Eliciting and Estimating Reservation Price: a Semi-Compensatory Approach

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ABSTRACT

This study proposes a two-stage method to elicit consumers' price acceptability range. The method combines a conjunctive stage to elicit price acceptability limits with a utility-based stage to choose a preferred product variation. The method is efficient in choice situations entailing many multi-attribute product variations under partial information conditions. A semi-compensatory model complements the method by jointly representing the conjunctive stage with multiple ordered-response models and the choice stage with a multinomial logit model. A case study of ceiling reservation price (CRP) elicitation for students' rental apartment choice shows (i) CRP distribution for different product variations, (ii) model estimation unraveling CRP determinants, and (iii) linkage between CRP and transaction price.

Keywords: price acceptability range, ceiling reservation price, direct elicitation, two-stage model

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INTRODUCTION

The immense variety of product variations typical of digital economy poses a new challenge for eliciting price acceptability range in a behaviorally realistic and efficient manner with existing methods.

Direct surveys, namely buying-response to priced products (Gabor and Granger, 1969), own-category procedure (e.g., Cox, 1986; Monroe, 1971), and open-ended questions (e.g., Janiszewski and Lichtenstein, 1999; Lichtenstein, Bloch and Black, 1988; Rao and Sieben, 1992), refer to a single product variation. Encompassing a wide range of product variations by using pre-specified product descriptions is burdensome and expensive. Using instead general product descriptions generates inconsistencies since people may conceptualize different reference product variations.

Conjoint analysis (e.g., Jedidi and Zhang, 2002; Kohli and Mahajan, 1991) and choice-based experiments (e.g., Chung and Rao, 2003; Jedidi, Jagpal, and Manchanda, 2003) handle several product variations simultaneously. However, these methods assume that consumers use utility maximization as sole cognitive decision process while being fully informed regarding every product variation in the universal realm. This assumption is behaviorally realistic only in choice situations involving a limited number of alternatives (Payne, 1976; Shocker, Ben-Akiva, Boccara, and Nedungadi, 1991).

Market data analysis relies on recurrent actual transactions. Traditional disadvantages are high operating costs, dependency on historical price fluctuations and inability to encompass new products (Breidert, Hahsler, and Reutterer, 2006). In digital economy, using recurrent choices for eliciting price acceptability range is impractical, due to the large number of on-line retailers.

This study proposes a direct elicitation method for choice situations entailing many alternatives, typical of digital economy. The method retrieves the price acceptability range simultaneously for different multi-attribute product variations from cross-sectional data and assumes a two-stage cognitive choice process consisting of a conjunctive strategy followed by utility maximization. As a complementary analysis tool, this study develops a semi-compensatory model that jointly reveals the determinants of the price acceptability range and the importance of transaction price relative to other attributes. This study applies the method and the model to a students' rental apartment case study, as an example of multi-attribute product with many variations.

TWO-STAGE ELICITATION METHOD

The proposed two-stage elicitation method relies on cumulative evidence from decision making studies showing that, when faced with many alternatives, individuals use a sequence of an attribute-based heuristic (e.g., conjunctive) and an alternative-based strategy (e.g., utility maximization) (Payne, 1976; Olshavsky, 1979).

At the first stage, consumers overtly select their tolerated criteria cut-offs concerning acceptable price and product quality from a fixed list of values to delimit the universal realm of product variations to a viable choice set. This stage is similar to the own-category procedure (Monroe, 1971), as consumers differentiate between "acceptable" and "unacceptable" values. At the second stage, consumers choose their preferred product variation from their retained choice set. If consumers do not find their ideal product variation within the choice set, they may select their preferred available variation, update their cut-offs, or decide not to choose and thus reveal the need for market expansion.

Figure 1 illustrates the elicitation procedure. A questionnaire supplements this procedure by collecting consumers' socio-economic characteristics, attitudes and perceptions in order to associate cut-off selection to consumers' observed heterogeneity.

Figure 1 here.

At the criteria specification stage, consumers do not receive full information about attribute values and price of all the product variations within the universal realm. Rather, they are only aware of the general product category delimited by the range of criteria values. At the choice stage, consumers receive complete information regarding product variations that satisfy their cut-offs. Partial information conditions are behaviorally realistic when consumers face a large universal realm, due to information search costs and time consumption. These conditions lead to consumers conceptualizing a product variation by specifying their tolerated quality criteria cut-offs solely based on their intrinsic constraints, instead of specifying their acceptable price for a fully-specified product variation. Hence, given a sizeable sample of consumers, the method enables eliciting price acceptability limits simultaneously for different product variations and identifying their market shares in a cost-efficient manner.

Computer-aided recording of two-stage choice protocols allows tracking consumers' price acceptability limits and quality criteria cut-offs, as well as attributes and transaction price for the chosen product variation. Specifically, the server records a series of consumer's typing actions during the two-stage procedure. The main benefits include preventing inconsistency and misinterpretation usually associated with verbal choice protocols (Olshavsky, 1979), avoiding interference to the natural choice process since consumers do not need to think aloud, and guaranteeing schedule and location flexibility to consumers.

The method is suitable for retrieving both stated preferences from hypothetical choice experiments and revealed preferences from actual consumer transactions.

When the method is applied to hypothetical choice experiments, strategic response bias and incentive compatibility bias may interfere. Survey design elements aim at mitigating strategic response bias by decreasing the attention to the pricing question as consumers (i) engage in a choice task that masks the importance of acceptable price range elicitation as main research purpose, (ii) choose from a fixed product inventory, (iii) do not see the price listed first among the criteria, and (iv) have complete discretion in selecting the criteria to form their viable choice set and are neither obliged nor advised to select price cut-offs. Similarly to Wang, Venkatesh and Chatterjee (2007), associating a hypothetical choice with an actual transaction probability can be used in the proposed method to mitigate incentive compatibility bias, although only for relatively low cost products. When the method is applied to retrieve the price acceptability range from actual consumer transactions, it is bias free.

SEMI-COMPENSATORY MODEL

The proposed model represents a two-stage process consisting of a conjunctive heuristic followed by utility maximization to express the probability of consumer q ($q=1,2,\ldots.Q$) to choose product variation i, as Q consumers face the same universal realm G:

$$P_q\left(i \mid G\right) = P_q\left(i \mid S\right) P_q\left(S \mid G\right) \tag{1}$$

where $P_q(S|G)$ is the probability that consumer q delimits the universal realm G to a viable choice set S, and $P_q(i|S)$ is the probability that consumer q chooses product variation i from S. Although the choice depends on the retained choice set, the two stages represent distinct cognitive processes and thus their error terms are assumed to be uncorrelated. Although being inspired by Manski's formulation (1977), the model differs by assuming that the choice set is observable and derives from a conjunctive heuristic.

The probability to select a choice set *S* derives from the selection probability of a combination of cut-offs:

$$P_q\left(S \mid G\right) = P\left(t^*_{1q}\right) \cap P\left(t^*_{2q}\right) \cap \ldots \cap P\left(t^*_{kq}\right) \cap \ldots \cap P\left(t^*_{Kq}\right) \tag{2}$$

where $P_q(t^*_{kq})$ is the probability that consumer q selects cut-off t^* of criterion k ($k=1,2,\ldots K$). A function of individual characteristics accounts for observed population heterogeneity in representing consumer specific cut-off t^*_{kq}:

$$t^*_{kq} = \alpha_k{}' Z_{kq} + \varepsilon_{kq} \tag{3}$$

where Z_{kq} contains the characteristics of consumer q (i.e., socio-economic variables, attitudes and perceptions) relevant to the selection of cut-off t^*_{kq}, α_k encompasses estimated parameters, and ε_{kq} is an error term.

Criteria cut-offs, similarly to response thresholds for physical stimuli, are revealed when inducing a response (Monroe, 1971), such as the refusal to purchase a product. Assuming that the error term for criterion k is identically and independently distributed normal across consumers, the ordered-probit model represents the probability that consumer q selects cut-off t^*_{kq}:

$$P\left(\theta_{(m-1)_k} < t^*_{kq} \le \theta_{m_k}\right) = \Phi\left(\theta_{(m-1)_k} - \alpha'_k Z_{kq}\right) - \Phi\left(\theta_{m_k} - \alpha'_k Z_{kq}\right) \tag{4}$$

where $\theta_{(m-1)_k}$ and θ_{m_k} are the lower and upper bounds of the cut-off category m_k ($m_k=1,2,\ldots M_k$) that represents cut-off t^*_{kq}, and Φ is the cumulative normal distribution.

The probability to choose alternative *i* from *J* viable alternatives within choice set *S* is represented by a multinomial logit model:

$$P_q\left(i \mid S\right) = \frac{\exp\left(\beta' X_i\right)}{\sum_{j \in S}^{J} \exp\left(\beta' X_j\right)} \tag{5}$$

where X_j represents the product attribute values of alternative j, and β encompasses the estimated parameters.

Assuming independence of the error terms across criteria, the log-likelihood LL for the model defined in equation (1) is:

$$LL = \sum_{q=1}^{Q} \log\left[L_q\left(i \mid S_q\right) L_q\left(S_q \mid G\right)\right] = \sum_{q=1}^{Q} \log\left[P_q\left(i \mid S_q\right)^{d_{qi}} \; P_q\left(S_q \mid G\right)^{d_{m_k q}}\right] =$$
$$= \sum_{q=1}^{Q} \log\left\{ \prod_{i \in S_q} \left[\frac{\exp\left(\beta' X_i\right)}{\sum_{j \in S_q} \exp\left(\beta' X_j\right)} \right]^{d_{qi}} \prod_{k=1}^{K} \prod_{m_k=1}^{M_k} \left[\Phi\left(\theta_{(m-1)_k} - \alpha_k' Z_{kq}\right) - \Phi\left(\theta_{m_k} - \alpha_k' Z_{kq}\right) \right]^{d_{m_k q}} \right\} \qquad (6)$$

where $d_{m_k q}$ equals one if consumer q selects cut-off category m of criterion k and zero otherwise, and d_{qi} equals one if consumer q chooses alternative i and zero otherwise. A custom code in GAUSS matrix language (Aptech Systems, 1992) simultaneously estimates α, β and θ by maximum likelihood.

STUDENTS' RENTAL APARTMENT CASE STUDY

A web-based experiment replicating actual on-line transactions illustrates the application of method and model to rental apartment choice by students living in the city of Haifa, Israel.

In the experiment, respondents access a custom designed website to search a synthetic real-estate inventory according to a pre-specified list of criteria cut-offs. The inventory textually details 18 attributes for each apartment, including neighborhood, rent price, structural features, location amenities, roommate policy and electrical appliances. The distribution of apartment attributes relies on the statistical analysis of local real-estate databases.

The criteria for the inventory search are apartment sharing (vacant versus shared), neighborhood, maximal monthly rent price (\$150-\$700 in \$10 increments), number of rooms (1-5), walking time to campus (5-30 minutes), noise level (rear versus street facing apartments in local and arterial roads), and parking availability (reserved versus non-reserved parking). Price cut-offs reflect the price range, currency and resolution level of local real-estate databases.

This study elicits the maximal rent price since a decreasing price acceptability function ("lower is better") is reasonable for expensive products and relatively low income population groups (Ofir, 2004). Following Wang et al. (2007), this study considers the maximal rent price as Ceiling Reservation Price (CRP), namely the "minimum price at or above which a consumer will definitely not buy the product (i.e., 0% purchase probability)".

Respondents revise their tolerated cut-offs until they obtain a satisfactory choice set from which they choose their preferred apartment, defined as the apartment that they most wish to visit in order to complete a prospective rental transaction. Respondents that do not find their ideal apartment (e.g., quiet low cost apartment) either choose a sub-optimal alternative (e.g., noisy low cost apartment) or abort. The latter case does not appear in the data since identifying the need for market expansion is out of scope.

The web-server automatically codes into a database the cut-offs θ_{m_k}, the choices $d_{m_k q}$ and d_{qi}, and questionnaire answers regarding respondents' socio-economic characteristics, price perceptions, travel preferences and study preferences that form the explanatory variables X_j and Z_{kq}. The next section shows the estimation results for the parameters β and α_k.

RESULTS

Results are based on a sample of 631 respondents searching the database according to the three most frequently selected criteria (i.e., CRP, apartment sharing and neighborhood) and choosing an apartment within a universal realm of 200 alternatives in the two most popular neighborhoods, named Neveshaanan and Carmel.

CRP Distribution

Most respondents (78.6%) select CRP cut-offs in multiples of $50 (i.e., $200, $250,…,$700), which reflects their sensitivity to rent price changes. The mean of selected CRP cut-offs (M=$417, SD=$161.7) is only 7.4% lower than the mean rent price of the 200 apartments (M=$450, SD=$159.9) in the synthetic inventory, which is based on market prices. Hence, elicited CRP values are unbiased.

Each respondent searches the database according to two binary non-price criteria (i.e., apartment sharing and neighborhood), thus selecting among four mutually exclusive product categories for which CRP are elicited. Market shares of the four categories are 42.3% and 38.8% for respectively shared and vacant apartments in Neveshaanan, and 1.9% and 17% for respectively shared and vacant apartments in Carmel. As illustrated in figure 2, the categories differ with respect to their mean CRP, as CRP is moderately correlated with neighborhood (Spearman's Rho=0.42) and apartment sharing (Spearman's Rho=0.68). Only respondents' perceptions regarding criteria linkage explains these correlations, since the experimental design does not suggest the linkage existence.

Figure 2 here.

Correlation between CRP and Transaction Price

Transaction price, equal to the price of the preferred alternative, is strongly correlated with the CRP (Pearson's r=0.75). Moreover, for 28.4% and 47.9% of the respondents the difference between CRP and transaction price is respectively less than 10% and 25%.

Since respondents specify their CRP under partial information, the available price range may be narrower than the specified one. In fact, for almost 60% of the respondents the highest available price within the viable choice set is approximately 15% lower than the elicited CRP. Interestingly, transaction price is strongly correlated with the minimum (Pearson's r=0.83), maximum (Pearson's r=0.87) and average price (Pearson's r=0.91) of the apartments included in the choice set, and according to Jarque-Bera test results is normally distributed around the average price. Likely, after selecting CRP under partial information, respondents adjust their willingness to pay by anchoring to either the maximum or the average price within the choice set.

Model Estimation Results

An ordered-probit model with 11 categories (i.e., 200, 250,…,700) represents the CRP and binary-probit models represent the non-price criteria. Socio-economic explanatory variables are directly inserted into the model, whereas perceptions and attitudes are incorporated after performing factor analysis. The best estimation results are presented in table 1.

Table 1 here.

The coefficients of the CRP ordered-probit model reveal consumers' characteristics influencing the selection of CRP cut-offs for the case of rental apartment choice by students. The probability of selecting higher CRP increases according to: (i) progression of the student's lifecycle and socio-economic status, as respondents who are married or have higher monthly expenses tend to select higher CRP values; (ii) reference to status quo product, as respondents currently paying higher rents in the center of Israel tend to select higher CRP values; (iii) product quality, as respondents associate higher CRP values with apartment sharing and neighborhood; (iv) self-reported price knowledge, in accordance with the literature (Rao and Sieben, 1992).

The probability of selecting lower CRP increases according to: (i) habit to travel daily to campus, likely related to shorter time spent in the apartment with respect to the campus; (ii) greater apartment search experience, likely reflecting a greater propensity to undergo the burden of replacing a status quo product with a more cost-efficient product.

The coefficients of the utility-based model allow inferring the importance of rent price in the choice process relative to other attributes.

CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

This study elicits the price acceptability range and unravels its determinants in choice situations entailing a large number of alternatives by jointly developing a novel two-stage direct elicitation method and a semi-compensatory model. Using a sample of 631 respondents and a universal realm of 200 alternatives, the method jointly elicits CRP, transaction prices and market shares for four product categories in a web-based experiment of rental apartment choice by students.

Results show: (i) CRP distribution and market shares for four mutually exclusive product categories; (ii) CRP correlation with product quality; (iii) unbiased elicited CRP values, (iv) strong correlation between CRP and transaction price, and between the available price range within the choice set and transaction price; (v) consumers' characteristics influencing CRP cut-offs selection, including socio-economic characteristics, price knowledge, paid price for respondents' status quo product and switching propensity to a new product; (iv) joint estimation of the CRP determinants and the role of price in the choice process.

The method allows reproducing market shares of consumers' current selection and forecasting future choices subject to assuming steady functional relationships over time in the model. The method is applicable to multi-attribute products including both functional and hedonic attributes (e.g., travel fares, recreation, portable computers), although is limited to choices governed by the utilitarian principle of bounded-rationality.

Future research directions include: (i) application of the developed method and model for different products by using actual on-line transactions from commercial shopping websites; (iii) investigation of whether absence of bias in the elicited CRP values is a general trait of the method, necessary to apply the method for eliciting the price acceptability range of expensive products.

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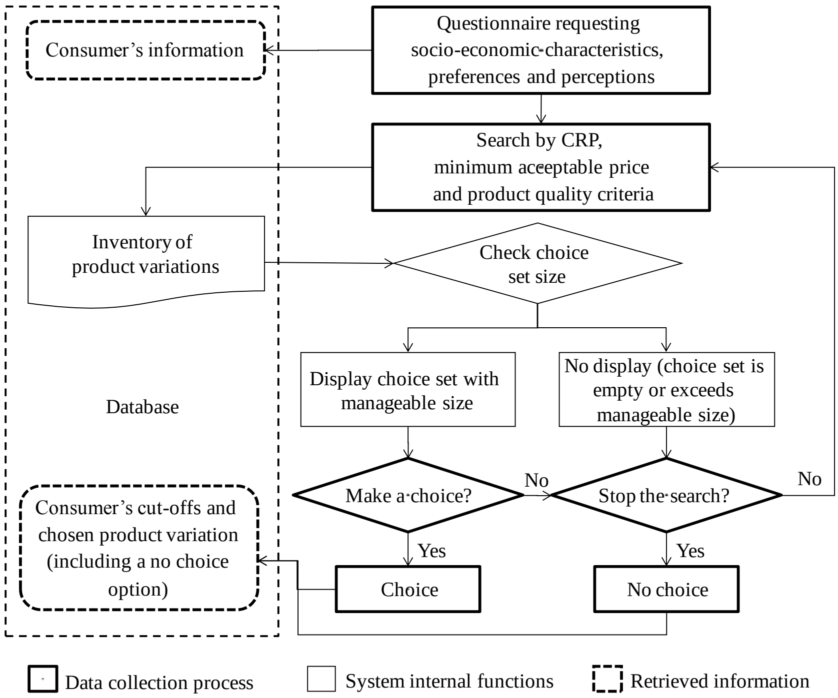

Fig. 1. Two-stage elicitation method.

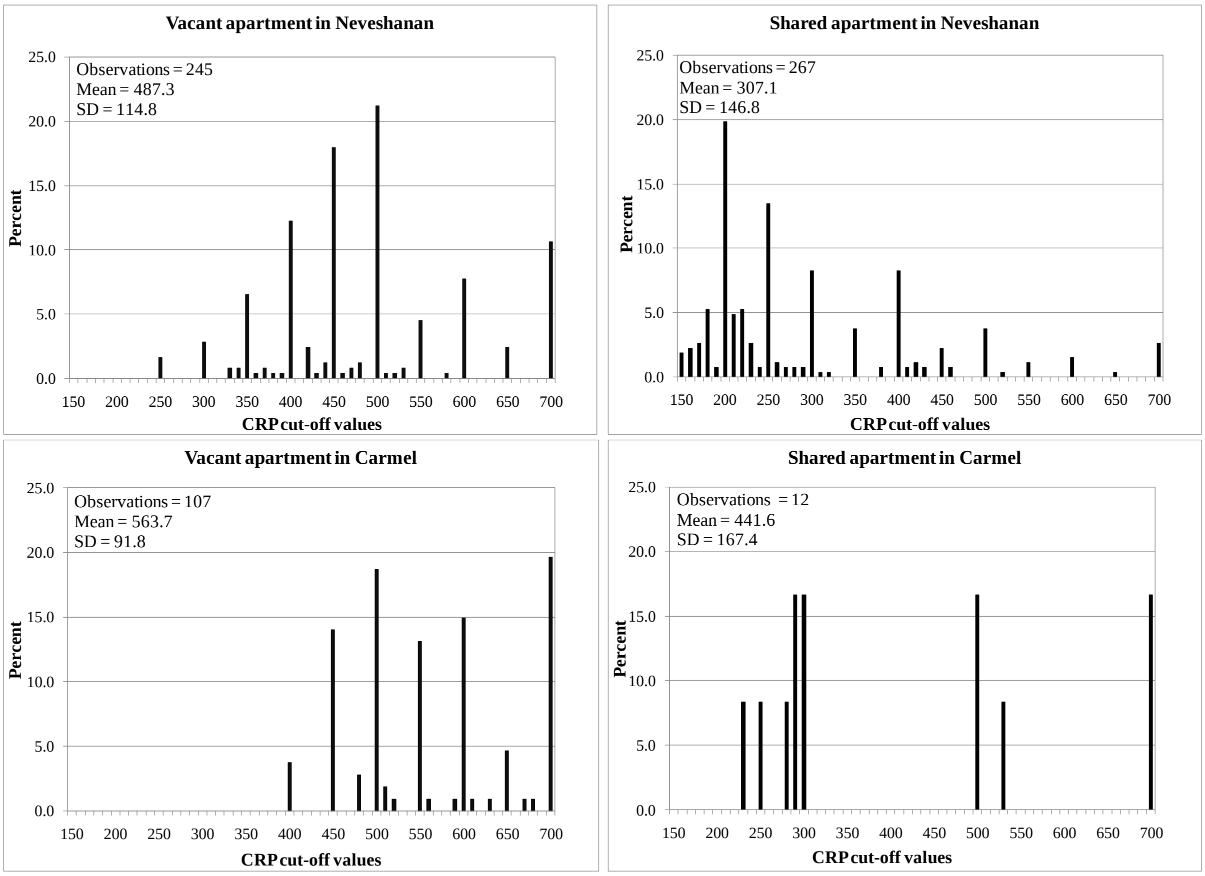

Fig. 2. Distribution of CRP cut-off values per product variation.

Table 1. Estimated model

Variable	Description/categories	parameters	t-stat.
	APARTMENT SHARING CRITERION		
Marital status	Married (1 = yes, 0 = no)	1.257	5.21
Gender	Male (1 = yes, 0 = no)	-0.518	-3.45
Age	Years	0.020	1.83
Car availability	Daily (1 = daily, 0 = Monthly/weekly)	0.391	2.48
Trip frequency to campus	Daily (1 = daily, 0 = Monthly/weekly)	-0.414	-2.76
Study on-campus to benefit from teacher-student interaction factor		-0.124	-2.63
Monthly expenses	< $750 [a]	-	-
	$750- $1000	0.503	2.06
	$1000-$1750	0.605	2.79
Current residential arrangement	Dormitories/parents [a]	-	-
	Roommates	-0.646	-3.14
	Alone	0.793	2.64
	Spouse	0.986	5.15
Current residential location	Haifa metropolitan core	-	-
	Haifa suburban cities	-0.610	-1.75
	Haifa northern outskirts	-0.917	-3.84
	Center of Israel	-	-
	LOCATION CRITERION		
Price-quality ratio consciousness factor		-0.290	-4.44
Age	Years	0.031	1.92
Car availability	Daily (1 = daily, 0 = Monthly/weekly)	0.410	2.45
Faculty location	Medical campus (1 = Medical campus , 0 = Main campus)	0.472	1.70
Monthly expenses	< $750 [a]	-	-
	$750 – $1500	0.243	1.30
	> $1500	0.479	2.20
Income source	No income/scholarship [a]	-	-
	Part-time job	-0.385	-1.92
	Full-time job	-	-
Difference in job opportunities between Carmel and Neveshaanan		0.083	1.99
Difference in parks availability between Carmel and Neveshaanan		0.211	4.15
Study on campus due to increased studying efficiency factor		-0.133	-3.21
Trip frequency to campus	Daily (1 = daily, 0 = monthly/weekly)	-0.286	-1.87
Retaining only vacant apartments (1 = yes, 0 = no)		0.639	3.21
	CEILING RESERVATION PRICE CRITERION		
Marital status	Married (1 = yes, 0 = no)	0.388	2.57
Monthly expenses	< $500 [a]	-	-
	$500– $750	0.288	2.33
	$750-$1500	0.366	2.66
	> $1500	0.640	3.45
Price-knowledge factor		0.124	3.78
Apartment search experience	≤ apartment changes [a]	-	-
	> 4 apartment changes	-0.508	-2.32
Trip frequency to campus	Daily (1 = daily, 0 = monthly/weekly)	-0.342	-3.41
Current residential arrangement	Dormitories/parents [a]	-	-
	Roommates	-	-
	Alone	-	-
	Spouse	0.339	2.46
Current residential location	Haifa metropolitan core	-	-
	Haifa suburban cities	-	-
	Haifa northern outskirts	-	-
	Center of Israel	0.476	3.40
Non-price search-criteria cut-offs	Shared apartment in Neveshaanan [a]	-	-
	Vacant apartment in Carmel	1.885	9.08

	Vacant apartment in Neveshaanan	1.355	9.65
	Shared apartment in Carmel	1.193	4.41
Cut-off points	$200 [a]	-	-
	$250	-0.235	-1.79
	$300	0.263	2.002
	$350	0.601	4.45
	$400	0.860	6.40
	$450	1.375	9.85
	$500	1.891	13.26
	$550	2.551	17.85
	$600	2.802	19.28
	$650	3.187	21.24
	$700	3.340	21.75
UTILITY MAXIMIZATION CHOICE STAGE			
Rent price (U.S.D.)		-0.004	-4.56
Size (square meters)		0.034	9.23
Number of roommates		-0.740	-4.36
Walking time to campus (minutes)		-0.073	-8.08
Quiet apartment (1 = quiet, 0 = noisy)		1.438	13.89
Parking (1 = private parking, 0 = no private parking)		0.398	3.03
Floor number		-0.194	-4.16
Number of balconies		0.177	2.54
Smoking allowed (1 = yes, 0 = no)		-0.345	-2.25
Security bars (1 = yes, 0 = no)		0.331	3.45
View (1 = a view to the bay or mountain, 0 = urban view)		0.465	4.13
Renovated (1 = yes, 0 = no)		0.751	6.93
Air conditioner (1 = yes, 0 = no)		0.617	5.81
Solar water heater (1 = yes, 0 = no)		0.606	4.10
Number of observations			631
Log-likelihood with initial parameters equal to zero			-6831.62
Log-likelihood with final estimated parameters			-3498.54
McFadden's adjusted R^2			0.479

Note: [a] base category