1)

The concept of locus of control has not been widely (explicitly) applied in the study of home energy use – the nearest work is in relation to pro-environmental behaviours (Cleveland et al. 2005; Kalamas et al. 2014). This is surprising because the extent to which people believe they are personally able to influence their household energy use seems likely to have a role in determining whether energy saving interventions targeting occupants are likely to save energy. Much more commonly employed is the 'perceived behavioural control' construct described in the theory of planned behaviour (Ajzen, 1991), which encompasses people's assessment of their ability to act effectively (self-efficacy) and the extent to which control is available to them (controllability). However, Ajzen (2002) cautions against assuming self-efficacy reflects the internal and controllability the external aspects of locus of control – this should be seen, rather, as an empirical question. For example, a homeowner may choose to insulate their walls or install an efficient boiler, while a renter would not be able to legally take these actions without permission from their landlord. For a renter, the controllability of their home's energy efficiency may objectively be lower, but their perception of where control over their energy use resides need not necessarily reflect this.

The perceived locus of control is interesting in the context of DSR since in this case there genuinely are external entities attempting to exert influence on people's patterns of electricity consumption. Does an internal or external perceived locus of control make it more or less likely that an individual would be accepting of this actual external influence? Since it is not clear in which direction (if any) this construct may be associated with tariff acceptance, the following hypothesis was tested:

H_3: Perceived locus of control is associated with DSR tariff acceptance.

Method

RESEARCH POPULATION

The study focused on Great Britain (GB – the countries of England, Scotland and Wales). While the GB electricity system is interconnected with those of both the island of Ireland and the European mainland, most DSR activity that is intended to be of benefit to the GB system would be required to take place locally. The unit of enquiry is individuals who are jointly or wholly responsible for payment of their household energy bills. This group were targeted as they represent consumers who would ultimately make decisions on tariff switching.

SURVEY APPROACH

The study employed a survey experiment to determine the relative acceptability of different ways of achieving DSR. The survey approach allowed quantitative exploration of the concepts of interest (in this case trust, privacy concern and locus of control), while the experimental design permits the possibility of attributing differences between groups to differences in experimental conditions (i.e. the specific tariff details). This section describes the survey and sample design, with a focus on the items used to measure trust, privacy concern and locus of control.

Sample design

The survey was administered by the research agency Populus. Populus retains a panel of members of the GB public who are invited (with incentive) to respond to online surveys.[1] In addition, they promote the possibility of participating in survey work through online advertising on a variety of websites. Together, the recipients of these invites and viewers of these advertisements constitute the sampling frame. Quotas are set to be representative of the research population on the basis of age, gender, region and social grade; once quotes are full, responding (potential) participants are screened out. The survey itself took place as part of a larger omnibus survey, so respondents were not aware in advance of the subject of this study. In total, 2,302 people completed the full omnibus, of which 2,159 were main/joint energy bill payers in GB. Only these 2,159 progressed to complete the study survey.

Survey design

Participants arriving at the study's section of the omnibus survey were first asked about their status as a bill payer; only people who identified as main/joint household energy bill payers were presented with the remainder of the questions. They were

1. Please visit http://www.populus.co.uk/Our-Methodology/Polling/ for information on how Populus conduct their survey work.

then asked to identify their electricity supplier, both to obtain this data and to ensure that it was salient in people's minds when they came to complete the rest of the survey.

Participants were then assigned by simple randomization into five groups. Each group saw a brief outline of the rationale for DSR, gave basic details on average cost per unit of electricity (and what a unit roughly equates to in terms of usage) and asked them to imagine that their heating operates exactly as it currently does but is powered by electricity (see Appendix A). This final point was important because the DSR offerings they were to encounter next were presented in the context of home heating. This was done for a number of reasons:

- The electrification of heating is a cornerstone of the decarbonisation of the heating sector in the UK, and is therefore expected to become a major constituent of electrical load (DECC, 2013).
- Heating is a background demand which often already has an element of automation.
- It provides opportunities for doing DSR since electricity consumption can be reduced for short periods with little impact on room temperature.

Employing a between-subjects experimental design, each group then saw a description of one of the following DSR product offerings (see Appendix A for full descriptions), which they were asked to imagine was being offered by their currently electricity supplier:

- static time of use (TOU) tariff
- static TOU with automated response to price changes
- dynamic TOU (with price band alerts 24 hours in advance)
- dynamic TOU with automated response to price changes (with price band alerts 24 hours in advance)
- a lower than average flat rate tariff with direct load control (cycling of heating off and on at times of high demand, unlimited override, effect on temperature capped to 1 degree Celsius).

The experimental approach made it possible to explore the effect of different levels of price change predictability and response automation. The tariffs were selected as reflecting existing offerings either under trial for use in the UK (in the case of the TOU tariffs) or in use elsewhere in the world (in the case of direct load control). Immediately after seeing the description, participants responded to a series of items designed to gauge their perceptions of control, ease of use, usefulness and overall attitude towards and acceptance of the offering.[2] Acceptance was gauged by asking participants the extent of their agreement with the item: 'If it was offered to me now, I would sign up to this plan' (see Table 1). There followed a range of other questions,[3] including items designed to measure their trust in their electricity supplier, their privacy concern and their locus of control in relation to energy.

The items for trust (Table 1) were adapted from a set used by the consumer organization Which? (2013a) in their tracking of UK public attitudes towards energy suppliers. They were selected because data was available to allow the results of this study to be compared with other work, which can enhance validity. They also broadly reflect three principal dimensions of trust as highlighted by Bhattacherjee (2002): ability (i.e. to perform their main function, which is providing electricity), integrity (e.g. in charging a fair price) and benevolence (e.g. in acting in the customer's best interest).

The privacy concern items (Table 1) were adapted from items originally developed by Culnan & Armstrong (1999). These items were selected because they tap ideas of both 'information privacy' and 'non-intrusion', which were identified above as being relevant to DSR. The scales were adapted to shorten the original items, and also to introduce the UK-specific TPS.

As introduced in the review section above, locus of control was considered in this study both in the conventional psychological sense and as it relates to people's actual ability to take action in relation to energy use or their energy tariff. For this reason a combination of measures were used. A question was included to determine whether or not people thought there would be able to switch their energy supplier if they wanted to (with the option to indicate why). A number of items were also included with the intention of measuring perceived locus of control (Table 1). The last two items are based on items used by Spence et al. (2010) to measure personal agency and perceived responsibility in relation to climate change, as these came conceptually closest to the construct of interest.

ANALYSIS

Anonymized data were received from the research agency Populus. The data were analysed in IBM SPSS Statistics 22. A check was carried out to identify participants who may of responded in an unengaged way to the survey (i.e. clicked through it without giving considered responses). This was achieved by calculating the standard deviation of the responses to scales measuring perceived control, ease of use and acceptance along with overall attitude and acceptance. A total of 189 people exhibited a standard deviation of 0, indicating that they gave the same response to every item. Since some items were reverse coded, this means that they either gave self-contradictory responses or answered with the central 'neither agree nor disagree' option to all items. Neither of these responses were considered useful to the study, so it was decided to exclude these participants from the analysis, resulting in a final number of valid participants of N=2002.

Despite the quota sampling approach, age and gender variation in the sample differed to that indicated by census data for the GB population (ONS, 2012). A weighting factor was calculated on the basis of these variables and applied in all subsequent analysis (Table 2[4]).

Exploratory factor analysis was conducted in SPSS to determine the internal validity of the scales proposed to measure the trust, privacy concern and locus of control constructs. Promax rotation was employed since theory predicts that these

2. The work on relative acceptability of the different tariffs, perceptions of control, ease of use and usefulness are the subject of a separate paper which is in preparation.

3. Please visit http://bit.ly/MJFsurveyDSR to view the survey questions.

4. Weighting factors greater than 1 indicate that this group was underrepresented in the survey, while a weighting factor less than one indicates over-representation.

Table 1. Items and response scales used to measure trust, privacy concern, locus of control and overall tariff acceptance.

Construct	Introduction	Item	Response
Trust	To what extent do you think your electricity supplier is trustworthy or untrustworthy with regard to the following …	• Ensuring you always have a reliable electricity supply • Providing information that you can easily understand • Charging a fair price for your electricity • Acting in your best interest	Very trustworthy, Fairly trustworthy, Neither trustworthy nor untrustworthy, Fairly untrustworthy, Very untrustworthy
Privacy concern	Please indicate if each of the following statements apply to you:	• I have refused to give information to a company because I thought that information was too personal • I have signed up to TPS [Telephone Preference Service, which allows people to opt out of receiving sales or marketing calls] • I have asked an organization to take my name off of a mailing or email list	Yes, No
Locus of control	How much do you agree or disagree with the following statements?	• The amount of money my household spends on energy is largely out of my control • There are external factors that make it difficult for me to take actions to reduce my energy bills • It is hard to reduce your energy bills even if you want to	Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly agree
Acceptance	How much do you agree or disagree with the following statements?	• If it was offered to me now, I would sign up to this plan	Strongly agree, Somewhat agree, Neither agree nor disagree, Somewhat disagree, Strongly agree

constructs would correlate to an extent with each other (see theory discussion above). Validity having been established (see results section below), a one way Analysis of Variance (ANOVA) was performed to check for significant differences in these constructs between groups. Since no significant difference was found (see results section below), the next stage of analysis could proceed. A multiple regression was run to identify associations between the constructs trust, trust (supply), privacy concern and locus of control and acceptance of the different DSR offerings. The following factors were controlled for by including them in the regression model (dummy variables are listed for each, with reference category in *italics*):

- Age (18–24, 25–44, *45–64*, 75–74, 75+).
- Gender (female, *male*).
- Housing tenure (*home owner*, social tenant, private tenant, other tenure).
- Employment status (*employed full-time*, employed part-time, not in paid employment, retired).
- Highest education level (*secondary school*, undergraduate degree, postgraduate degree, other/refused).

Table 2. Weighting factors.

Age	Males	Females
18–24	1.72	0.82
25–34	1.30	1.23
35–44	1.04	1.30
45–54	0.91	1.13
55–64	0.82	1.04
65+	0.62	1.02

- Annual household income (less than £14 k, £14 k to less than £28 k, *£28 to less than £48 k*, £48 k+, income not disclosed).
- Presence in the household of children aged 15 or under (*not present*, present).
- Whether the participant lived alone (*does not live alone*, lives alone).

- Whether the participant was already on a TOU tariff (*not on TOU tariff*, on TOU tariff).
- Whether they had ever, or in the last year, switched energy supplier (*never switched*, switched but not in last year, switched in last year).
- Their assessment of how easy their home was to heat (five-point response scale, strongly disagree through strongly agree).
- Their stated level of concern about future climate change, and reliability and affordability of energy (five-point response scale from very unconcerned to very concerned).

Results

People who judged their electricity supplier to be fairly or very untrustworthy ranged from 6 % of the sample for 'ensuring a reliable supply', to 29 % of the sample for 'acting in your best interest'. Regarding privacy concern, 69 % and 70 % of people had respectively opted not to provide personal information and asked for personal information to be removed from a database, while 55 % said they had signed up to the Telephone Preference Service.

Table 3 shows the results of an exploratory factor analysis of the trust, privacy concern and locus of control items.

As Table 2 indicates, there is no cross-loading between factors and the constructs exhibit reasonably good convergent and discriminant validity (the loadings are quite low, but acceptable, for the privacy concern construct). Mean scores were therefore calculated for the trust and locus of control constructs, while a sum was calculated for the privacy construct. While loadings for all items intended to measure the trust construct were high, they were higher for the items measuring the integrity and benevolence aspects of trust (i.e. charging a fair price, providing clear information, acting in consumer's best interest) that for the ability item (i.e. provide a reliable electricity supply). We therefore decided to use a mean score for the integrity and benevolence items (hereafter simply 'trust', and to treat the ability item separately in case this yielded any additional insights (hereafter 'trust (supply)').

Table 3. Exploratory factor analysis with promax rotation.

	Factor		
	1	2	3
Trust (price)	.853	-.017	.039
Trust (best interest)	.833	.024	.072
Trust (info)	.807	-.017	-.041
Trust (supply)	.559	.011	-.117
Locus A	.051	.765	-.001
Locus B	-.005	.745	.039
Locus C	-.050	.690	-.045
Privacy (remove)	-.024	.005	.736
Privacy (refuse)	.026	-.001	.464
Privacy (TPS)	-.059	-.011	.425

Since trust, privacy concern and locus of control should be relatively stable in individuals, they should be unaffected by the experimental group which an individual was assigned to (i.e. which DSR offering each participant saw). To check this, a one-way Analysis of Variance (ANOVA) was performed. None of the constructs were significantly different between groups:

- Trust, $F(4,1976)=1.134$, $p=.339$.
- Trust (supply), $F(4,1976)=.588$, $p=.671$.
- Privacy concern, $F(4,1976)=1.427$, $p=.223$.
- Locus of control, $F(4,1976)=1.780$, $p=.130$.

A multiple regression was run to identify associations of the constructs trust, trust (supply), privacy concern and locus of control, with acceptance of the different DSR offerings. Table 4 gives the overall regression results. Specific details are included for trust, trust (supply), privacy concern and locus of control for all tariffs, along with other variables where they show significance of at least p<.05. Overall acceptance was highest for the DLC option, which is an interestingfinding but beyond the scope of this paper and is discussed in detail in another article currently in preparation.

Trust is significantly positively associated with acceptance of all the tariffs, although to a lesser degree for the automated TOU tariffs than for the non-automated tariffs and the direct load control (DLC) option. The largest effect size was for the dynamic TOU tariff (Beta=0.286), followed by DLC and the static TOU tariff, and finally the automated TOU tariffs. The specific item dealing with trust in the reliability of supply was only significant in the case of the dynamic TOU tariff with automation, in which case there was a negative association with acceptance.

The measured level of privacy concern was negatively associated with acceptance of all tariffs – that is, the more someone reported actions taken to protect privacy, the less likely were to accept the tariffs. The effect size was largest for the automated dynamic TOU tariff (Beta=-0.245), and in all other cases fell in the range Beta=-0.113 to -0.145. Locus of control was only significantly associated with one tariff – DLC – and in this case the more external the locus of control, the higher the acceptance of the DLC tariff. Regarding the demographic and other variables:

- There are significant associations between age and acceptance only for the unautomated static and dynamic TOU tariffs. In both cases the tariffs are less popular with people aged 65–74, while for the static TOU tariff is also more popular amongst people under 45.
- Being on a TOU tariff currently is associated with higher acceptance of the static TOU and dynamic TOU with automation tariffs.

Table 4. Multiple regression results. B = unstandardized regression coefficient; Beta = standardized coefficient.

Tariff	*F*	*Adjusted R^2*	*p*	Construct	B	Std. Error	Beta	Sig.
Static TOU	*F*(28,394) =4.125	0.172	0.000	Trust	0.273	0.073	0.217	0.000
				Trust (supply)	0.054	0.072	0.042	0.449
				Privacy	-0.160	0.053	-0.141	0.003
				Control	0.044	0.066	0.033	0.506
				Age 18-24	0.582	0.23	0.133	0.012
				Age 25-44	0.361	0.149	0.143	0.016
				Age 65-74	-0.389	0.197	-0.138	0.049
				Existing TOU	0.399	0.143	0.134	0.005
Static TOU with automation	*F*(28,344) =2.484	0.100	0.000	Trust	0.163	0.078	0.130	0.037
				Trust (supply)	0.049	0.079	0.038	0.531
				Privacy	-0.120	0.057	-0.113	0.036
				Control	0.083	0.071	0.066	0.241
				Live alone	0.476	0.157	0.175	0.003
				Concern about future power cuts	0.15	0.068	0.137	0.027
Dynamic TOU	*F*(28,384) =4.099	0.174	0.000	Trust	0.375	0.075	0.286	0.000
				Trust (supply)	-0.231	0.076	-0.169	0.002
				Privacy	-0.144	0.059	-0.120	0.016
				Control	-0.097	0.066	-0.071	0.142
				Age 65-74	-0.472	0.222	-0.153	0.034
				Private tenant	0.438	0.165	0.136	0.008
				Income £14-28k	-0.33	0.142	-0.134	0.021
				Income not disclosed	-0.519	0.254	-0.100	0.042
				Concern about future climate change	0.135	0.054	0.128	0.012
Dynamic TOU with automation	*F*(28,341) =3.168	0.141	0.000	Trust	0.171	0.074	0.137	0.022
				Trust (supply)	0.068	0.071	0.055	0.334
				Privacy	-0.256	0.054	-0.245	0.000
				Control	-0.005	0.062	-0.004	0.936
				Social tenant	-0.434	0.162	-0.149	0.008
				Existing TOU	0.46	0.143	0.164	0.001
				Concern about future climate change	0.122	0.056	0.123	0.031
Direct Load Control	*F*(28,373) =2.618	0.102	0.000	Trust	0.285	0.070	0.239	0.000
				Trust (supply)	-0.130	0.074	-0.104	0.080
				Privacy	-0.160	0.056	-0.145	0.005
				Control	0.228	0.069	0.180	0.001

- Tenure is significant for both dynamic TOU tariffs, where being a private tenant is positively associated with acceptance of dynamic TOU without automation, while being a social tenant is negatively associated with the automated dynamic TOU tariff.
- Living alone is positively associated with acceptance of the static TOU tariff.
- Income is only significant for the dynamic TOU tariff without automation, where income of £14–28 k and non-disclosure of income with negatively associated with acceptance.
- Concern about future climate change was positively associated with both of the dynamic TOU tariffs, while concern about future power cuts was positively associated with the static TOU tariff with automation.
- Acceptance of DLC was not significantly associated with any of the other demographic/attitudinal control factors.

Discussion

This study has confirmed hypothesis H_1 that trust in electricity supplier is positively associated with DSR tariff acceptance. This was the case for all the offerings presented. Indeed, in the case of unautomated static and dynamic TOU tariffs, and of DLC, a person's trust in their electricity supplier has the single strongest association (of the variables measured) with tariff acceptance. This finding has important ramifications for how DSR offerings are designed, offered and communicated. Clearly, the high level of public distrust of energy suppliers in the UK (as presented in the review section above) potentially presents a barrier to tariff acceptance where such tariffs are offered by those companies. It suggests a challenge to energy companies to focus even more strongly on building trust amongst their customer base, as well as an opportunity for more trusted companies operating in other sectors to enter or expand in the DSR market. It is noteworthy that the proportion of people who said they distrust their energy company is lower for this study than for Which? research cited earlier. This may be due to changes in the way in which the items were phrased, or because this survey dealt specifically with electricity while the Which? figures are for energy in general.

It is interesting to note the range of effect sizes for trust. It is largest for the dynamic TOU tariff with no automation. Its importance here is unsurprising as someone on such a tariff is clearly making themselves quite vulnerable to the supplier's choice as to when to charge peak, medium or low rate prices, with no guarantee that they (the consumer) will be able to respond appropriately. However, it is somewhat surprising that trust was not still more important in the case of DLC. In this case the vulnerability is to direct action affecting an individual's home heating system. It is probable that the very benign nature of the DLC tariff presented (with unlimited overrides and only a small possible effect on temperature) allayed concerns. It is striking that trust was less important where the possibility of an automated response to TOU pricing was offered. This may be because people feel assured that they are less likely to have to alter the way the live to fit the goals of their supplier; rather they can have a technology over which they have overall supervisory control optimize their cost performance. They may feel insulated by automated technology (which is under their control) from this novel exposure to the energy market.

The results for privacy confirm hypothesis H_2 that privacy concern is negatively associated with acceptance. These results confirm previous findings (e.g. Hoenkamp et al. 2011) that privacy is an important concern in relation to smart energy systems, and that acceptance can only be expected where people feel assured that they have appropriate control over their data and how it is used. Again, it is interesting to note that the association is not strongest for DLC, where there is the most direct 'intrusion' by an external agency into the home, but for the dynamic TOU tariff with automation – although it is unclear why this should be the case. It is possible that the explicit ability to override was sufficient to allay concerns about such intrusion.

The only significant association with locus of control was for the DLC offering, where people who perceived themselves to have less personal control in relation to energy (i.e. a more external locus of control) were more likely to accept the tariff. Hypothesis H_3 is therefore confirmed for the DLC tariff, but not for the TOU tariffs. A plausible explanation for its significance in the case of DLC is that people who are more habituated to having control in relation to energy use may be less willing to cede control of technology in their home to a third party (and people who do not believe themselves to be in control lose nothing by ceding it).

STUDY LIMITATIONS

It is well established that stated behavioural intention to act (as measured in this study) does not perfectly predict behaviour – indeed, a review by Sheeran (2002) found that of the studies reviewed, an average of 28 % of the variance in behaviour was explained by intention. The results of this study should not, therefore, be taken as a precise description of likely roles of the constructs tested on actual uptake of DSR offerings. However, in the absence of studies measuring actual uptake, they provide a unique insight into the potential significance of trust, privacy concern and locus of control.

The product offerings were designed to be as realistic as possible. However, asking participants to imagine themselves as having electric heating (while we believe it was necessary and justified for the reasons given in the methods section) may have been confusing for some participants. The product descriptions were intentionally neutral in tone, while it is reasonable to believe that many people will encounter such offerings in the form of advertisements which would be expected to make a much more positive case for signing up. While the scales used to measure the constructs of interest were all based on existing measures, adaptations were made to their wording or content, often for reasons of brevity of context. The scale measuring locus of control in particular was not developed specifically for this purpose and future work would be required to determine the external validity of this measure. Finally, it is noted that people who sign up to take part in online panel surveys may differ in consistent ways from the general population. Importantly for this study, their concerns around privacy could be different since they have agreed to regularly provide a lot of information on their actions and opinions to a third party in return for an incentive. However, again, this would not be expected to affect the general trends exhibited.

DIRECTIONS FOR FUTURE RESEARCH

Some associations were found which cannot be explained with confidence on the basis of the data available, and suggest interesting future avenues for research. Trust in the supplier's ability to ensure a reliable electricity supply was negatively associated with acceptance of the dynamic TOU tariff (only). A possible explanation for this is that people for whom reliability of supply is a salient issue may be more likely to recognise the benefits of tariffs such as this which can adapt to the specific ever-changing needs of the grid. Were this the case, it may suggest is that if the much-discussed tightening of capacity margins in the UK does result in increasing power interruptions, people could increasingly see the value of DSR tariffs. However, since there was no association between lack of trust in a reliable supply and acceptance of the other tariffs, more focused research on this question would be required to establish whether this is a genuine issue.

Being a private tenant was positively associated with acceptance of the dynamic TOU tariff. It is possible that private tenants who want to save money on their energy bill viewed this as an option that was open to them to achieve this, where other options (such as fabric improvements) were not. If this were the case, it is possible that certain DSR tariffs could be viewed as giving some empowerment in relation to energy use for people who otherwise have little other opportunity to act in this area – and therefore targeted in this area. However, it is not clear why this should only apply to the dynamic TOU tariff. Additionally, being a social tenant did not show an association here, and it was negatively associated with acceptance of the dynamic TOU tariff with automation. These findings are contradictory and would benefit from further research, especially in light of concerns that everyone should feel able to benefit from smart grid applications such as DSR.

Finally, being the sole occupant is significantly positively associated with acceptance of the static TOU tariff with automation. It is plausible that having some automated function would be important for certain lone occupants as they would not be able to rely on other household members to turn appliances of and on for them. However, it is – again – unclear why this should not also apply in the case of automated dynamic TOU.

Conclusions

This study employed a representative survey of GB energy bill payers to investigate the role of trust, privacy concern and locus of control in acceptance of a range of DSR product offerings (including static and dynamic time of use tariffs with and without automated response, and direct load control). Trust in electricity supplier was found to be positively associated with acceptance, most strongly for the static and dynamic TOU tariffs without automation and for direct load control. Privacy concern was negatively associated with acceptance, most strongly for the dynamic TOU tariff with automation. Locus of control was only significantly associated with acceptance of direct load control, where people with a more external locus of control were more likely to state an intention to sign up to it.

These results have several implications for the design of DSR product offerings, who offers them, and to whom they are offered. The findings on trust should be of concern to energy industry incumbents in the UK, since levels of trust in energy companies are low relative to comparable industries. They suggest that they will need to work to improve trust amongst their customers if they are to successfully offer DSR products – or alternatively that the door is open to new entrants to the industry, perhaps known and trusted by consumers from their work in other sectors. However, they also suggest that when consumers have the option of automating their response to TOU pricing the role of trust is less important.

The results for privacy concerns confirm the importance of this subject in acceptance of smart energy systems in general, especially where the presence of automation means that large quantities of data are likely to be changing hands. Somewhat surprisingly, direct load control did not have the strongest association with privacy concern, suggesting that the mere fact that an external agent is acting directly in the home is not considered to be a greater threat to privacy that having an automated (or even manual) response to price signals. However, the finding that those people who feel least control of their energy use are most likely to say they would sign up to a direct load control tariff does raise the concern about the potential for targeting such people. While this certainly should not be ruled out (indeed, it may be a way for previously disempowered people to play a larger role in the energy system), approriate protections should be considered to ensure people are not exploited.

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5. Items shown at 12:10.

Appendix A

The following introduction was included for each tariff, followed by one of five plan descriptions:

Some electricity tariffs try to encourage people to use electricity at times of day when it is cheaper and cleaner to produce.

The next three pages ask for your thoughts on one such tariff. Please read the description and imagine that **it is being offered to you by your present electricity supplier**. A couple of points to note:

- People on standard flat-rate tariffs pay on average **14 p[6] per unit of electricity** (one unit is enough to run a fridge-freezer for a day, a PC for three hours or half a cycle of a washing machine).
- More people are expected to use electric heating in future. If you have a non-electric heating system, please imagine that **your heating system works exactly as it does now except that it runs on electricity**.

STATIC TIME OF USE:

On this plan you have **three different rates** for your electricity – low, medium and high. They apply for **fixed times** of the day and week. Here are the rates:

Weekend (all day)	**Low rate (10 p/unit)**
Weeknight (8 pm–7 am)	**Low rate (10 p/unit)**
Week day (7 am–4 pm)	**Medium rate (14 p/unit)**
Weekday peak (4 pm–8 pm)	**High rate (30 p/unit)**

If you sign up your electricity supplier will give you a smart thermostat which allows you to monitor and change the temperature in your home remotely online or with a smartphone app.

STATIC TIME OF USE WITH AUTOMATION:

On this plan you have **three different rates** for your electricity – low, medium and high. They apply for **fixed times** of the day and week. Here are the rates:

Weekend (all day)	**Low rate (10 p/unit)**
Weeknight (8 pm–7 am)	**Low rate (10 p/unit)**
Week day (7 am–4 pm)	**Medium rate (14 p/unit)**
Weekday peak (4 pm–8 pm)	**High rate (30 p/unit)**

If you sign up your electricity supplier will give you a smart thermostat which allows you to monitor and change the temperature in your home remotely online or with a smartphone app. You can also set it to **respond automatically** to price changes so that you have heat and hot water when you need them but at the lowest cost (e.g. by pre-heating your home when prices are lower).

DYNAMIC TIME OF USE:

On this plan you have **three different rates** for your electricity – low, medium and high. The times when these rates apply **change** depending on predicted amounts of wind power and national electricity demand. Your electricity supplier will send you an alert (by text message, email or an in-home energy monitor) the day before, letting you know when each rate applies. Here are the rates:

Low rate	**10 p/unit**
Medium rate	**14 p/unit**
High rate	**30 p/unit**

If you sign up your electricity supplier will give you a smart thermostat which allows you to monitor and change the temperature in your home remotely online or with a smartphone app.

DYNAMIC TIME OF USE WITH AUTOMATION:

On this plan you have **three different rates** for your electricity – low, medium and high. The times when these rates apply **change** depending on predicted amounts of wind power and national electricity demand. Your electricity supplier will send you an alert (by text message, email or an in-home energy monitor) the day before, letting you know when each rate applies. Here are the rates:

Low rate	**10 p/unit**
Medium rate	**14 p/unit**
High rate	**30 p/unit**

If you sign up your electricity supplier will give you a smart thermostat which allows you to monitor and change the temperature in your home remotely online or with a smartphone app. You can also set it to **respond automatically** to price alerts so that you have heat and hot water when you need them but at the lowest cost (e.g. by pre-heating your home when prices are lower).

DIRECT LOAD CONTROL:

On this plan you pay a **lower than average flat rate** for your electricity – **12 p/unit**.

If you sign up your electricity supplier will give you a smart thermostat which allows you to monitor and change the temperature in your home remotely online or with a smartphone app.

While you are on this plan, the thermostat also allows your electricity supplier to **cycle your heating off and on** for short periods at times when there is high demand for electricity, but this will only have a small (less than 1 degree C) effect on the temperature of your home. Your thermostat will show when this is happening, and you have the option to override it.

6. 14 p, or £0.14, is equivalent to approximately €0.18.