Consumers and experts: An econometric analysis of the demand for water heaters*

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Abstract: Consumers can accumulate product information on the basis of a combination of searching, product advertising and expert advice. Examples of experts who provide product information include doctors advising patients on treatments, motor mechanics diagnosing car problems and recommending repairs, accountants recommending investment strategies, and plumbers making recommendations on alternative water heaters. In each of these examples, the transactions involve the sale of goods and services where the seller is at the same time an expert providing advice on the amount and type of product or service to be purchased. In the case of water heaters, the plumber advising a consumer on their choice of water heater, will most likely also install the appliance. Hence there is a strategic interaction between the plumber and the consumer because of asymmetric information and potential differences in preferences. This paper reports on an econometric investigation of the extent to which plumbers act in the best interests of their customers. The empirical work is made possible by the availability of stated preference data generated by designed experiments involving separate samples of Australian consumers and plumbers.

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1. Introduction

For some goods, consumers are not well placed to immediately judge product attributes, a situation which leads to a derived demand for information. Product information can be obtained through consumer search, product advertising and/or from experts who provide advice. It is the latter case with which we are most concerned. Examples of experts who provide product information include doctors advising patients on treatments, motor mechanics diagnosing car problems and recommending repairs, accountants recommending investment strategies, and plumbers making recommendations on alternative water heaters.

Nelson (1970, 1974) makes a distinction between *search* characteristics of goods and *experience* characteristics. *Search* characteristics are product attributes about which consumers are able to obtain relevant information and make judgements prior to purchase, whereas *experience* characteristics are product attributes about which judgements can only be made some time after purchase of the product, for example, reliability. Darby and Karni (1973) added the concept of *credence* characteristics, which are attributes that are difficult to evaluate even after purchase. In each of the examples cited above, the transaction involves the sale of goods and services that can be classified as possessing experience or credence characteristics. Moreover, the seller is at the same time an expert providing advice on the amount and type of product or service to be purchased.

Much of the theoretical literature on experts has been devoted to organizational aspects of markets where there is information asymmetry. Because of the information asymmetry there is typically a strategic element in the transmission of information from expert to consumer. Darby and Karni (1973) note that for firms involved in the joint provision of diagnosis and services, the combination of information asymmetry, together with the high cost of detection of "fraud", implies that firms have an incentive to provide false or misleading information. The consumer may, of course, be aware of this aspect of their interaction and might react accordingly by asking for a second opinion from another doctor, or by seeking other quotes for their car repair or plumbing work. Wolinsky (1993, 1995) has stressed the role of consumer search for multiple opinions and reputation effects as mechanisms for disciplining the behavior of experts. Taylor (1995) concentrates on repair markets and is able to provide theoretical underpinnings for other market features such as the prevalence of ex-post contracts and free diagnostic checks.

Biglaiser (1993) emphasizes the role that experts play as guarantors of quality. More specifically, he considers middlemen, who facilitate trades between suppliers and consumers. Such middlemen are likely to be more frequent traders than the ordinary buyer, and hence they have an incentive to invest in skills that enable them to detect a good's quality. It is also possible that continued involvement in the market means that such experts will have a strong incentive to accurately report quality in order to protect their reputation.

In Biglaiser and Friedman (1994), firms selling a product choose the quality of the product, but the consumer can not identify the product's true quality without making a purchase. In this situation, it may be possible to sell the product more cheaply in a market where there are middlemen than by direct trade between producers and consumers since the middlemen alleviate the moral hazard problem associated with inducing firms to maintain quality. Middlemen are profitable because they increase the speed with which consumers learn about product quality, and they increase the cost associated with firms reneging on their advertised quality. Since the

middlemen handle the products of more than one supplier they have less incentive to sell a low quality good than an individual supplier does. A middleman who sells a low quality good suffers a loss of reputation and loses customers for all of its goods.

In this paper, our interest in the role of experts is somewhat different. Rather than concentrating on the role that experts play in markets, our concern is with how the involvement of experts in the decision-making process complicates the standard analysis of consumer choice. Our empirical work attempts to help us better understand some of these issues in the context of a consumer deciding, with the assistance of a plumber, on what type of water heater to purchase. In many countries water heating is one of the two most important uses of gas in the home, and a study by the International Energy Agency (IEA, 1989) found that water heating was one of the top three residential uses for electricity in each of six OECD countries studied. In the state of New South Wales in Australia, water heating accounts for over 50% of residential gas consumption and over 30% of residential electricity consumption (Fiebig and Woodland, 1994). Moreover, there are new technologies, like high-efficiency instantaneous gas water heaters and electric heat pump water heaters, which could have a major impact on the energy requirements of water heating (Rollin and Beyea, 1985). Hence, an understanding of the decision processes underlying the choice of water heater should be a key element in any policy aimed at reducing energy consumption or CO_2 emissions in the residential sector.

As well as advising consumers on their choice of water heater, the plumber usually also installs the appliance. There will be situations where the two roles are divorced. A consumer may go to a retail outlet for their expert advice and on making a choice employs a plumber to make the installation. Naturally the consumer can bypass all expert advice, in which case they make the choice of water heater and then employ a plumber for installation. However, our empirical evidence indicates that in a substantial proportion of cases, the plumber acts both as an expert adviser to the consumer and as the tradesman. In such cases there is scope for strategic interaction between the plumber and consumer because of asymmetric information and potential differences in preferences. For example, ease of installation may be an important factor influencing the advice given by the plumber, but may be of little interest to the consumer. Our econometric analysis aims to investigate the extent to which plumbers act in the best interests of their customers.

In his analysis of the selection of space and water heater systems, Dubin (1986a, p.112) chooses to avoid the type of problem that concerns us by assuming that:

> "… the structure of supply and demand encourages sellers to act as de facto agents for buyers so that the distinction between construction to stock and construction to order disappears."

Whether such distinctions are important or not would seem to warrant further investigation. Green (1983) recognized the potential for similar influences in his econometric analysis of the choice of space heating fuel, but, unlike Dubin, his modeling distinguishes between houses built by owners and those built for sale. Green (1983, p. 338) notes that this distinction:

> "… was made in order to examine the contention that individuals building for sale will act to minimize the construction costs without regard to what this might do to operating costs."

In a similar vein, Hubbard (1998) investigates the probability that motor vehicles fail emissions inspections as a function of vehicle and inspector characteristics. The extent of the moral hazard problem is measured by the differences between the failure probabilities associated with inspectors in a private firm that also carries out repairs, and inspectors that are state officials having no affiliation with a repair operation.

We extend this type of modeling by taking a closer look at the interaction between the consumer and the expert. The econometric analysis is guided by the Random Utility Model (RUM) that underpins the empirical modeling of discrete choice situations. Consumers are assumed to base their decision on the physical attributes of the water heater, the running cost and purchase cost of the water heater, financing options, and the plumber's advice. The willingness of the consumer to accept the advice of the plumber will depend on an evaluation of the plumber's capability. Hence, variables which capture the technical competence of the plumber (eg. trade certificates) and the nature of the relationship between the two parties, are also included in the consumer model.

Plumbers are assumed to make a recommendation to the consumer on what type of water heater to purchase that is based on the consumer's characteristics and needs, and the plumber's own preference for doing the job. The plumber is concerned about the consumer's preferences because they need to protect their reputation as an expert and because of the possibility of obtaining future work from the consumer. Hence, we also include variables relating to the nature of the relationship between the parties in the plumber model. To capture the plumber's preference for doing the job, we include variables such as the profit that he/she expects to make, the ready availability of the water heater, and the ease of installation. We also test whether, in making their recommendations, plumbers assign relative weights to different attributes of a water heater that are consistent with the relative weights that consumers use in making their choices – in other words, whether or not the plumbers act as "perfect agents" for the consumers.

Several aspects of the consumer/expert relationship included in our work cannot be tested with the type of data used by Green (1983) and Hubbard (1998), which are obtained from natural experiments. Our work benefits from the availability of stated preference data collected specifically for this study. These data were obtained using designed experiments involving separate samples of Australian consumers and plumbers. Although the two data sets were collected separately, our experimental design specified a number of common variables and attribute levels across the two data sets, and included variables that capture the impact of each party on the other. This enables the interactions between consumers and plumbers to be simulated.

2. Data

Studies of appliance choice typically model appliance *penetrations* in terms of the socio-economic characteristics of the household. Examples are Bartels (1988); Fiebig and Woodland (1994); Plumb (1995); and Vaage (2000). Studies with a more detailed treatment of water heaters include Dubin (1986a,b) and Hartman (1984). A few studies have estimated the implicit discount rates used by purchasers to trade-off between purchasing and operating costs with surprising results. For example, Hausman (1979) found an annual discount rate of about 25% for air conditioners, which is considerably higher than the market rate of interest. Also see

Loewenstein and Thaler (1989). But, generally, studies in this field do not adequately consider the factors relevant to the *purchase* of the appliances such as purchase cost, running cost, energy efficiency etc.

The main stumbling block in estimating credible empirical models of the appliance purchase decision is the lack of suitable data. Typically, work on appliance stocks is done using surveys of the equipment that exists in the home. There are a number of problems in using such data for understanding the purchase decision.

a) The current occupier may have moved into the home after the original purchase.
b) Even if this is not the case, they may not have been involved in the decision process; the developer/builder/plumber may have made the decision.
c) Even if the current occupiers were involved in the decision, their circumstances may have changed (income etc.); often the purchase was made up to 10 or 15 years before the survey.
d) It is difficult to accurately determine the age of the equipment, and hence to link the purchase with the appropriate purchase cost and expected running costs of the chosen water heater and competing products.
e) A retrofit may have taken place in the past, in which case it is important to know what equipment was in place before the retrofit.

In view of these difficulties, typical appliance choice studies merely identify the relationships between appliance stocks and current home occupiers, and have little value for understanding the decision-making processes actually involved in the purchase of the appliance. In an attempt to overcome these problems our work employs stated preference methods to collect the data required to model water heater choice.

Despite there being a history in economics of using intentions data (see the survey of Juster, 1964), in recent times economists have neglected such data, and have opted for working with market or revealed preference data. However, there has been a rapid development in the use of data generated by stated preference experiments in other areas of the social sciences, notably in marketing and transportation; see Louviere, Hensher and Swait (2000) for a recent overview. Part of the reason for this development is the appreciation that stated preference data can provide useful information when revealed preference data are deficient or non-existent.

In this study we use stated preference data that were collected in 1999 from a sample of 129 plumbers and a sample of 312 consumers, all of whom lived in Sydney, Australia. In order to provide a specific choice context, consumers were told that they needed to buy and install another water heater but that it was not an emergency, and consequently they had some time to consider options. To ensure that respondents were familiar with such a process, they were required to have been involved with the purchase of a water heater in the last two years. Plumbers were asked to consider a situation where a client asks them to recommend, supply and install a new water heater. They were told that the client lives in the house where the heater had to be installed and that the household comprised an adult couple with two children. The existing water heater had to be removed and replaced but again it was not an emergency situation so that the plumber knew the client had time to consider various options.

Both types of respondents were presented with hypothetical choice situations and were asked to choose (in the case of consumers) or recommend (in the case of plumbers) from a set of

hypothetical alternatives. Following the recommendation of Carson et al. (1994), both choice experiments included a reference alternative that is constant across all the choice sets. Plumbers were asked which of two hypothetical water heaters they would recommend, but they were given the option of a ticking the "constant" reference alternative of not recommending either water heater. In the case of consumers, the "constant" reference alternative was the option of choosing their current water heater in preference to the two hypothetical heaters. This adds to the realism of the choice tasks, but, in the case of the consumer, it means that we have a combination of stated and revealed preference data.

As is common with stated preference experiments, in order to increase the sample size in a cost-effective manner, each respondent was asked to perform not just one choice task as described above, but rather each consumer was asked to perform eight choice tasks, and each plumber sixteen choice tasks. This naturally imparts a panel-data structure to the two data sets. The hypothetical water heaters were characterized by several attributes, the levels of which were manipulated systematically between different choice tasks, and designed to be orthogonal across each data set. Variables ultimately used in the analysis are described in Table 1.

Before embarking on a study of this type which focuses on the relationship between a consumer and an expert (here a plumber), it is natural to ask how important expert advice is in the choice of consumer durables such as a water heater. In our sample of 129 plumbers, 67.4% indicated that, in their most recent job, consumers asked for their advice about the type and model of water heater to install. This is higher than when the 312 consumers were asked a comparable question. Because the consumers were screened, a separate survey was commissioned from Newspoll using a representative sample of Australians consumers. In this representative sample, 45.1% of respondents indicated that they received advice from their plumber when buying a water heater. Naturally this advice need not be heeded. However, a surprisingly high proportion (94.2%) of respondents who sought advice indicated that they accepted at least some of the plumber's recommendations. While the impact of plumbers is possibly not as great as they think, it seems plausible that for a substantial portion of cases the plumber's advice will be sought and will have some impact on the choices made by the consumer.

To put these findings in a broader context, the 312 consumers in the stated preference study were asked to indicate their willingness to seek advice from eleven different types of experts. Of these eleven types of experts, people were most willing to accept the advice of a policeman on parking restrictions or the advice of their doctor. Plumbers were on a par with mechanics advising someone about engine repairs. In these cases the average response was somewhere between: "accept most and probably do" and "may have doubts but do most". People were least likely to accept the advice of a hairdresser/barber advising them on shampoos or their accountant advising them about share investments. In terms of investigating the interplay between consumers and experts, plumbers seem to be a good choice in that their advice is unlikely to be accepted blindly nor is it likely to be completely ignored.

Table 1: Variable Descriptions

Variable	Definition
	X1: Heater characteristics *(Consumer and Plumber Models)*
TYPE	Type of heater (electric = 1, gas = 0)
CAP	Capacity of water heater (1.5 times household's needs = 1, just enough =0)
WARR	Length of warranty in (tens) years
	X2: Heater cost variables *(Consumer and Plumber Models)*
TCOST	Total cost of heater and installation less rebates to consumer (thousands $)
RUNCOST	Monthly running costs (tens $ where average = $20/month)
	X3: Plumber's ratings relative to household's needs *(Consumer Model)*
NORATE	Plumber making no rating (yes = 1, otherwise = 0)
RATESAT	Plumber's rating satisfactory (yes = 1, otherwise = 0)
RATEVG	Plumber's rating very good (yes = 1, otherwise = 0)
RATEEXCEL	Plumber's rating excellent (yes = 1, otherwise = 0)
	X4: Financing variables *(Consumer Model)*
REBATE	Qualifies for 20% Green rebate (yes = 1, otherwise = 0)
NODEAL	Payment deal (none = 1, otherwise = 0)
CASH5	5% discount if paying in cash (yes = 1, otherwise = 0)
LOAN5	Loan at 5% interest for 12 months (yes = 1, otherwise = 0)
LOAN10	Loan at 10% interest for 12 months (yes = 1, otherwise = 0)
ADISC	Some other discount offered (yes = 1, otherwise = 0)
FSTPAY	First payment of loan (due now = 1, due in 3 months time = 0)
	X5: Plumber characteristics and relationship *(Consumer Model)*
NOCERT	Plumber has no government certificate (yes = 1, otherwise = 0)
CERTB	Plumber has both a Green and Gold certificate (yes = 1, otherwise = 0)
CERTGR	Plumber has a Green certificate (yes = 1, otherwise = 0)
CERTGO	Plumber has a Gold certificate (yes = 1, otherwise = 0)
PLCHRGE	Plumber charge for installation (rate different to standard = 1, otherwise = 0)
MAG1	Installation cost in Choice magazine (acceptable range = 1, otherwise = 0)
PLDKN	Plumber not known to consumer (yes = 1, otherwise = 0)
	Z1: Consumer income *(Interacted with Costs in Consumer Model)*
INC16	Income less than $16,000 (yes = 1, otherwise = 0)
INC16-50	Income between $16,000 and $50,000 (yes = 1, otherwise = 0)
INC50-90	Income between $50,000 and $90,000(yes = 1, otherwise = 0)
INC90	Income greater than $90,000 (yes = 1, otherwise = 0)
INCREF	Individual refused to answer income question (yes = 1, otherwise = 0)
INCUNK	Income unknown (yes = 1, otherwise = 0)
	X6: Plumber – job related variables *(Plumber Model)*
AVAIL	Availability of heater (in stock now = 1, 3-5 days wait = 0)
INST	Difficulty of installation (job more difficult than average = 1, otherwise = 0)
PROFIT	Quote for supply and installation, less retail price after trade discounts
	X7: Consumer characteristics and relationship *(Plumber Model)*
SUB	Suburb in which consumer lives (upper middle class = 1, working class = 0)
OTHBIDS	Consumer will ask for other bid (likely = 1, otherwise = 0)
MAG2	Consumer has access to Choice magazine (yes = 1, otherwise = 0)
BEF	Consumer has worked with plumber before (yes = 1, otherwise = 0)
FUT	Plumber likely to receive future work from consumer (yes = 1, otherwise = 0)

3. Model Specification

Both the consumer and the plumber utility maximization problems are characterized using the standard Random Utility Model (RUM); see eg Louviere et al (2000). We use an extreme-value distribution specification for the random component in the RUM resulting in a multinomial model; but we allow for the panel-nature of the data by treating one coefficient in each of the models as random individual effects. This results in a mixed logit model (McFadden and Train, 2000). In order to test whether plumbers and consumers might make the same tradeoffs between common attributes in their respective choice tasks, we estimate models for the pooled consumer/plumber data set, as well as separate models for consumers and for plumbers.

Below we describe the variables included in the RUM's for the consumers and for the plumbers. Descriptions of the variables are given in Table 1. The sets of variables denoted by *X1* and *X2*, representing the water heater's characteristics and cost variables, are common to both the consumer and the plumber models.

3.1 Consumer's random utility function

In each of eight choice tasks, the consumer is asked to choose between three different water heater/plumber situations. Two of the alternatives constitute hypothetical situations ($j = 1$ and 2), while the third alternative is the consumer's current water heater ($j = 0$).

The main variables assumed to affect the consumer's choices are (see Table 1): water heater attributes (*X1*), cost variables (*X2*), plumber's advice (*X3*), financing options (*X4*), and variables that capture plumber characteristics and the plumber-consumer relationship (*X5*). For various reasons, it might be expected that some of the coefficients in the utility function for the current water heater are different to those for the other two alternatives. In particular, we allow for a "revealed preference" effect by including an alternative-specific intercept for $j = 0$. One can also view this as possible habit formation – the consumer may have a preference for a heater similar to the current one, irrespective of its attribute values, since that type is familiar to the consumer. The model also allows for the current water heater to have different slope coefficients for the variables capturing the plumber's advice (*X3*) and the plumber and relationship characteristics (*X5*). The dummy variable, *RP*, represents the current water heater, which we refer to as the "revealed preference".

A final feature of the model is that it allows for the fact that household income might influence the way consumers view cost variables by including interactions between these two types of variables.

Thus we assume that the utility that consumer *i* receives from alternative $j \geq 0$ is given by:

$$(1)\quad U_{ij} = X_{1j}'\beta_1 + \lambda X_{2j}'\beta_2 + X'_{3j}\beta_3 + X_{4j}'\beta_4 + X_{5j}'\beta_5 + RP^*(\beta_6 + X_{3,0}'\beta_7 + X_{5,0}'\beta_8) + \varepsilon_{ij} \qquad j = 0,1,2$$

where $j = 0$ represents the consumer's current water heater, and $j = 1$ and 2 represent the two hypothetical water heaters the consumer is asked to consider. The interaction between cost variables and income is captured by the term $\lambda = Z_1'\pi$, which is parameterised so that $\lambda = 1$ for the median income class.

All variables relating to the "revealed preference" alternative ($j = 0$) is constant across all the eight choice tasks faced by the consumer. Hence this alternative can be seen as the consumer's reference alternative. The coefficient β_6 is treated as a random individual effect, which is constant for the eight choice tasks faced by each individual consumer, but which varies across consumers. Thus the consumers are assumed to have individual-specific valuations of the difference between their current water heater and the hypothetical alternatives.

3.2 Plumber's random utility function

In each of sixteen choice tasks, the plumber is asked to choose between two water heater/consumer situations and to recommend one of them ($j = 1$ and 2). They can also decide that they can't recommend either of the two alternatives ($j = 0$). In making their recommendations, it is assumed that the plumbers will look at their own interests as well as those of the consumers. In particular, in the short term, they will be concerned with the profits they will make from the project. But there is also a longer-term interest in building up a good relationship with the consumer since this may lead to future jobs.

The main variables affecting the plumber's choices are (see Table 1): water heater attributes (*X1*), cost variables (*X2*), plumber's advice (*X3*), job-related variables (*X6*) and variables that capture consumer characteristics and the plumber-consumer relationship (*X7*). The choice of "can't recommend either alternative" is treated as constant reference alternative across all choice sets and its utility function contains only the alternative-specific intercept and the random error term.

Thus we assume that the utility that plumber *i* receives from alternative $j \geq 0$ is given by:

$$(2) \qquad U_{ij} = X_{1j}'\alpha_1 + X_{2j}'\alpha_2 + X_{6j}'\alpha_3 + X_{7j}'\alpha_4 + \varepsilon_{ij} \qquad j = 1, 2$$

$$U_{i0} = \alpha_5 + \varepsilon_{i0} \qquad j = 0$$

where $j = 0$ represents "can't recommend either alternative", and $j = 1$ and 2 represent the two hypothetical water heaters the plumber is asked to consider.

The coefficient α_5 is treated as a random individual effect, which is constant for the sixteen choice tasks faced by each individual plumber, but which varies across plumbers. Thus the plumbers are assumed to have individual-specific reference points for evaluating the hypothetical alternatives.

Among the job-related variables (*X6*), is the variable PROFIT, which is the difference between the plumber's quote for the job and the purchase cost to the plumber of the water heater. This variable is treated as exogenous in the present analysis. When one considers that the plumber is likely to include a similar profit margin when quoting for both hypothetical water heaters in each choice task, exogeneity is not an unreasonable first assumption. However, the approach that plumbers take to quoting for jobs, and the relationship of quotes to recommendations, is of considerable independent interest and we intend to explore this topic in future work.

3.3 Some propositions regarding consumers and plumbers

Since the consumer and plumber models have two sets of variables in common (*X1* and *X2*), it is possible to investigate a number of hypotheses regarding similarities between the preferences of consumers and plumbers. Of particular interest is whether plumbers act as "perfect agents" for consumers in the sense of Culyer (1989), namely, whether they make the same choices as consumers would make if consumers possessed the full information held by the plumbers.

***Proposition 1*: $\beta_1 = \alpha_1$**

Plumbers make the same tradeoffs between the water heater's non-monetary attributes as the consumers.

Rejection of Proposition 1 might point to a misperception by the plumbers of the consumers' preferences. Or it could point to different levels of profitability of water heaters with different characteristics that are not reflected in the plumbers' quotes or in the other variables in X_4.

***Proposition 2*: $\beta_2 = \alpha_2$**

Plumbers make the same tradeoff between different monetary attributes as the consumers.

It is possible that both Propositions 1 and 2 hold, but that they differ from consumers in the relative weight they put on non-monetary versus monetary attributes but not necessarily the same trade off between these two sets of attributes. This leads to:

***Proposition 3*: $\beta_1 = \alpha_1$ and $\beta_2 = \alpha_2$**

Plumbers make the same tradeoffs as the consumers between attributes within the sets of non-monetary and monetary attributes, as well as the same tradeoff as consumers between monetary and non-monetary attributes.

If we assume that the consumers possess the same information as the plumber, then this proposition states that plumbers act as perfect agents for consumers with respect to water heater attributes and costs.

3.4 Estimation

Each of our consumers and plumbers face a choice amongst *J* alternatives repeated under *S* alternative scenarios or choice situations. Both can be represented in a common framework where the utility that individual *i* derives from choice *j* in scenario *s* is denoted by

$$(3) \qquad U_{isj} = \mathbf{X}_{isj}'\boldsymbol{\beta}_i + \varepsilon_{isj}$$

where $\boldsymbol{X}_{isj}$ is a *K* x 1 vector of explanatory variables and $\boldsymbol{\beta}_i$ is a conformable vector of coefficients.

Conditional on $\boldsymbol{\beta}_i$, and assuming the disturbance terms ε_{isj} to be distributed as iid extreme value, the standard multinomial logit specification results with the probability that individual *i* chooses *j* in scenario *s* given by:

$$(4) \qquad P_{isj} = \frac{\exp(\mathbf{X}_{isj}'\boldsymbol{\beta}_i)}{\sum_j \exp(\mathbf{X}_{isj}'\boldsymbol{\beta}_i)}.$$

This specification can be generalized to account for the panel structure of the data and to allow for possible heterogeneity amongst consumers and plumbers. Parameter heterogeneity can be accommodated by setting:

$$(5) \qquad \boldsymbol{\beta}_i = \boldsymbol{\beta} + \boldsymbol{\sigma}\boldsymbol{\mu}_i$$

where $\boldsymbol{\beta}_i$ is a K x 1 vector of mean utility weights, $\boldsymbol{\sigma}$ is a diagonal K x K matrix containing the standard deviations of the utility weights along the diagonal and

$$(6) \qquad \boldsymbol{\mu}_i = (\mu_{i1}, \ldots\ldots, \mu_{iK})' \text{ with } \mu_{ik} \text{ being iid } N(0,1).$$

Notice that this specification allows for $\boldsymbol{\beta}_i$ to vary over individuals, but not over the repeated choices made by that individual. The resultant random parameter or mixed logit model has recently become very popular in empirical work providing a flexible and computationally practical discrete choice specification. [See Brownstone and Train (1999), McFadden and Train (2000) and Revelt and Train (1998) for applications and further support for this type of specification.]

Estimation by simulated maximum likelihood (SML) proceeds by maximizing the following criterion:

$$(7) \quad SLL = \sum_{i,s,j} d_{isj} \ln \hat{P}_{isj}$$

where $d_{isj} = 1$ if individual i chooses j in scenario s, and zero otherwise, and

$$(8) \quad \hat{P}_{isj} = \frac{1}{R}\sum_r \left. \frac{\exp[\mathbf{x}_{isj}'(\boldsymbol{\beta} + \boldsymbol{\sigma}\boldsymbol{\mu}_i^r)]}{\sum_j \exp[\mathbf{x}_{isj}'(\boldsymbol{\beta} + \boldsymbol{\sigma}\boldsymbol{\mu}_i^r)]} \right|$$

is the simulation estimator of the unconditional probabilities obtained by generating R draws of $\boldsymbol{\mu}_i$. Our code for this estimator was written in GAUSS and was tested by comparing the results of appropriate models against the estimates obtained using LIMDEP and using a program for mixed logit estimation downloaded from Kenneth Train's website.

4. Estimation Results and Discussion

Estimation results for various variants of our models are presented in Tables A1 to A7 in the Appendix. Tables A1 and A2 present the results for a standard multinomial logit (MNL) model for the consumer data, and for the corresponding mixed logit model with β_6, the coefficient of *RP*, treated as random. Tables A3 and A4 present analogous results for the plumber data. For

the plumber mixed logit model, the coefficient that is treated as random is, α_5, the alternative-specific intercept for the "can't recommend either" alternative.

The results in Tables A5 to A7 represent "combined" mixed logit models estimated on the pooled set of consumer and plumber data, with various restrictions applied to test for common tradeoffs between consumers and plumbers in regard to the water heater's attributes and costs, *X1* and *X2*. In each case, the restriction is that the parameters for the consumer are proportional to those for the plumber. If this restriction is accepted for a particular subset of attributes, then we can conclude that the consumers and the plumbers make the same tradeoffs with respect to those particular attributes.

In the results for the consumer models and the combined models there are three dummy variables that represent missing data for the current water heater, *mtype*, *mwarr* and *mtcost*. These variables are prefixed with an "m", so that, for example, *mtype* indicates that the consumer did not answer the *type* variable, i.e. did not indicate whether the current water heater was gas or electric. Analogous definitions apply to *mwarr* and *mtcost*.

Table 3: Mixed Logit versus Multinomial Logit

Test statistic	Consumers	Plumbers
t-value of s.d. of random coefficient	20.0	8.0
LR-statistic (1 df)	732	138

The first question of interest is what benefit there is in moving from a standard MNL model to a mixed logit model. Relevant test results are summarized in Table 3. For the consumer model [see eq (1)], the standard deviation in Table A2 associated with the coefficient β_6 is highly significant with a t-values of 8.0. The standard deviation of α_5 in the plumber model [see eq (2) and Table A4] is even more significant, with a t-value of 138. The likelihood ratio tests for comparing the MNL and the mixed logit models are equally impressive, with values of 20.0 and 732 respectively, on one degree of freedom. Thus, for both consumers and plumbers, the mixed logit model seems to be far superior to the corresponding standard MNL model. Hence we will restrict our comments on the results to the mixed logit model.

[Note that comparisons of the MNL and mixed logit results require some care. If, in fact, the latter is the more appropriate specification, then the standard errors are not comparable because those in the MNL model will be inconsistent. With respect to the coefficient estimates, the MNL results are typically smaller in magnitude. This is to be expected since, in the mixed logit model, the parameter estimates are normalized relative to the extreme value part of the disturbance term, that is, net of the error component introduced by the random coefficient. Since the disturbance in the MNL specification captures both sources of error, it will have a larger variance and hence normalization relative to this variance will lead to estimated parameters that can be expected to be smaller than those of the mixed logit.]

We now turn to the results for the mixed logit model for consumers presented in Table A2. Note that coefficient signs are typically sensible and a large number of effects are precisely estimated. The results show that consumers have a slight preference for gas over electricity (not significant), they value more capacity and longer warranty, they are conscious of capital costs, but apparently not concerned about running costs. The variable REBATE measures the "green" effect as the rebate itself has been accounted for in the cost. Its coefficient is small and insignificant. Similarly, apart from cash discounts, consumers don't seem to value financing options. Consumers do value plumber certificates, both green and gold, but they don't seem to pay much attention to plumber recommendations. Only a rating of "excellent" has a significant impact, and then only for the hypothetical alternatives.

Our result that consumers put a high value on certificates is consistent with previous empirical studies on the economics of advertising and information provision. For example, Laband (1986) and Mixon (1995a,b) provide support for the proposition that of suppliers of experience or credence goods provide more informational cues, such as licenses and certificates, than do suppliers of search goods.

Income in our model is included as an interaction with the cost variables. This enables us to examine whether price responses are sensitive to income. The base income class was chosen to be the $50K - $90K income class. The results show that consumers in all income classes are more price sensitive than those in the base class. Low-income households are especially price sensitive.

Results for the mixed logit model for the plumbers are presented in Table A4. As with the consumer results, the signs of the coefficients are typically sensible and a large number of effects are precisely estimated. Compared to consumers, plumbers seem to have a much stronger preference for gas. A possible explanation is that a plumber is typically also a gas fitter, and, unlike with electricity, he doesn't have to engage another tradesman for the connecting the water heater to the gas grid. In regard to extra capacity, longer warranty, and capital costs, plumbers mimic consumer preferences. However, unlike consumers, plumbers place considerable weight on running costs. Characteristics related to the nature of the job impact significantly on the plumber's recommendations, but factors related to reputation do not seem to be important. Presumably repeat business is not an important characteristic of the plumber's market.

In order to test more formally the extent to which plumbers reflect consumer preferences, we have estimated three "combined" mixed logit models using the pooled consumer and plumber data sets. The results for these three models are presented in Tables A5 to A7. Note that in the combined models it is not possible to estimate the individual variance components for consumers and plumbers separately. As is usual, some normalization is required. Here we set the standard deviation of the extreme value distribution for the consumers at the standard value, and estimate the ratio between this and the standard deviation of the disturbance for the plumbers.

The hypotheses we have tested are the first two propositions in Section 3.3, namely:

1. H1: $\beta_1 = c_1\alpha_1$, where c_1 is a scaling constant
   ie. plumbers make the same tradeoffs between the non-monetary attributes TYPE, WARR and CAP as consumers do.

2. H2: $\beta_2 = c_2\alpha_2$, where c_1 is a scaling constant
   ie. plumbers make the same tradeoffs between the monetary attributes TCOST and RUNCOST as consumers do.

Since it has already been noted that plumbers have a much stronger preference for gas than consumers do, we have also tested a modified version of H1, namely:

1* H1 holds for the coefficients of CAP and WARR
   ie. plumbers make the same tradeoffs between the non-monetary attributes WARR and CAP as consumers do.

The results of the corresponding constrained "combined" models are presented in Tables A5, A6 and A7. In each table it is possible to see which coefficients are constrained by the 0.0000 estimates in the lower half of the table. The actual estimates for these coefficients are shown against the same variables in the top half of the table. Likelihood ratio tests of the three hypotheses described above are summarized in Table 4.

Table 4: Tests of Hypotheses

Test	LR statistic	Degrees of freedom	Critical values 1% (5%)
1	7.00	2	9.21 (5.99)
1*	3.12	1	6.63 (3.84)
2	27.82	1	6.63 (3.84)

When we look at the non-monetary attributes (Test 1), we note that the evidence for plumbers making the same tradeoffs as consumers is not overly strong. However, as we've already noted, the rejection of this hypothesis (at the 5% level, but not at the 1% level) may be due to the fact that plumbers have a much stronger preference for gas than consumers do. Test 1* confirms this hypothesis; more specifically, it confirms that the tradeoffs that plumbers make between capacity and warranty are not significantly different to those made by consumers (at both levels of significance).

With respect to the monetary attributes TCOST and RUNCOST, there clearly are significant differences between plumbers and consumers. Recall that the discrepancy in the weights attached to RUNCOST was especially marked in the separate consumer and plumber models.

The differences in the tradeoffs made by consumers and plumbers need to be interpreted with some care. In the health economics literature, where the doctor-patient relationship parallels our plumber-consumer relationship, the concept of the "perfect agent" has been introduced. According to Culyer (1989), the perfect agent chooses/advises as the patient/consumer would choose if the patient/consumer possessed the full information held by the doctor/plumber. This suggests that we need to take account of, not only a possible difference between the preferences of the two types of agents, but also the difference in the amount of information each may have. A

well-intentioned plumber might recommend a particular type of water heater, despite the fact that the plumber knows that it is not the consumer's preferred choice, because the plumber has more information, and he believes that based on this information, his recommendation is the best choice for the consumer.

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APPENDIX: Estimation Results

TABLE A1: CONSUMERS MNL

Log-likelihood = -2206.00

Parameters	Estimates	Std. err.	Est./s.e.	Prob.	Gradient
type	-0.0074	0.0396	-0.186	0.4261	0.5696
mtype	0.6424	0.2061	3.117	0.0009	0.1953
cap	0.4389	0.0747	5.877	0.0000	-0.2481
warr	0.7209	0.0747	9.648	0.0000	0.4919
mwarr	0.1125	0.0567	1.983	0.0237	0.4532
rebate	0.1710	0.0714	2.395	0.0083	0.2532
tcost	-0.9958	0.1066	-9.338	0.0000	-0.0125
mtcost	-1.0562	0.1263	-8.365	0.0000	-0.7099
runcost	0.0116	0.0463	0.251	0.4009	0.1805
costs*inclt16	2.8102	0.8275	3.396	0.0003	0.0262
costs*inc1650	0.2056	0.0777	2.647	0.0041	-0.3624
costs*incgt90	0.2564	0.0869	2.950	0.0016	-0.1913
costs*incref	1.0409	0.1983	5.249	0.0000	-0.4846
costs*incdk	-0.2257	2.3962	-0.094	0.4625	0.1432
ratesat	-0.1232	0.1369	-0.900	0.1841	0.1760
ratevg	0.1052	0.1114	0.944	0.1727	-0.1759
rateex	0.2497	0.1192	2.095	0.0181	0.2627
pldkn	-0.0307	0.1251	-0.246	0.4030	0.0263
plchrge	-0.0149	0.1241	-0.120	0.4524	0.8449
mag1	0.0499	0.0867	0.576	0.2824	0.0748
certb	0.7043	0.1454	4.843	0.0000	0.2241
certgr	0.4580	0.1527	2.999	0.0014	0.0371
certgo	0.6394	0.1645	3.886	0.0001	0.3671
fstpay	0.0406	0.0872	0.466	0.3207	-0.1117
cash5	0.1969	0.1059	1.859	0.0315	-0.1714
loan5	0.0710	0.1216	0.583	0.2798	-0.0165
loan10	-0.1435	0.1067	-1.346	0.0892	0.3704
rp	2.2445	0.1821	12.328	0.0000	0.0733
rp*sat	0.2926	0.1621	1.805	0.0355	-0.2980
rp*vg	-0.0098	0.1281	-0.077	0.4695	-0.0564
rp*ex	-0.2541	0.1312	-1.937	0.0264	-0.2029
rp*pldkn	-0.0082	0.1343	-0.061	0.4755	0.0022
rp*certg	-0.5433	0.1748	-3.108	0.0009	-0.6090
rp*othdisc	-0.1089	0.0549	-1.983	0.0237	0.2941

TABLE A2: CONSUMERS MIXED LOGIT

Log-likelihood = -1839.76

Parameters	Estimates	Std. err.	Est./s.e.	Prob.	Gradient
type	-0.0938	0.0628	-1.492	0.0678	-0.0282
mtype	0.6975	1.2421	0.562	0.2872	-0.2122
cap	0.5842	0.0774	7.548	0.0000	-0.0431
warr	1.0083	0.1871	5.390	0.0000	0.8221
mwarr	-0.3085	0.3244	-0.951	0.1708	-0.1250
rebate	-0.0353	0.0744	-0.474	0.3177	-0.0998
tcost	-1.1814	0.2646	-4.465	0.0000	-0.5236
mtcost	-1.0644	0.3414	-3.118	0.0009	0.0559
runcost	0.0380	0.0323	1.176	0.1198	-0.1120
costs*inclt16	2.4950	1.3152	1.897	0.0289	-0.3006
costs*inc1650	1.1587	0.4313	2.686	0.0036	0.3166
costs*incgt90	1.6577	0.4484	3.697	0.0001	0.0920
costs*incref	1.0812	0.4003	2.701	0.0035	0.5974
costs*incdk	0.3260	3.2218	0.101	0.4597	0.1483
ratesat	-0.1396	0.1425	-0.980	0.1636	-0.2382
ratevg	0.1558	0.1206	1.292	0.0982	-0.2557
rateex	0.3465	0.1232	2.812	0.0025	0.7393
pldkn	-0.1100	0.1319	-0.834	0.2022	-0.1196
plchrge	-0.0805	0.1295	-0.622	0.2671	-0.1461
mag1	0.0927	0.0922	1.006	0.1573	-0.2392
certb	1.2693	0.1549	8.193	0.0000	-0.0825
certgr	0.8158	0.1562	5.222	0.0000	-0.4886
certgo	1.0643	0.1773	6.002	0.0000	-0.6626
fstpay	0.0725	0.0913	0.794	0.2137	0.8198
cash5	0.2453	0.1135	2.162	0.0153	0.8131
loan5	0.0229	0.1317	0.174	0.4309	0.1128
loan10	-0.1417	0.1139	-1.244	0.1067	0.2273
rp	3.3063	0.4582	7.215	0.0000	0.0388
rp*sat	-0.0482	0.5512	-0.087	0.4652	0.2013
rp*vg	-0.2926	0.3879	-0.754	0.2253	0.0707
rp*ex	-1.2712	0.3822	-3.326	0.0004	-0.2881
rp*pldkn	0.2621	0.3423	0.766	0.2219	0.3835
rp*certg	-0.5583	0.3756	-1.486	0.0686	-0.3376
rp*othdisc	-0.1910	0.3362	-0.568	0.2850	0.0616
sd_rp	2.7764	0.1373	20.218	0.0000	-0.0792

TABLE A3: PLUMBERS MNL

Log-likelihood = -1598.40

Parameters	Estimates	Std. err.	Est./s.e.	Prob.	Gradient
neither	-2.2313	0.2823	-7.903	0.0000	0.0000
type	-0.5116	0.0746	-6.860	0.0000	-0.0000
cap	0.9853	0.0742	13.275	0.0000	-0.0000
warr	1.2030	0.1524	7.894	0.0000	-0.0000
tcost	-1.2609	0.1863	-6.768	0.0000	-0.0000
runcost	-0.4761	0.0348	-13.697	0.0000	-0.0001
avail	0.1740	0.0730	2.382	0.0086	-0.0000
inst	-0.2137	0.0749	-2.852	0.0022	-0.0000
profit	0.7713	0.2787	2.768	0.0028	-0.0000
sub	-0.1481	0.1545	-0.959	0.1689	0.0000
bef	0.0208	0.1566	0.133	0.4472	0.0001
fut	0.1323	0.1558	0.850	0.1978	-0.0001
othbids	0.0256	0.1552	0.165	0.4344	-0.0002
mag2	0.0273	0.1572	0.174	0.4311	-0.0001

TABLE A4: PLUMBERS MIXED LOGIT

Log-likelihood = -1529.18

Parameters	Estimates	Std. err.	Est./s.e.	Prob.	Gradient
neither	-2.8355	0.3642	-7.787	0.0000	0.0234
type	-0.5256	0.0762	-6.897	0.0000	-0.0136
cap	1.0217	0.0763	13.396	0.0000	0.0003
warr	1.2564	0.1565	8.030	0.0000	-0.0161
tcost	-1.3080	0.1912	-6.840	0.0000	-0.0335
runcost	-0.4924	0.0356	-13.814	0.0000	-0.0675
avail	0.1707	0.0742	2.300	0.0107	-0.0122
inst	-0.2300	0.0767	-2.997	0.0014	-0.0155
profit	0.8877	0.2985	2.974	0.0015	-0.0232
sub	-0.2166	0.1715	-1.263	0.1033	-0.0086
bef	0.0142	0.1686	0.084	0.4665	-0.0172
fut	0.1517	0.1726	0.879	0.1897	-0.0169
othbids	0.0128	0.1845	0.069	0.4724	-0.0108
mag2	0.0989	0.1730	0.572	0.2837	-0.0107
sd_neither	1.8331	0.2310	7.937	0.0000	0.0298

TABLE A5: COMBINED MODEL: "EQUALITY" OF HEATER ATTRIBUTE PARAMETERS (X1)

Log-likelihood = -3372.44

Parameters	Estimates	Std. err.	Est./s.e.	Prob.	Gradient
type	-0.2542	0.0381	-6.680	0.0000	-0.5872
mtype	0.7669	1.2434	0.617	0.2687	-0.1566
cap	0.5898	0.0666	8.853	0.0000	0.0441
warr	0.7778	0.1075	7.239	0.0000	-0.4290
mwarr	-0.3235	0.3123	-1.036	0.1501	0.0759
rebate	-0.0183	0.0805	-0.227	0.4102	0.7760
tcost	-1.2862	0.2619	-4.911	0.0000	0.0757
mtcost	-1.0951	0.3521	-3.110	0.0009	0.3560
runcost	0.0437	0.0361	1.211	0.1130	-0.0687
costs*inclt16	2.3783	1.1454	2.076	0.0189	-0.2491
costs*inc1650	0.9417	0.3603	2.613	0.0045	-0.3045
costs*incgt90	1.4615	0.3725	3.924	0.0000	-0.1483
costs*incref	0.8112	0.3358	2.416	0.0079	-0.2970
costs*incdk	0.3396	3.0759	0.110	0.4560	0.1210
ratesat	-0.1418	0.1417	-1.001	0.1585	0.1178
ratevg	0.1628	0.1201	1.356	0.0876	0.3501
rateex	0.3343	0.1231	2.715	0.0033	0.2182
pldkn	-0.1145	0.1315	-0.871	0.1920	-0.6015
plchrge	-0.1044	0.1295	-0.806	0.2102	-0.5147
mag1	0.0812	0.0918	0.885	0.1881	-0.3793
certb	1.3012	0.1539	8.453	0.0000	-0.0382
certgr	0.8679	0.1558	5.572	0.0000	0.0254
certgo	1.1306	0.1777	6.361	0.0000	0.6622
fstpay	0.0670	0.0902	0.743	0.2288	0.3623
cash5	0.2100	0.1132	1.854	0.0319	-0.4384
loan5	0.0081	0.1311	0.062	0.4754	0.3564
loan10	-0.1689	0.1128	-1.497	0.0672	-0.0597
rp	3.0736	0.4386	7.008	0.0000	-0.0400
rp*sat	-0.0114	0.5414	-0.021	0.4916	0.1642
rp*vg	-0.1796	0.3783	-0.475	0.3175	0.2743
rp*ex	-1.0994	0.3779	-2.909	0.0018	-0.1453
rp*pldkn	0.1938	0.3369	0.575	0.2826	0.0091
rp*certg	-0.5752	0.3695	-1.557	0.0598	0.2655
rp*adisc	-0.1546	0.3291	-0.470	0.3193	0.1260
sd_rp	2.7176	0.1334	20.371	0.0000	-0.5278
neither	-1.5678	0.2840	-5.520	0.0000	0.0909
type	0.0000	.	.	.	0.0000
cap	0.0000	.	.	.	0.0000
warr	0.0000	.	.	.	0.0000
runcost	-0.2845	0.0355	-8.025	0.0000	0.2523
tcost	-0.7666	0.1294	-5.926	0.0000	-0.0205
avail	0.0930	0.0475	1.956	0.0252	0.1572
inst	-0.1377	0.0443	-3.110	0.0009	-0.4708
profit	0.5531	0.2009	2.753	0.0030	0.0689
sub	-0.1225	0.1210	-1.012	0.1558	0.0873
bef	0.0096	0.1218	0.079	0.4686	0.1373
fut	0.0917	0.1225	0.748	0.2272	0.1641
othbids	0.0022	0.1195	0.018	0.4927	0.1339
mag2	0.0709	0.1168	0.607	0.2719	0.1922
sd_neither	1.0714	0.1557	6.881	0.0000	0.4236
scale	1.7313	0.2008	8.623	0.0000	-0.5902

TABLE A6: COMBINED MODEL: "EQUALITY" OF CAP & WARR PARAMETERS

Log-likelihood = -3370.50

Parameters	Estimates	Std. err.	Est./s.e.	Prob.	Gradient
type	-0.0949	0.0625	-1.519	0.0644	-0.2104
mtype	0.6827	1.1804	0.578	0.2815	-0.1950
cap	0.6260	0.0725	8.640	0.0000	0.1400
warr	0.8338	0.1176	7.092	0.0000	-0.0833
mwarr	-0.2675	0.3138	-0.853	0.1969	0.2615
rebate	0.0024	0.0820	0.029	0.4882	1.6106
tcost	-1.2575	0.2605	-4.827	0.0000	0.3309
mtcost	-0.9543	0.3427	-2.784	0.0027	0.6402
runcost	0.0434	0.0361	1.203	0.1146	-0.8724
costs*inclt16	1.9747	1.0265	1.924	0.0272	-0.5759
costs*inc1650	0.9621	0.3692	2.606	0.0046	-0.2684
costs*incgt90	1.4664	0.3813	3.846	0.0001	-0.2492
costs*incref	0.8594	0.3383	2.541	0.0055	0.0931
costs*incdk	0.4008	2.5308	0.158	0.4371	0.1288
ratesat	-0.1707	0.1423	-1.200	0.1151	-0.0332
ratevg	0.1327	0.1197	1.109	0.1338	0.1038
rateex	0.3033	0.1228	2.470	0.0068	-0.1542
pldkn	-0.1167	0.1324	-0.881	0.1891	-0.8349
plchrge	-0.0990	0.1298	-0.762	0.2229	-0.4806
mag1	0.0820	0.0917	0.894	0.1857	-0.5481
certb	1.2574	0.1539	8.169	0.0000	-0.4651
certgr	0.8180	0.1562	5.236	0.0000	-0.5763
certgo	1.0884	0.1778	6.121	0.0000	-0.0253
fstpay	0.0739	0.0907	0.815	0.2075	0.5551
cash5	0.2301	0.1138	2.021	0.0216	0.4340
loan5	0.0274	0.1317	0.208	0.4177	0.4468
loan10	-0.1530	0.1140	-1.342	0.0897	0.2942
rp	2.9532	0.4380	6.742	0.0000	-0.3288
rp*sat	0.3619	0.5717	0.633	0.2633	0.5260
rp*vg	0.0044	0.3787	0.012	0.4953	0.2824
rp*ex	-0.8383	0.3827	-2.190	0.0142	0.1509
rp*pldkn	0.1547	0.3406	0.454	0.3248	-0.1420
rp*certg	-0.6113	0.3770	-1.622	0.0525	-0.4148
rp*othdisc	-0.1684	0.3330	-0.506	0.3065	0.0248
sd_rp	2.7256	0.1342	20.309	0.0000	0.1468
neither	-1.7435	0.3238	-5.385	0.0000	0.3237
type	-0.3327	0.0564	-5.902	0.0000	-1.4334
cap	0.0000	.	.	.	0.0000
warr	0.0000	.	.	.	0.0000
runcost	-0.3076	0.0399	-7.715	0.0000	-0.3894
tcost	-0.8259	0.1419	-5.821	0.0000	-0.4994
avail	0.1014	0.0517	1.960	0.0250	-0.9429
inst	-0.1479	0.0483	-3.062	0.0011	-0.8084
profit	0.5723	0.2151	2.661	0.0039	-0.0097
sub	-0.1361	0.1310	-1.039	0.1494	-0.1892
bef	0.0086	0.1319	0.065	0.4741	-0.2090
fut	0.0943	0.1322	0.713	0.2378	-0.2004
othbids	0.0054	0.1292	0.042	0.4833	-0.2840
mag2	0.0618	0.1260	0.490	0.3121	-0.1431
sd_neither	1.1510	0.1736	6.630	0.0000	0.3080
scale	1.6030	0.1963	8.164	0.0000	0.4679

TABLE A7: COMBINED MODEL: "EQUALITY" OF COST OF HEATER PARAMETERS (X2)

Log-likelihood = -3396.76

Parameters	Estimates	Std. err.	Est./s.e.	Prob.	Gradient
type	-0.0939	0.0629	-1.492	0.0679	-0.1934
mtype	0.4305	1.5237	0.283	0.3888	-0.0029
cap	0.5644	0.0771	7.319	0.0000	0.6578
warr	1.0659	0.1816	5.869	0.0000	-0.1808
mwarr	-0.2636	0.3155	-0.836	0.2017	0.2650
rebate	0.3961	0.1181	3.353	0.0004	-0.1896
tcost	-0.6261	0.1707	-3.668	0.0001	-0.3242
mtcost	-0.5517	0.4390	-1.257	0.1044	-0.1294
runcost	-0.1862	0.0499	-3.734	0.0001	-0.7493
costs*inclt16	1.2437	1.0565	1.177	0.1196	0.1372
costs*inc1650	0.4656	0.2837	1.641	0.0504	-0.0663
costs*incgt90	0.3345	0.2226	1.503	0.0664	-0.3878
costs*incref	0.4777	0.3688	1.295	0.0976	0.2103
costs*incdk	0.3610	11.0194	0.033	0.4869	0.0304
ratesat	-0.1422	0.1457	-0.976	0.1646	0.3613
ratevg	0.1262	0.1142	1.106	0.1344	0.1602
rateex	0.3108	0.1245	2.497	0.0063	0.5671
pldkn	-0.0594	0.1332	-0.446	0.3278	0.7574
plchrge	-0.0615	0.1311	-0.469	0.3195	0.3930
mag1	0.0883	0.0915	0.965	0.1672	0.8777
certb	1.2897	0.1540	8.374	0.0000	-0.5942
certgr	0.8341	0.1562	5.341	0.0000	0.3763
certgo	1.1187	0.1775	6.302	0.0000	-0.8987
fstpay	0.0474	0.0888	0.534	0.2966	-1.0050
cash5	0.2160	0.1134	1.905	0.0284	-0.6043
loan5	0.0030	0.1292	0.023	0.4907	-0.0536
loan10	-0.1884	0.1118	-1.685	0.0460	-0.1656
rp	3.7863	0.4295	8.815	0.0000	0.2222
rp*sat	0.4163	0.5512	0.755	0.2250	0.8275
rp*vg	0.0443	0.3810	0.116	0.4537	0.7479
rp*ex	-1.0265	0.3893	-2.637	0.0042	-0.2677
rp*pldkn	-0.0184	0.3351	-0.055	0.4781	-0.2944
rp*certg	-0.8653	0.3830	-2.259	0.0119	-0.6345
rp*othdisc	-0.4211	0.3314	-1.271	0.1019	-0.5493
sd_rp	2.6828	0.1349	19.892	0.0000	-0.0323
neither	-1.1736	0.3473	-3.379	0.0004	-0.3360
type	-0.2048	0.0605	-3.385	0.0004	0.2721
cap	0.4056	0.1105	3.672	0.0001	0.6020
warr	0.4954	0.1436	3.451	0.0003	-0.3499
tcost	0.0000	.	.	.	0.0000
runcost	0.0000	.	.	.	0.0000
avail	0.0658	0.0369	1.785	0.0372	0.3979
inst	-0.0919	0.0377	-2.437	0.0074	0.4360
profit	0.4491	0.1668	2.692	0.0035	0.8201
sub	-0.0860	0.0861	-0.998	0.1590	-0.2987
bef	0.0108	0.0839	0.128	0.4490	0.6944
fut	0.0601	0.0853	0.705	0.2405	-0.0437
othbids	-0.0024	0.0825	-0.030	0.4882	0.2135
mag2	0.0376	0.0800	0.470	0.3191	-0.0239
sd_neither	0.7166	0.2041	3.512	0.0002	-0.7320
scale	2.5231	0.6780	3.722	0.0001	0.0888