The Value of Using Stated Preference Methods: A Case Study in Modelling Water Heater Choices

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Abstract: The main stumbling block in estimating credible empirical models of appliance purchase decisions is the lack of suitable data. Appliance choice studies typically 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 we argue that it is necessary to move away from the usual revealed preference sources and employ stated preference data collection methods. These arguments are made with specific reference to the design, collection and analysis of stated preference data for water heater choices using separate samples of Australian consumers and plumbers. The preferences of plumbers are important because of their role in advising consumers on alternative water heaters.

Keywords: Choice modelling; Experimental data; Water heaters

1. INTRODUCTION

Most studies of appliance choice model the *stock* of appliances in terms of the socio-economic characteristics of the household. But such studies generally do not adequately consider the factors relevant to the *purchase* of the appliances such as purchase cost, running cost, energy efficiency, and the influence of an expert providing advice. The main stumbling block in estimating credible empirical models of the appliance purchase decision is the lack of suitable data. 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 we argue that it is necessary to move away from the typical revealed preference (RP) data sources and employ stated preference (SP) methods to collect the data required to better understand water heater choice. There has been a rapid development in the use of data generated by SP experiments especially in the areas of marketing and transportation. Louviere et al. [2000] provide a recent and comprehensive overview, including documentation of the power and predictive accuracy of choice modelling using SP data in a range of complex choice contexts. Our arguments in favour of this type of approach are made with specific reference to the design, collection and analysis of SP data for water heater choices using separate samples of Australian consumers and plumbers. The preferences of plumbers are important because of their role in advising consumers on alternative water heaters.

2. WHY A STATED PREFERENCE APPROACH?

Australian studies of appliance choice where the stock of appliances is modelled in terms of the socio-economic characteristics of the household include Bartels [1988]; Fiebig and Woodland [1994]; and Plumb [1995]. Overseas studies with a more detailed treatment of water heaters include Dubin [1986a,b], Hartman [1984] and Vaage [2000]. But such studies generally do not adequately consider the factors relevant to the purchase of the appliances such as purchase cost, running cost, energy efficiency, etc. Some 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].

Typically, studies of appliance choices are undertaken using survey data on the equipment that exists in the home. There are a number of problems in using such revealed preference data for understanding the purchase decision:

- The current occupier may have moved into the home after the original purchase.
- 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.

- It's 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.
- A retrofit may have taken place in the past, in which case it's important to know what equipment was in place before the retrofit.

Even without these problems there is an inherent difficulty in modelling consumer choice solely on the basis of consumer characteristics when the product is one where consumers are not well placed to judge product characteristics. Consumers will attempt to obtain more product information with one potential source being the advice of an expert. In our case a developer/builder/plumber may have made the decision about the water heater or at least have been involved in the decision process. Such data are unlikely to be routinely collected in typical energy surveys.

SP data provide a viable option. SP experiments are implemented in "choice surveys" that allow one to model preferences in terms of attributes of the good (here a water heater). In a SP choice experiment a sample of people are offered several hypothetical but realistic options from which they choose their preferred alternative. The technique allows estimation of the impact of attributes on choices, by systematically changing the attribute levels faced by respondents.

The most important benefits of these data include the ability to estimate the impact of explanatory variables fully independently of each other by using statistical experimental designs to control for the variation in the description of these variables. This is in sharp contrast to RP data where limited variation in characteristics causes multicollinearity problems that often impede econometric work.

Possibly a more important advantage is the capability to include choice options in the hypothetical situations that are presently not available in the market. For example, suppose the government were considering a policy to encourage the uptake of gas heaters. If the policy instrument is a rebate, there is limited experience with such schemes and even less information available to evaluate them. Moreover, how could one evaluate the relative effectiveness of providing the rebate to the consumer rather than the plumber?

Ultimately we want to be in a position to simulate such policy options. It is difficult to imagine how suitable RP data could be collected even if you wanted to. Thus a final advantage of SP data is the ability to collect data that otherwise would be difficult or impossible to collect in an RP setting.

The underlying validity of the models that use SP data depends on the analyst's ability to specify correctly the product attributes that are relevant. This requires detailed understanding of the consumer's experience and point of view. In the next section a brief overview of the data collection process is outlined. Interested readers should consult Bartels, Fiebig and McCabe [2001a] for a more comprehensive discussion.

3. DATA

In 1999, data were collected 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. They were also required to have access to the gas grid, making the choice between gas and electricity a familiar option.

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 (scenarios) 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 scenarios. Plumbers were asked which of two hypothetical water heaters they would recommend, but they were given the option of a picking the "constant" reference alternative of not recommending either water heater. For 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 also means that we have a combination

of SP and RP data. Apart from giving consumers the possibility of choosing the RP alternative, detailed questions were asked about the RP heater and its mode of purchase including plumber involvement. There are divided opinions about the usefulness of RP and SP data types but we are firmly of the view that both can provide useful information. They should be viewed as complements rather than substitutes.

As is common with SP 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 consider eight scenarios, and each plumber sixteen scenarios. The hypothetical water heaters were characterized by several attributes, the levels of which were manipulated systematically between different scenarios.

The number of possible scenarios (combinations) that could be generated from the complete factorial enumeration of the attributes and levels is too many to be used in a study of the type reported below because of sample size limitations. Hence we developed 64 scenarios based on an orthogonal main effects design. There were eight versions of the consumer survey and four of the plumbers survey. The scenarios were placed in a survey format and their order of appearance was randomized to control for order effects.

There has been no attempt to directly simulate the interaction between consumers and plumbers by actually bringing our two types of respondents together. While such an approach is possible, Brewer and Hensher [2000] is the only example of this type of SP experiment that we know of and their empirical work is limited to 20 pairs of agents. As Brewer and Hensher [2000, p. 118] acknowledge:

"The complexity of a stated choice experiment with offers and feedback necessitates a small sample at this stage in exploring the potential of *interactive agency choice experiments* (IACE's)."

Matching the attributes presented to both types of respondents links our plumbers and consumers and enables us to simulate interaction while delivering dramatic savings in survey costs relative to a fully interactive approach.

4. EXPLORATORY DATA ANALYSIS

It is natural to ask how reliable the responses were and whether our design was successful in representing realistic choice options. Evidence supporting positive responses to these two questions is reported in Bartels et al. [2001a]. In what follows we present some preliminary regression analyses that have been conducted in an effort to provide an indication of what the important factors are in determining heater choice by consumers and heater recommendations by plumbers. Both consumers and plumbers were required to rate each of the SP heaters appearing in their choice sets. Bartels et al. [2001b] have analyzed the consumer ratings data at an individual level. Here we have taken the consumer and plumber SP data and constructed the average ratings for each of these 128 distinct heater types. (There are 64 scenarios each containing two SP heaters.) Consumers were asked for ratings out of 100, and hence the calculation of the average rating is straightforward. In the case of plumbers they were asked to rate water heaters on a four-level scale. The dependent variable used here is the proportion of times the heater was rated as excellent or very good.

Tables 1 and 2 contain the consumer and plumber regression results. The fact that coefficient estimates typically have the expected sign is another internal validity check on our approach. A number of interesting conclusions are indicated by how consumers rate different water heaters. In terms of financial characteristics, the price and running cost effects are correctly signed and are significant determinants of ratings but installation costs and incentives such as rebates or loans are not significant. Characteristics of heaters that have a significant impact on average ratings include capacity and warranty, which consumers value. However, they seem to be indifferent between whether the water heater is gas or electric.

Amongst the plumber characteristics, the presence of different types of certification is highly regarded by consumers. Each of the coefficient estimates on the certificate dummies is large and precisely estimated. Consumers have a preference for gold over green certificates but they clearly want their plumber to have some sort of certification and if they have some, extra certification doesn't substantially improve ratings. Positive recommendations, and knowing the plumber, have positive and marginally significant effects on ratings but the magnitude of these are much less than the certification effects.

Turning to the plumber regression results, capacity stands out in terms of significance and size of the effect. In making their recommendations, plumbers place a great deal of weight on whether the heater has excess capacity. Anyone familiar with water heating advertising in Australia knows that this is a key element of the advertising program of the country's major brand.

Table 1. Regression results for consumer ratings.

Variable	Coefficient	Standard error
CONSTANT	58.60**	2.97
TYPE (electric = 1, gas = 0)	-0.20	0.81
CAP (1.5 times household's needs = 1, just enough = 0)	3.67**	0.81
WARR (Length of warranty in years)	0.62**	0.16
PRICE (Retail price of heater $)	-0.0079**	0.0018
INSTCOST (Installation cost for consumer $)	-0.0034	0.0040
RUNCOST (Monthly running costs $)	-0.21**	0.04
NORATE (Plumber makes no rating = 1, otherwise = 0)	0.03	1.14
RATEVG (Plumber's rating very good = 1, otherwise = 0)	2.21*	1.14
RATEEXCEL (Plumber's rating excellent = 1, otherwise = 0)	2.20*	1.14
REBATE (Qualifies for 20% Green rebate = 1, otherwise = 0)	1.06	0.81
CASH5 (5% discount if paying in cash = 1, otherwise = 0)	0.62	1.14
LOAN5 (Loan at 5% interest for 12 months = 1, otherwise = 0)	-0.28	1.14
LOAN10 (Loan at 10% interest for 12 months = 1, otherwise = 0)	-0.47	1.14
FSTPAY (First payment of loan due now = 1, due in 3 months time = 0)	0.10	0.81
CERTB (Plumber has both a Green and Gold certificate = 1, otherwise = 0)	10.37**	1.13
CERTGR (Plumber has a Green certificate = 1, otherwise = 0)	8.11**	1.13
CERTGO (Plumber has a Gold certificate = 1, otherwise = 0)	10.06**	1.13
PLCHRGE (Plumber charge for installation not standard = 1, otherwise = 0)	-0.58	0.81
MAG1 (Installation cost in Choice acceptable range = 1, otherwise = 0)	0.93	0.81
PLDKN (Plumber not known to consumer = 1, otherwise = 0)	-1.35*	0.81
Adjusted R^2	0.60	

* Indicates significance at 10% level.
** Indicates significance at 5% level.

Table 2. Regression results for plumber ratings.

Variable	Coefficient	Standard error
CONSTANT	42.00**	5.35
TYPE (electric = 1, gas = 0)	5.65**	1.67
CAP (1.5 times household's needs = 1, just enough = 0)	31.20**	1.67
WARR (Length of warranty in years)	1.44**	0.33
PRICE (Retail price of heater $)	-0.0073*	0.0037
RUNCOST (Monthly running costs $)	-0.57**	0.07
PLDKN (Plumber not known to consumer = 1, otherwise = 0)	-0.69	1.67
AVAIL (Heater available now = 1, 3-5 days wait = 0)	2.55	1.67
INST (Installation more difficult than average = 1, otherwise = 0)	-4.63**	1.67
REB100P (Rebate of $100 to plumber = 1, otherwise = 0)	1.95	2.36
REB20P (Rebate of 20% to plumber = 1, otherwise = 0)	2.31	2.36
REB20C (Rebate of 20% to consumer = 1, otherwise = 0)	3.29	2.36
TDISC10 (Trade discount of 10% to plumber = 1, otherwise = 0)	-2.05	2.36
TDISC25 (Trade discount of 25% to plumber = 1, otherwise = 0)	0.87	2.36
TDISC33 (Trade discount of 25% to plumber = 1, otherwise = 0)	1.07	2.36
SUB (Consumer lives is upper middle class suburb = 1, working class = 0)	-0.72	1.67
OTHBIDS (Consumer will likely ask for other bid = 1, otherwise = 0)	2.33	1.67
MAG2 (Consumer has access to Choice magazine = 1, otherwise = 0)	0.14	1.67
FUT (Plumber likely to receive future work from consumer = 1, otherwise = 0)	1.70	1.67
Adjusted R^2	0.78	

* Indicates significance at 10% level.
** Indicates significance at 5% level.

Longer warranties, and whether the heater is electric or not, are also significant factors determining plumber recommendations. The impact of price on recommendation is negative and precisely estimated but the actual magnitude of the effect is small, the elasticity at the means is only – 0.12. The other factors that have a significant impact on plumber recommendations are running costs and whether the installation is going to be difficult or not. Factors that were included to capture reputation effects were not significant. Repeat business is possibly not a major concern for plumbers.

Comparing the results associated with attributes that are common to both consumer and plumber models in terms of the pattern of coefficient signs and significance, one major difference emerges. While consumers have a preference for gas, the difference in ratings between gas and electric heaters is small in magnitude and not significantly different from zero. By contrast plumbers rate gas heaters much higher and the difference is very significant. The explanation lies in the nature of the installation tasks. Plumbers are typically also gas fitters, and, unlike with electricity, they don't have to engage another tradesman to connect the water heater to the gas grid. Such comparisons raise issues about the agency relationship existing between the plumber and the consumer. These are discussed more formally in Bartels et al. [2001c].

As an alternative representation of the differences between the ratings of the consumers and plumbers we have estimated dollar equivalents of the common attributes and presented them in Table 3. Thus, for consumers we calculate the dollar amount by which the heater price would have to change in order to keep the predicted rating constant when a particular attribute level is changed. The values for plumbers are the necessary changes in the retail price. For TYPE the change is from electricity to gas, for CAP it is from "just enough" to "1.5 times needs", for WARR it is a one year increase and for RUNCOST it a $5 per month decrease.

Table 3. Dollar equivalents of attributes.

	Consumers	Plumbers
TYPE	25	774
CAP	466	4272
WARR	79	198
RUNCOST	135	388

As previously noted, consumers prefer gas but a $25 price difference is not large compared to a total heater cost of approximately $1,000. The very large estimate associated with TYPE indicates the reluctance of plumbers to give a high rating to electric heaters. As we have explained the reason behind this preference is most likely to do with the nature of the installation task rather than any benefit to the consumer perceived by the plumber.

Both consumers and plumbers value extra capacity, a longer warranty and lower running costs. In each case their dollar equivalences are substantial. The plumber dollar equivalence for capacity may seem unreasonably large but remember that CAP is only a two-level variable. This very large estimate should be interpreted to mean that plumbers would not rate highly any heater that only provides minimal capacity. This is confirmed by taking a closer look at the distribution of ratings over all 128 alternatives. This distribution is clearly bi-modal and the shape is largely attributable to capacity. The top 39 ranked heaters all had high capacity (1.5 times household needs). In order to get a better picture of the plumber's dollar/capacity tradeoff we would need to have included more levels of over-capacity in our experimental design.

Plumbers seem to have the consumer's best interests in mind by placing substantial value on longer warranties and lower running costs. Interestingly, these valuations are both considerably higher than the valuations estimated for consumers. For running costs, the estimate for consumers of $135 translates into approximately 27 months of savings while plumbers value the $5 per month savings nearly three times higher.

Again we stress that some of these conclusions would not be possible with typical RP data sources. Even less common is RP data on the behaviour of plumbers making the SP data and the resultant regression results unique.

5. CONCLUSIONS

We have argued that typical data available on actual market transactions will be unable to effectively describe the consumer's decision-making process when choosing durable goods. Stated preference techniques are presented as a viable alternative. Using the example of the choice of water heaters, we have outlined the details of a stated preference experiment conducted on a sample of Australian consumers and plumbers. The data that have been collected have passed several internal validity checks and initial indications are that they will provide useful insights into the behaviour of consumer and their relationship with experts such as plumbers.

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