Development and estimation of a semi-compensatory residential choice model based on explicit choice protocols

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Abstract

This paper presents the development and estimation of a novel semi-compensatory model for residential choice. The model assumes that apartment seekers engage in a two-stage process including a non-compensatory strategy retaining only alternatives that meet search-criteria thresholds, followed by a compensatory strategy, namely utility maximization, for finalizing the choice. The model combines hierarchically correlated ordered-response models with a multinomial logit model, jointly estimated, based on data retrieved from a real-estate website designed to track seamlessly two-stage choice protocols.

Estimates demonstrate that: i) the selection of thresholds is explained by individual characteristics, preferences and perceptions; ii) unlike other semi-compensatory models the proposed model is tractable with large number of alternatives, making it especially suitable for modeling residential choice; iii) The model outperforms the multinomial logit model and reveals that the parameters of the logit exhibit an upward bias.

JEL classification: C5, R2, R3

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1. Introduction

Residential choice in metropolitan areas is one of the most complex lifestyle decisions, both because of its importance, high cost and long-term impact, and because of the immense variety of alternatives in the real-estate market. This immense variety derives from the inherently large number of dwelling unit attributes, including location characteristics and amenities, accessibility indicators, structural features and costs. Further contribution to increasing the dwelling units variety stems from urban planning policies, which encourage a variety of housing types and densities, affordable housing, mixed land-use and a wide range of dwelling units that meet the needs of a diverse population.

In choice situations characterized by a large number of alternatives, studies have shown (Payne 1976; Lussier and Olshavsky 1979) that individuals engage in a two-stage choice process. At the first stage, they utilize non-compensatory heuristics such as elimination-by-aspects (Tversky, 1972) to simplify the choice task by reducing its dimensionality to a manageable choice set. At the second stage, they perform a compensatory evaluation process, namely utility maximization, to finalize the choice.

Regardless of the large number of alternatives characterizing residential choice, the vast majority of models applied in the literature do not comply with the described semi-compensatory perspective; rather they are based on the assumption that individuals perform exclusively a compensatory evaluation process, namely utility maximization. A substantial bulk of studies shows that the Multinomial Logit (MNL) is by far the prevailing model used for residential choice over the last thirty years (e.g., Lerman 1976; Quigley 1976; Weisbrod et al. 1980; Anas 1981; Friedman 1981; Gabriel and Rosenthal 1989; Hunt et al. 1994; Tu and Goldfinch 1996; Cho 1997; Freedman and Kern 1997; Rapaport 1997; Nechyba and Strauss 1998; Sermons and Koppelman 2001; Sermons and Seredich 2001; Earnhart 2002;

Galilea and Ortúzar 2005; Shiftan, 2008). A smaller number of studies illustrates the application of more elaborated generalized extreme value (GEV) models such as Nested Logit (e.g, Quigley 1985; Waddell 1996; Abraham and Hunt 1997; Ben Akiva and Bowman 1998; Levine 1998; Skarburskis 1999; Chattopadhyay 2000; Deng et al. 2003) and heteroscedastic extreme value (Yates and Mackay 2005). A few studies recently show the estimation of mixed models such as the mixed spatially correlated logit (Bhat and Guo 2004), the mixed correlated logit for joint decisions (Bhat and Guo 2007) and the random coefficients logit (Barrios-Garcıá et al. 2007).

All the aforementioned studies generate a choice set exogenously prior to the estimation of the compensatory choice model, without any knowledge about the process in which individuals eliminate alternatives and the actual choice set considered by them. Methods applied for choice set generation in residential choice include (i) the application of deterministic availability rules on the universal realm (e.g., Levine, 1998 and Nechyba and Strauss,1998), (ii) the aggregation of alternatives according to their similarities or geographical proximity (e.g., Friedman, 1981 and Gabriel and Rosenthal, 1989), and (iii) the random or stratified sampling of the universal realm (e.g., Waddell, 1996, Chattopadhyay, 2000, Sermons and Koppelman, 2001, Earnhart, 2002, Quigley, 1985, Ben-Akiva and Bowman 1998, Prashker et al., 2008). Given the lack of information contained in traditional choice data about the actual subsets that individuals consider prior to choosing a residence, an obvious disadvantage of these methods is that the specified choice set may be incorrect (Horowitz, 1991). As a result, the misspecification of the choice sets may lead to inconsistent and biased estimates (Stopher, 1980; Williams and Ortuzar, 1982). Further, the purely compensatory approach introduces another limitation related to the assumption that individuals are fully informed regarding each alternative that is considered during the choice process. This assumption does not hold in realistic choice situations characterized by a large number of alternatives, since the acquisition of complete information about each alternative is costly and time consuming (Shocker et al. 1991, Horowitz, 1991).

Semi-compensatory choice models, representing a sequence of a non-compensatory strategy followed by a compensatory strategy, are potentially more suitable for properly representing human behavior when faced with a choice task consisting of many alternatives. Following Manski (1977), semi-compensatory choice models assume that the universal realm of alternatives is reduced to a viable choice set that satisfies an array of criteria thresholds, from which a single alternative is chosen. A major weakness of semi-compensatory models is that in the absence of information regarding the selected choice sets, they become intractable as the number of theoretically possible choice sets increases. Thus, semi-compensatory choice models are seldom applied. In fact, the few models suggested based on Manski's (1977) framework (Başar and Bhat 2004; Ben-Akiva and Boccara1995; Cantillo and Ortuzar 2005; Swait and Ben-Akiva 1987; Morikawa 1995; Zheng and Guo 2008) or on a similar perspective (Borgers et al. 1986, Swait 2001) are subject to severe constraints regarding choice-set size and the structure of thresholds to maintain tractability. In terms of choice set size, most of the estimated models (Başar and Bhat 2004; Ben-Akiva and Boccara 1995; Cantillo and Ortúzar 2005; Cantillo et al. 2006; Swait 2001; Swait and Ben-Akiva 1987) are based on the assumption of a narrow universal realm of three alternatives, which is unrealistic for residential choice. Borgers et al. (1986) and Morikawa (1995) worked with larger choice sets of thirteen and eighteen alternatives respectively. However, the required data for estimation is cognitively demanding for respondents and thus impractical for a large number of alternatives: Borgers et al. (1986) required data ranking all the alternatives in the universal realm and Morikawa (1995) necessitated data regarding the considered, though non-chosen, alternatives in addition to the chosen one. Zheng and Guo (2008) managed to estimate a destination choice model including for twenty-seven alternatives. However, their model limits the choice set structure by considering only nine ordered choice sets deriving from a single ordered criterion (distance).

Regarding the structure of thresholds, none of the aforementioned studies expressed correlations among criteria threshold, while the current study demonstrates that such correlations exist in the case of residential choice. Borgers et al. (1986) limited the representation of thresholds to an ordinal scale, while dwelling unit attributes are measurable more naturally on a cardinal scale. Swait and Ben Akiva (1987) proposed independent normally distributed random thresholds across the population. Ben-Akiva and Boccara (1995), Morikawa (1995) and Başar and Bhat (2004) represented thresholds as logistically distributed latent variables associated with binary indicators that express whether threshold values were satisfied. Further, Ben-Akiva and Boccara (1995) associated attribute thresholds exclusively with alternatives and Başar and Bhat (2004) employed a consideration utility threshold for all the alternatives. Both approaches are unfeasible for large choice sets. Cantillo and Ortúzar (2005) and Cantillo et al. (2006) estimated the parameters of a normal and triangular distribution of thresholds across individuals respectively, without accounting for the impact of individual characteristics. Zheng and Guo (2008) expressed a single ordered-response threshold as a function of only two individual characteristics. An important conclusion deriving from this review of semi-compensatory models is that gathering information regarding threshold selection in addition to choice outcomes is possibly the key for significantly increasing the manageable choice set size and refining the representation of thresholds and their resulting choice sets.

The present study proposes the development and estimation of an innovative semi-compensatory model for residential choice based on a unique survey that collected explicit choice protocols detailing not only choice outcomes, but also threshold selection during the non-compensatory stage. The direct observation of the thresholds and their resulting choice sets alleviates the computational complexity embedded in Manski's (1977) framework without the need for simplifying assumptions, by reducing the theoretical number of choice sets to the actually chosen ones. Hence, the present model accounts for multiple choice-sets and a large realm of two-hundred alternatives. An additional benefit is the refinement of the representation of thresholds, thus increasing the accuracy of representing individual choice sets.

The present study proposes the estimation of the model based on data retrieved from a custom designed real-estate website. Despite their rapid market penetration in recent years as a new source of information for renters and buyers, Internet real-estate databases have never been used for modeling residential choice. In particular, data retrieved from Internet real-estate databases is suitable for semi-compensatory models' estimation since offer search possibilities according to predefined criteria and encourage the user to create an account in order to save his search results. The present study demonstrates the potential of existing websites to provide suitable data for the estimation of semi-compensatory models.The semi-compensatory model is applied in the present study to the off-campus rental apartment choice of students.

The remainder of the paper is organized as follows. Sections 2 and 3 illustrate the methodology by detailing the model framework and web-survey design, respectively. Estimation results of the semi-compensatory model are presented in section 4 and compared with the largely used MNL model. Last, in section 5, conclusions are drawn from the study and further research is recommended.

2. Model framework

The proposed framework assumes a two-stage process for residential choice. At the first stage, individuals use a non-compensatory strategy in order to eliminate non-viable alternatives. At the second stage, individuals apply a compensatory strategy in order to choose their preferred alternative from the remaining choice set. The mathematical representation of two-stage models is presented in equation (1), first suggested by Manski (1977):

$$P_q(i \mid G) = \sum_{S \in G} P_q(i \mid S) P_q(S \mid G) \qquad (1)$$

where G is the universal realm shared by q individuals and S are selected choice sets that differ among individuals. $P_q(S|G)$ is the probability of individual q (q=1,2,….Q) to reduce the universal realm of alternatives G to a viable choice set S at the first stage, and $P_q(i|S)$ is the probability of individual q to choose alternative i out of S at the second stage. The number of theoretically possible choice sets for j alternatives is 2^j-1. Relying solely on choice outcomes (the choice of alternative i) necessitates either considering the total number of possible choice sets, which is practical only for a small number of alternatives, or relying on simplifying assumptions regarding the choice set formation. Thus, the current study proposes to observe the choice sets in addition to choice outcomes in order to alleviate the complexity by reducing the number of possible choice sets to the actually chosen ones.

The present study explicitly represents a sequence of a non-compensatory strategy followed by a compensatory strategy. At the first stage, individuals overtly specify their tolerated search-criteria thresholds in order to delimit the universal realm to a viable choice set. The term “search-criteria” refers to a conjunctive screening rule, in which an alternative is viable if it satisfies a set of relevant criteria thresholds. At the second stage, individuals choose their preferred alternative from their retained choice set.

In accordance with Shocker et al. (1991) and Horowitz (1991), who indicate that individuals typically are not fully informed about each alternative in the universal realm, the proposed framework assumes partial product information at the search-by-criteria stage, which is realistic when the universal realm is extremely large. Specifically, individuals are aware of the general choice scope, namely “rental apartments”, delimited by the possible range of attribute values, but they are not informed about specific alternatives. Theoretically, repetitive search trials could retrieve such information, although it is difficult to do so in practice. Thus, the search process depends solely on individual intrinsic constraints and perceptions.

The proposed non-compensatory strategy is in accordance with the concept of “elimination-by-aspects” suggested by Tversky's (1972). However, it differs with respect to three main assumptions: a) the search-criteria and consequent elimination process are traceable rather than covert; b) individuals receive partial rather full information about the alternatives in the universal realm; c) the elimination process does not necessarily yield a single alternative.

The main difference between the proposed two-stage approach and the compensatory approach traditionally applied to residential choice (Yates and Mackay, 2006), as shown in Figure 1, is the systematic representation of choice set reduction out of the universal realm of alternatives.

“Insert Figure 1 about here”

The probability to select a choice set S is the probability to select a threshold combination leading to its formation, as described in equation (2), following Andrews and Manrai (1998):

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

where P (t_{kq}^*) is the probability of individual q to select the threshold $t^*$of the k^{th} criterion (k=1,2,…K).

The threshold t_{kq}^* can be expressed as a function of individual characteristics as follows:

$$t_{kq}^* = \alpha_{0k} + \sum_{l=1}^{L} \alpha_{lk} SE_{kq} + \sum_{n=L+1}^{N} \alpha_{nk} AP_{kq} + \varepsilon_{kq} = \alpha_k ' Z_{kq} + \varepsilon_{kq} \tag{3}$$

where SE_{kq} are L socio-economic characteristics of individual q relevant for the k^{th} criterion, AP_{kq} are N perceptions and attitudes of individual q, and Z_q is a matrix that contains all the explanatory variables. The vector α_k encloses all the parameters to be estimated and ε_{kq} is an error term. The probability function of selecting threshold t_{kq}^* is according to the nature of the discrete dependent variable and the assumed error distribution.

The measurement of criteria thresholds is similar to the measurement of response thresholds to physical-stimuli that even though continuous, can only be revealed when they induce a response (Monroe, 1971). Accordingly, criteria thresholds are modeled as unobserved continuous variables measured by observed discrete indicators. For example, a price threshold is defined as the price at or above which an individual will refuse to choose an alternative. The indicators are selected thresholds from a list of pre-determined values during the search-by-criteria stage. Ordered-response models are suitable for representing such a variable (Aitchison and Silvey, 1957). Hence, threshold t_k^* is represented by pre-defined M_k observed threshold categories (m_k=1,2,…M_k).

Consider a set of constants $\theta_1 < \theta_2 < ... < \theta_{m_k} < \ldots < \theta_{M_k}$ that correspond to each threshold category for the k^{th} criteria. These constants serve as the upper and lower bounds for the threshold selection. The unobserved dependent variable belongs to an observed category m when its value lies between its upper and lower bounds ($\theta_{(m-1)_k}$ and θ_{m_k} , respectively):

$$\theta_{(m-1)_k} < t_k^* \le \theta_{m_k} \tag{4}$$

Assuming that the error term for each criterion k is identically and independently distributed (i.i.d.) normal across individuals, the probability of individual q to select threshold t^* of the k^{th} criterion is represented by an ordered-probit model (Maddala 1983, pp. 46-49):

$$P\left(\theta_{(m-1)_k} < t^*_{kq} \leq \theta_{m_k}\right) = \Phi\left(\theta_{(m-1)_k} - \alpha'_k z_{kq}\right) - \Phi\left(\theta_{m_K} - \alpha'_k z_{kq}\right) \tag{5}$$

where Φ is the cumulative normal distribution.

Assuming independence of the error terms across different criteria, the unconditional likelihood of selecting choice set S by individual q is:

$$L_q(S \mid G) = \prod_{k=1}^{K} \prod_{m_K=1}^{M_K} \left[P\left(\theta_{(m-1)_k} < t^*_{kq} < \theta_{m_k}\right)\right]^{d_{m_k q}} \tag{6}$$

where $d_{m_k q}$ is an indicator function that equals unity if the m^{th} threshold category of the k^{th} criteria is selected by individual q and zero otherwise.

The utility-based choice stage is modeled considering a MNL structural form. Accordingly, the choice probability of alternative i from choice set S, which includes J viable alternatives, is described in equation (7).

$$P_q(i \mid S) = \frac{\exp(\beta' X_i)}{\sum_{j \in S}^{J} \exp(\beta' X_j)} \tag{7}$$

where X_j is a vector of attribute values of the j^{th} alternative and β is a vector of parameters to be estimated. Interaction terms of individual characteristics with apartment attributes are included in X_j. The corresponding likelihood is:

$$L_q(i \mid S) = \prod_{i \in S} \left[\frac{\exp(\beta' x_i)}{\sum_{j \in S}^{J} \exp(\beta' x_j)}\right]^{d_{qi}} \tag{8}$$

where d_{qi} equals unity if alternative i is chosen by individual q, and zero otherwise.

The threshold selection stage and the choice stage are explicitly observed and their error terms are assumed to be uncorrelated. Accordingly, combined unconditional log-likelihood over Q individuals to select choice set S out of the universal realm G, followed by choice of alternative i from choice set S can be written as:

$$\ell(S \mid G) = \sum_{q=1}^{Q} \log\left(\prod_{k=1}^{K} \prod_{m_K=1}^{M_K} \prod_{i \in S} \left[\frac{\exp(\beta' x_i)}{\sum_{j \in S}^{J} \exp(\beta' x_j)} \right]^{d_{q_i}} \left[\Phi\left(\theta_{(m-1)_k} - \alpha_k' z_{kq}\right) - \Phi\left(\theta_{m_K} - \alpha_k' z_{kq}\right) \right]^{d_{m_k q}} \right) \quad (9)$$

The parameter vectors α, β and θ are estimated simultaneously using maximum likelihood estimation, which was undertaken by a specially written GAUSS (Aptech, 1994) code.

3. Web survey design

A custom designed website was developed in order to collect the necessary data for model estimation. The website included a questionnaire and a semi-compensatory choice experiment. In the experiment, respondents searched a synthetic real-estate database according to a pre-defined list of criteria and threshold values. From the search results, they chose their three preferred apartments, ranked according to their preference priorities. The design of the experiment was based on existing real-estate websites, in order to evoke the feeling of a realistic choice situation. The website was connected to a database, which contained a synthetic apartment inventory and tables for automatic coding of the respondents' answers. The computer environment served to record seamlessly the choice protocols of the respondents. The advantages of the web-based survey versus a laboratory experiment are low operational costs in terms of hardware and staff hours, and schedule flexibility for the respondents.

Students at the Technion - Israel Institute of Technology in Haifa were the target population. The survey was conducted during the spring semester of 2007 over a period of one month, was advertised among the students by the official Technion e-mail system, and was promoted through the distribution of 3,000 leaflets. The participation incentive was a raffle of 23 prizes with a total amount of $1,000, the highest prize being close to the average student monthly rent. The website structure and information flow are illustrated in Figure 2.

"Insert Figure 2 about here"

It is noticeable from Figure 2 that apartment list is displayed to the respondents only after they perform the filtering process. This feature allows to record the search criteria and the apartment choice for each respondent. Similarly to existing real-estate web-sites, if the respondent is not satisfied with the choice set, it is possible to go back to the search criteria window and change the threshold value. The database for the modeling experiment records the final choice performed by the respondent.

3.1. Semi-compensatory experiment design

The synthetic real-estate database included an inventory of 600 apartments representing six neighborhoods in the city of Haifa. The distribution of the apartment characteristics was based on a statistical analysis of all the apartments for rent in the city of Haifa advertized on actual free-access real estate databases during the winter semester of 2007. Overall, 310 apartments were extracted. The considered apartment characteristics were location, proximity to the Technion campus (walking time in minutes), noise level, price, size, number of rooms and balconies, renovation status, floor, number of roommates and their smoking policy. Further, characteristics included the availability of view, parking, security bars, elevator, air conditioning, solar water heating and washing machine.

The attributes, apart from rent price, were drawn randomly and independently from normal distributions, with means and variances extracted from the observed apartment sample. Statistical analysis showed that the rent price was related to apartment location, size, number of rooms and renovation status. Thus, the mean rent price was expressed as a function of these variables and was estimated from the actual sample by regression. With the intention to maintain the realistic nature of the data, but to still provide variability and independence between rent price and other attributes, rent prices were randomly drawn from a normal distribution with the estimated mean and a standard deviation (SD). The rent price distribution for different locations allowed partial overlap, preventing respondents from making inferences regarding correlation between rent price and location.

The database search criteria, which served to eliminate the alternatives, were derived from a preliminary survey among 74 students. These criteria were apartment sharing, neighborhood, maximal rent price, number of rooms, proximity to the Technion (walking time in minutes), noise level and parking availability. Figure 3 presents the web page for the database search procedure.

"Insert Figure 3 about here"

Price threshold values were expressed in U.S. dollars, as is common practice in Israel for expressing monthly rents and house values. The rent price range varied between $150-$700 per month, with increments of $10, to reflect the actual price range found on real-estate websites. Apartment sharing was defined as the possibility to select either a vacant apartment or an apartment with roommates. The location criterion included the six Haifa neighborhoods. The number of rooms varied between 1 and 5. The walking time ranged between 5 and 30 minutes. The noise criterion included four levels. Parking availability was binary. Respondents selected a threshold value for their preferred criteria from a list of given values.

In accordance with existing literature on semi-compensatory models (for example Andrews and Manrai, 1998), the experiment assumed a-priori independence among the search criteria. The independence was supported by two design features: (i) at the search-by-criteria stage, respondents were not informed about any linkage among apartment attributes (ii) the selection of search criteria was entirely at the discretion of the respondents.

3.2. Questionnaire design

The questionnaire was aimed at collecting information regarding socio-economic characteristics, perceived location amenities, latent money and price perceptions, travel preferences and study preference (on-campus versus home). The socio-economic characteristics were age, gender, marital status, field and degree of studies, income source and monthly expenses as proxy variables for income, apartment search experience, car availability and main travel-mode in the city of Haifa, trip frequency to the campus, smoking habits, current residential arrangement and location.

Perceived location amenities for each neighborhood, expressed on a seven-point Likert scale ranging from 1 (very poor) to 7 (excellent), were accessibility to student jobs, accessibility to entertainment, availability of parks and ease of reaching the campus by public transport. The perceived car travel time from the six neighborhoods to the campus was expressed in minutes.

Information regarding perceptions and preferences was collected through indicators expressed on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Money perceptions were based on Furnham (1984) and were designed to measure the tendency to spend or save. Price perceptions were based on Lichtenstein et al. (1993) in order to express value consciousness, price knowledge, price-quality inference, price consciousness and sales proneness. Study preference (on-campus vs. home) represented schedule flexibility, on-campus study efficiency and professor-student interaction similarly to attitudes towards telecommuting (Mokhtarian and Bagley, 2000). Travel preferences for non-motorized modes and travel minimization were adopted from Handy et al. (2006).

4. Empirical analysis

4.1. Sample characteristics

The survey yielded 1,121 completed questionnaires, of which 1,049 questionnaires were valid after removing duplicate answers and performing consistency and non-randomness checks. The average completion time was 4.7 min (SD = 2.5 min) for the experiment, and 5.3 min (SD = 2.9 min) for the accompanying questionnaire.

The three most frequently selected search criteria are apartment sharing, location and maximal rent price, chosen by 94.5%, 87.2% and 88.9% of the respondents, respectively. The two most popular neighborhoods are Carmel and Neveshanan, altogether selected by 63.3% of the respondents. The neighborhood Neveshanan is a middle-class neighborhood, which offers some student job opportunities, shopping and leisure activities. Its main attractiveness to students derives from its proximity and extremely high public transport accessibility to the main campus. The neighborhood of Carmel is a middle-upper class neighborhood and is generally considered as one of the city centers. It offers many shopping, leisure and entertainment opportunities and is highly accessible to a hi-technology industrial park, which offers an abundance of student job opportunities. In addition, the neighborhood contains many green and wooded areas and offers a stunning view over the Haifa Bay. These neighborhoods contained a realistically large realm of 200 alternatives in the synthetic database. In order to illustrate model estimation, 631 observations (60.2% of the valid questionnaires) are selected. These observations correspond to respondents who searched the database according to a combination of one of the two neighborhoods, price and apartment sharing (either vacant or with roommates). The model accounts for the first choice priority apartment for each respondent. Sample characteristics are summarized in Table 1.

"Insert Table 1 about here"

The percentage of female respondents is close to the 35.3% female student population at the Technion (Central Bureau of Statistics, 2006). The median age of the respondents corresponds to the median age of 26.1 years of the general student population (Central Bureau of Statistics, 2005a). The share of respondents living on-campus matches the dormitories capacity. Table 1 shows that 55.3% of the respondents live off-campus. Of these respondents, 33.5% rent an apartment alone or with roommates, 12.6% cohabit with their spouse and 53.9% are married. These percentages agree with data on the general student population (Central Bureau of Statistics, 2005b), which indicate that 32.8% of students who do not reside with their parents rent an apartment, 9.4% cohabit with a spouse and 57.8% are married. The distribution of the place of residence is compatible with the geographic location of the Technion. The above comparison with public records shows that the extracted sample is representative of the Technion student population. It follows that the monetary prize raffle did not adversely affect the sample composition, in accordance with recent literature concerning web-based surveys (for example, Goritz, 2004).

4.2. Distribution of search criteria thresholds

55.8% of the respondents retain only vacant apartments, while 44.2% prefer to retain only shared apartments in their choice set. 81.1% prefer to retain only apartments located in Neveshanan, while 18.2% prefer to retain only apartments located in Carmel. The distribution of the selected rent price thresholds is presented in figure 4. The mean rent price threshold is \$415.2 (SD=\$159.5). Even though the fixed price list is in \$10 increments, the majority of the respondents (78.6%) select threshold values in multiples of $50. This finding agrees with the notion of measuring price threshold through observed discrete indicators.

“Insert Figure 4 about here”

Apartment sharing is weakly correlated (Spearman's Rho=0.313) with location. The price threshold is moderately correlated with location (Spearman's Rho=0.415) and apartment sharing (Spearman's Rho=0.674). All the correlations are significant at the 0.01 significance level. The correlation implies that students who have a greater propensity to retain vacant apartments have a higher propensity to retain apartments located in Carmel and have a greater propensity to select higher price thresholds. It should be noted that the design of the choice experiment does not provide any information regarding linkage between the search-criteria. Moreover, their selection was entirely at the discretion of the respondents. Thus, the correlation is related to respondents’ intrinsic perceptions.

4.3. Model estimation results

Table 2 presents the estimation results of the proposed model, based on many trials of different variable combinations, hypothesis tests for variable significance and hypothesis tests for aggregation of variable categories. The model contains several explanatory variables, which were grouped into the following categories: apartment sharing threshold, location threshold, price threshold, choice stage variables and interaction variables.

Apartment sharing equals unity for a vacant apartment and zero for a shared apartment. Apartment location equals unity when an apartment is located in the Carmel neighborhood and zero when it is located in Neveshanan. Hence, these criteria are modeled with a binary-response probit model. The price threshold is best described by the ordered-response probit model with 11 categories (200, 250,…,700), deriving from the observed distribution in figure

4. Grouping the observations into the categories is conducted by rounding the observations within the range of ±$25 of each category. The chosen search criteria yield 44 threshold combinations that lead to the formation of choice sets. Three of these combinations yield empty choice sets and are aggregated into their nearest non-empty category.

Monetary and place of study perceptions are found to influence residential choice. Whereas socio-demographic variables are directly used as explanatory variables, latent perceptions are incorporated in the model after performing a factor analysis. The found monetary constructs are price-knowledge, value-price ratio consciousness, price-consciousness and awareness of one's own expenses. The found study preferences are on-campus studying in order to increase efficiency, on-campus studying to benefit from teacher-student communication and off-campus studying in order to enjoy schedule flexibility.

The correlations among the search-criteria thresholds are accounted for by adding dummy variables into the deterministic part of equation (3). Considering a hierarchical non-compensatory process, each criterion depends also on its preceding criteria. Thus, dummy variables are added according to the order of appearance of the criteria on the web page dedicated to the database search procedure: apartment sharing, location and price. Accordingly, a dummy variable for selecting to retain vacant apartments is an explanatory variable for location. Dummy variables for selecting combinations of apartment sharing and location are explanatory variables for the price threshold.

Apartment location and presence of roommates are determined at the search-by-criteria stage. Thus, these variables are constant within each choice set and do not influence the utility maximization stage. Rent price vary within each choice set and thus is accounted for in the utility maximization stage. The model in table 2 is presented both with and without interaction terms of individual characteristics with rent price at the compensatory stage, in order to investigate whether individual differences influence preferences at the choice stage, even when they are considered also as choice set formation constraints.

"Insert Table 2 about here"

The following subsections present the interpretation of the model in table 2. While the magnitude of the parameters may be specific to the study area, the trends in rental apartment choice by students may be transferable to other regions and countries as well. Thus, only general trends are reported and discussed.

4.3.1. Apartment sharing criterion

The propensity to retain solely vacant apartments within the choice set increases with age, marital status and monthly expenses. Thus, estimates reflect a greater demand for a higher standard of living, as life cycle progresses and monthly expenses increase.

Respondents are generally satisfied with their actual residential arrangement. In fact, respondents who currently reside with roommates prefer to retain solely shared apartments, while respondents living alone or with a spouse prefer to retain exclusively vacant apartments.

Daily trips to campus and the latent preference to study there in order to benefit from teacher-student interaction increase the probability of retaining only apartments with roommates. Possibly, respondents who spend less time in their apartment than on campus prefer to ease apartment chores by sharing them.

Daily car availability increases the propensity to retain only vacant apartments, whereas the latent preference for non-motorized modes decreases it. Since 60.9% of the respondents who normally walk or bike, share a ride occasionally, ride sharing is another possible reason for apartment sharing.

4.3.2. Apartment location criterion

Daily car availability versus weekly and monthly car availability increases the propensity to retain only apartments located in the Carmel neighborhood. Greater car availability allows disperse activity patterns and provides easy accessibility to campus. Thus, it encourages students to live farther away from campus and saves the need to share an apartment from reasons of ride sharing.

Proximity to campus is important to the location decision. Daily trips to campus and the latent preference to study there, for reasons of efficiency, increase the probability to select Neveshanan. Medical students favor the Carmel neighborhood, presumably, since it offers better accessibility to the Faculty of Medicine, which is located away from the main campus.

Respondents have a higher propensity to retain apartments in the neighborhood that they perceive better in terms of accessibility to student jobs and availability of green spaces. The effect of perceived accessibility to leisure activities, perceived travel time by car and perceived accessibility to campus by public transport are highly insignificant and are not presented in Table 2. The insignificance of travel time by car is probably due to the similarity between the perceived car travel times from the two neighborhoods to campus (a difference of 10 minutes or less for 75.4% of the respondents). A possible reason for the insignificance of perceived accessibility to campus by public transport is the high ride sharing (77.3%) among respondents who are public transport riders.

4.3.3. Maximal rent price criterion

The propensity to select higher price thresholds increases with the progression of the student lifecycle (marital status or living with a spouse) and the growth of monthly expenses, reflecting a higher willingness to pay with the ability to do so and the demand for higher living standards.

Daily trips to the campus increase the probability to state lower price thresholds, possibly due to the lesser time spent at the apartment versus the time spent on campus.

Daily car availability increases the probability to select higher price thresholds. Replacing daily car availability with the preference for private parking at the search-by-criteria stage yields the same goodness-of-fit results. Including both variables in the model results in the insignificance of the daily car availability coefficient. Thus, it serves as a proxy for a minimal requirement for parking, which is associated a-priori by the respondents with higher rents.

The probability to select higher price thresholds increases with self-reported price knowledge, in accordance with existing literature (Rao and Sieben, 1992).

Respondents who have searched for an apartment more than four times within the five years prior to the survey are inclined to select lower price thresholds. Hence, lower price thresholds are related to the willingness to undergo the burden of searching a new apartment and moving.

Respondents living in the center of Israel state higher maximal prices. Since, on average, rents in the central region of Israel are higher than rents in the city of Haifa, the currently paid price possibly serves as a reference point for price threshold selection.

Higher propensity to retain only vacant apartments and apartments located in the neighborhood of Carmel increase the propensity to select higher price thresholds, reflecting the higher willingness to pay for higher quality products.

4.3.4 Utility maximization

As expected, the lower an apartment's rent, the greater the probability of renting it. Interaction terms of price with monthly expenses, price knowledge, apartment search experience, trip frequency to campus and current residential location are significant. The results of a likelihood ratio test show that the null hypothesis that the parameters of the interaction terms equal zero can be rejected at the 0.05 significance level (LR=48.16 > $\chi^2(9)=16.92$). Thus, differences among population groups should be accounted for at both the non-compensatory choice set formation stage and at the compensatory choice stage. The price interaction parameters show the same trends as their counterparts at the non-compensatory stage.

Structural features (size, balconies) and physical condition (renovation) of the apartment positively influence its attractiveness for students. Apartments located on lower floors are preferred, probably due to the scarcity of elevators in the two neighborhoods.

Security bars positively influence the propensity to rent the apartment. Thus, in the present study they are viewed as an apartment amenity rather than as a proxy of high crime levels. Parking availability increases the probability of renting an apartment. Respondents prefer fewer roommates and a non-smoking policy. Presumably, the latter preference stems from the high proportion (87.0%) of non-smoking respondents. The presence of solar water heating (a cost-efficient appliance), as well as air conditioning, which is an important amenity in the Mediterranean climate raise the attractiveness of the apartment.

Location-related amenities (proximity to the campus, low noise level and view) increase the probability of renting an apartment. The probability of renting an apartment decreases as the walking time to the campus increases. The description of an apartment as having a “stunning view” increases its attractiveness. The noise level is expressed in terms of the combination of street hierarchy (local street or main arterial) and the apartment orientation (rear or street facing). Rear apartments in local streets (the lowest noise level) raise the propensity of renting an apartment.

4.4. Comparison with the compensatory approach

To compare the semi-compensatory framework with the compensatory approach to residential choice modeling, a MNL model is estimated for the same data and presented in Table 3. The choice set for the MNL estimation is the total realm of 200 alternatives. Three MNL models are estimated. The first model includes only apartment attributes. The second model includes both apartment attributes and interaction terms of individual variables with apartment sharing, location and rent price, in parallel to the threshold models representing the non-compensatory conjunctive strategy in the semi-compensatory model. The third model is a restricted version of the second model, for testing the hypothesis that the coefficients of highly insignificant variables equal zero. In all the estimated MNL models, dummy variables account for intrinsic preference for vacant apartments located in Carmel, vacant apartments located in Neveshaanan and shared apartments located in Carmel versus shared apartments located in Neveshaanan as the base category.

McFadden's (1978) pseudo-R^2 measure, adjusted for the number of the estimated parameters, is separately calculated for each of the estimated models versus its respective null model, which assumes random probabilities. The goodness-of-fit of the models including interaction terms are better than the MNL including only apartment attributes (McFadden's adjusted R^2 equals 0.246 and 0.249 for the second and third model respectively versus 0.182 for the first model). The results of a likelihood ratio test show that the null hypothesis of the restricted model cannot be rejected at the 0.05 significance level ($LR=12.16 < \chi^2(17)=27.59$) and thus the third model is preferable over the second model in terms of parsimony. The goodness-of-fit of the proposed semi-compensatory model both without and with interaction terms (McFadden's adjusted R^2 equals 0.479 and 0.481 respectively) is by far superior in comparison with the MNL model including interaction terms.

The main difference of the proposed semi-compensatory model and the MNL is their treatment of the choice set, from which the choice is made. In the semi-compensatory model, alternatives that do not meet the price threshold are eliminated from further consideration at the choice stage. In the MNL the full universal realm is considered during the choice stage, although interaction terms account for intrinsic preferences regarding certain types of alternatives over other types. Thus, it is interesting to compare the estimated parameters of apartment attributes in the two models.

Since the observed choice process is semi-compensatory, the estimated parameters of apartment attributes in the semi-compensatory model are more precise estimates of the "true" parameters than the MNL model parameters. Considering both the semi-compensatory model with interaction terms and the MNL with interaction terms, the estimated parameters of the MNL that are not related to the search criteria are within less than a standard deviation of their semi-compensatory counterparts. The difference between the price parameters in the two models is 2.5 standard deviations. This difference is easily explainable. The price variable appears both in the non-compensatory stage and in the compensatory stage. While in the semi-compensatory model, it serves to eliminate alternatives and thus narrows the range of considered prices, in the MNL model the full price range is considered. As a result, the choice between alternatives within the full choice set expresses an increased sensitivity to price.

5. Summary and conclusions

The vast majority of discrete-choice models applied to residential choice are based on the assumption that individuals perform exclusively a compensatory evaluation process, namely utility maximization. Although attractive in terms of their computational tractability and reproduction of market shares, compensatory models have three limitations. First, they do not correspond to the actual human two-stage choice process, combining non-compensatory heuristics with compensatory evaluation, conducted in choice situations entailing many alternatives. Second, they assume that individuals are fully informed regarding each alternative, which is unrealistic when the universal realm of alternatives in extremely large. Third, the exogenous choice set formation conducted as a preliminary stage for model estimation in the compensatory approach, may lead to misspecification of individual choice sets and thus may result in inconsistent and biased parameters.

Semi-compensatory choice models representing a sequence of a non-compensatory strategy representing individual choice set formation followed by a compensatory strategy to finalize the choice are potentially more suitable for properly representing human behavior when faced with a choice task consisting of many alternatives. However, in the past, the reliance of semi-compensatory models solely on choice outcomes prevented their use for complex choice situations characterized by many alternatives such as residential choice.

This study presents a novel semi-compensatory model for modeling residential choice that relies on data regarding both criteria thresholds and choice outcomes, rather than relying solely on choice outcomes as customary. The unique data alleviates the complexity embedded in semi-compensatory models without the need for simplifying assumptions, thus allowing the estimation a semi-compensatory model for several search-criteria and a realistically large realm of several hundreds of alternatives. Hence, the proposed semi-compensatory model becomes a practical option for estimation in the area of residential choice.

The model is based on the realistic assumption that individuals rely on partial information in order to form the choice set and rely on detailed information at the choice stage. Specifically, individuals are aware of the general choice scope, namely “rental apartments”, delimited by the possible range of attribute values, but they are not informed about specific alternatives. Thus, the search process depends solely on individual intrinsic constraints and perceptions.

Data were collected by means of a web-based experiment and survey, which enabled the explicit and seamless recording of the two-stage semi-compensatory choice process and the gathering of information regarding individual characteristics, preferences and perceptions. In recent years, Internet real-estate databases are rapidly penetrating the real estate market a new information source for renters and buyers. The present study demonstrates their potential to provide suitable data for estimating semi-compensatory models for residential choice.

The estimated semi-compensatory model sheds light on rental apartment choice by students in the private rental sector. The three most frequently chosen search criteria are apartment sharing, apartment location and maximal rent price. The explanatory variables of the three criteria are individual socio-economic characteristics, latent preferences and perceptions. Apartment attributes that are important to students include structural features and physical conditions, number of roommates and their smoking attitudes, appliances that influence recurrent costs (solar water heater), air conditioning and location amenities.

Previously estimated semi-compensatory models assumed independence among the selected criteria thresholds. The current study reveals that, at least for residential choice, selected thresholds are hierarchically correlated. These correlations are related solely to the prior knowledge and intrinsic perceptions of the respondents, since information regarding the correlation among search-criteria was not provided during the experiment. Considering a hierarchical non-compensatory process, each criterion depends on its preceding criteria. Thus, the correlations are accounted for by adding dummy variables into the deterministic part of the function related to the threshold selection, according to the order of appearance of the criteria on the database-search web page.

The proposed semi-compensatory model includes price interaction terms at the compensatory stage in addition to individual characteristics as explanatory variables for price threshold selection at the non-compensatory stage. The results of a likelihood ratio test show that the null hypothesis that the parameters of the interaction terms equal zero can be rejected at the 0.05 significance level. Thus, individual characteristics influence both stages of the choice process and differences among population groups should be accounted for at both the non-compensatory choice set formation stage and at the compensatory choice stage, rather than in a single stage (either the compensatory or non-compensatory).

The goodness-of-fit of the proposed semi-compensatory model with and without interaction terms is (McFadden's adjusted R^2 equals 0.481 and 0.479 respectively) is by far superior in comparison with the MNL model both with and without interaction terms (McFadden's adjusted R^2 equals 0.249 and 0.182 respectively).

The main difference of the proposed semi-compensatory model and the MNL is their treatment of the choice set. In the semi-compensatory model, alternatives that do not meet the price threshold are eliminated, while in the MNL, the full universal realm of alternatives is considered, although interaction terms account for intrinsic preferences regarding certain types of alternatives over others. Thus, it is interesting to compare the estimated parameters of apartment attributes in the two models. Since the observed choice process is semi-compensatory, the estimated parameters of apartment attributes in the semi-compensatory model cab be considered as more precise estimates of the "true" parameters than the MNL model parameters. Considering both the semi-compensatory model with interaction terms and the MNL with interaction terms, the estimated parameters of apartment attributes in the MNL model that are not related to the search criteria are within less than a standard deviation of their counterparts in the semi-compensatory model. The difference between the price parameters in the two models is 2.5 standard deviations. This difference is easily explainable.

The price variable appears both in the non-compensatory stage and in the compensatory stage. While in the semi-compensatory model, it serves to eliminate alternatives and thus narrows down the range of considered prices, in the MNL model the full price range is considered. As a result, the choice between alternatives within the full choice set expresses an increased sensitivity to price. Thus, the results point to the existence of an upward bias in the price parameter of the compensatory model in comparison with the price parameter of the semi-compensatory model.

Further development of the current research may include application of the framework and methodology to different residential choice problems, such as purchase or rent transactions of different population sectors, as well as other spatial choice problems such as trip destination, recreational location, work location and firm location choice. Following the successful estimation of the proposed semi-compensatory model with data from a synthetic real-estate website, the next step is estimating similar models with data from commercial real-estate websites.

References

Abraham J.E, Hunt J.D (1997) Specification and estimation of nested logit model of home, workplaces, and commuter mode choices by multiple-worker households. Transp Res Rec 1606:17-24

Aitchison, J., Silvey, S.D. (1957) The generalization of probit analysis to the case of multiple responses. Biometrika 44: 131-140

Anas, A. (1981) The estimation of multinomial logit models of joint location and travel mode choice from aggregated data. J Reg Sci 21: 223-242

Andrews, R.L., Manrai, A.K. (1998) Feature based elimination: a model and empirical comparison. Eur J Oper Res 111: 248-267

Aptech systems (1994) Gauss User_s Manuals. Maple Valley.

Başar, G., Bhat C.R. (2004) A Parameterized Consideration Set Model for Airport Choice: Application to the San Francisco Bay Area. Transp Res Part B 38: 889-904

Ben-Akiva, M.E., Boccara, B. (1995) Discrete choice models with latent choice sets. Int J Res Market 12: 9-24

Ben-Akiva, M.E., Bowman, J.L. (1998) Integration of an activity-based model system and a residential location model. Urban Stud 35: 1131-1153

Bhat, C.R., Guo, J. (2004) A mixed spatially correlated logit model: formulation and application to residential choice modeling. Transp Res Part B 38: 147-168

Bhat, C.R., Guo, J. (2007) A comprehensive analysis of built environment characteristics on household residential choice and auto ownership levels. Transp Res Part B 41: 506-526

Borgers, A., Timmermans, H., Veldhuisen, J. (1986) A hybrid compensatory-non-compensatory model for residential preference structures. J Hous Built Environ 1: 227-234

Cantillo, V., Heydecker, B., Ortuzar, J.d.D. (2006) A discrete choice model incorporating thresholds for perception in attribute values. Transp Res Part B 40: 807–825.

Cantillo, V., Ortuzar, J.d.D. (2005) A semi-compensatory choice model with explicit attribute-thresholds of perception. Transp Res Part B 39: 641-657

Central Bureau of Statistics (2005a) Demographic characteristics of university candidates, students and graduates - Table 22: Student Population by Degree, Age and Field of Stududies. http://www.cbs.gov.il/www/publications/educ_demog_05/educ_demog_h.htm (accessed October 15, 2007).

Central Bureau of Statistics(2005b) Living arrangements of young adults in Israel in 2000 by demographic and socio-economic characteristics - Working paper No. 17 of the demography sector. http://www.cbs.gov.il/www/publications/pwmegurim17.pdf (accessed October 15, 2007).

Central Bureau of Statistics (2006) Students in universities and other higher-education institutes - Table 5: percent of women in the student population by degree, field of study and institution. http://www.cbs.gov.il/www/publications/stud_04/stud_h.htm (accessed October 15, 2007).

Charbonneau, P., Johnson, L.C., Andrey, J. (2006) Characteristics of university student housing and implications for urban development in mid-sized cities. Can J Urban Res 15: 278-300

Chattopadhyay, S. (2000) The effectiveness of McFadden's nested logit model in valuing amenity improvement. Reg Sci Urban Econ 30: 23-43

Cho, C.J. (1997) Joint Choice of Tenure and Dwelling Type: A Multinomial Logit Analysis for the City of Chongju. Urban Stud 34: 1459- 1473

Deng Y., Ross, S.L, Wachter S.L (2003) Racial differences in homeownership: the effect of residential location. Reg Sci Urban Econ 33: 517-556

Earnhart, Dietrich (2002) Combining Revealed and Stated Data to Examine Housing Decisions Using Discrete Choice Analysis. J Urban Econ 51: 143-169

Freedman O., Kern C.R. (1997) A Model of Workplace and Residential Choice in Two-Worker Households. Reg Sci Urban Econ 27: 241-260

Friedman, J. (1981) Conditional logit model of the role of local public services in residential choice. Urban Stud18: 347-358

Furnham, A.(1984) Many sides of the coin: the psychology of money usage. Pers Indiv Differ 5: 501-509

Gabriel, S., Rosenthal, S. (1989) Household location and race: estimates of a multinomial logit model. Rev Econ Stat 71: 240-249

Galilea, Patricia and Juan de Dios Ortúzar (2005) Valuing noise level reductions in a residential location context Transp Res Part D 10: 305-322

Barrios-Garcıá J. A. and José Enrique Rodriguez-Hernández (2007) Housing and urban location decisions in Spain: an econometric analysis with unobserved heterogeneity. Urban Stud 44: 1657–1676

Gensch, D.H. (1987) A two-stage disaggregate attribute choice model. Market Sci 6: 223-231

Goritz, A.S. (2004) The impact of material incentives on response quantity, response quality, sample composition, survey outcome, and cost in online access panels. Int J market Res 46: 327-345

Handy, S., Cao, X., Mokhtarian, P.L. (2006) Self-selection in the relationship between the built environment and walking. J Am Plan Assoc72: 55-74

Horowitz J. L (1991) Modeling the choice of choice set in discrete-choice random-utility models Environ Plann A 23: 1237-1246

Hunt J.D, McMillan J.D.P, Abraham, J.E (1994) Stated preference investigation of influences on attractiveness of residential locations Transp Res Rec 1466: 79-87

Lerman, S.R. (1976) Location, housing, automobile ownership, and mode to work: a joint choice model. Transp Res Rec 610: 6-11

Levine, J. (1998) Rethinking Accessibility and Job-Housing Balance J Am Plan Assoc 64: 133-149

Lichtenstein, D.R., Ridgway, N.M., Netemeyer, R.G. (1993) Price perceptions and consumer shopping behavior: a field study. J market Res 30: 234-245

Louviere, J., 1979. Modeling individual residential preferences: a totally disaggregate approach. Transp Res Part A 13: 373–384

Lussier, D. A., Olshavsky R. W. (1979), Task Complexity and Contingent Processing Brand Choice. J Consum Res 6: 154-65

Maddala, G.S. (1983) Limited-Dependent and Qualitative Variables in Econometrics. New York: Cambridge University Press.

Manski, C.F. (1977) The structure of random utility models. Theor Decis 8: 229–254

McFadden, D. (1978) Modelling the choice of residential location. In: Karlqvist, A., Lundqvist, L., Snickars, F., Weibull, J. (Eds.), Spatial Interaction Theory and Planning Models, Amsterdam: North-Holland: 75-96

Mokhtarian, P.L., Bagley, M.N. (2000) Modeling employees' perceptions and proportional preferences of work locations: the regular workplace and telecommuting alternatives. Transp Res Part A 34: 223-242

Monroe, K.B. (1971) Measuring price thresholds by psychophysics and latitudes of acceptance. J market Res 8: 460-464

Morikawa, T. (1995) A hybrid probabilistic choice set model with compensatory and non-compensatory choice rules. Proceedings of the 7th World Conference on Transport Research, Sydney, Australia.

Nechyba Thomas J., Robert P. Strauss (1998) Community Choice and Local Public Services: A Discrete Choice Approach. Reg Sci Urban Econ 28: 51-73

Payne, J.W. (1976) Task complexity and contingent processing in decision making: an information search and protocol analysis. Organ Behav Hum Perform 16: 366-387

Prashker J, Shiftan, Y and Hershkovitch-Sarusi, P. (2008) Residential choice location, gender and the commute trip to work in Tel Aviv. J Transp Geogr 16: 332-341

Quigley J.M (1976) Housing demand in the short run: an analysis of polytomous choice. Explor Econ Res 3: 76-102

Quigley, J.M. (1985) Consumer choice of dwelling neighborhood and public services. Reg Sci Urban Econ 15: 41-63

Rapaport C. (1997) Housing Demand and Community Choice: An Empirical Analysis. J Urban Econ 42: 243-260

Rao, A.R., Sieben, W.A. (1992) The effects of prior knowledge on price acceptability and the type of information examined. J Consum Res 19: 256-270

Rugg, J., Rhodes, D., Jones, A. (2002) Studying a niche market: UK students and the private-rented sector. Hous Stud 17: 289-303

Sermons, W.M., Koppelman, F.S. (2001) Representing the differences between female and male commute behavior in residential location choice models. J Transp Geogr 9: 101-110

Sermons W. M., Seredich, N. (2001) Assessing traveler responsiveness to land and location based accessibility and mobility solutions Transp Res Part D 6: 417-428

Shiftan, Yoram (2008) The Use of Activity-Based Modeling to Analyze the Effect of Land-Use Policies on Travel Behavior. Ann Reg Sci 42: 79-97

Shocker, A.D., Ben-Akiva, M., Boccara, B., Nedungadi, P. (1991) Consideration set influences on consumer decision-making and choice: issues, models and suggestions. Market Lett 2:3: 187-197

Skaburskis, A. (1999) Modelling the Choice of Tenure and Building Type Urban Stud 36: 2199- 2215

Stopher P., (1980) Captivity and choice in travel-behavior models Transp J of ASCE 106: 427-435

Swait, J., Ben-Akiva, M. (1987) Incorporating random constraints in discrete choice models of choice set generation. Transp Res Part B 21B: 91-102

Swait, J. A. (2001) Non-compensatory choice model incorporating attribute cut-offs. Transp Res Part B 35: 903-928

Tu, Y., Goldfinch J. (1996) A Two-stage Housing Choice Forecasting Model. Urban Stud 33: 517-537

Tversky, A. (1972) Elimination by aspects: a theory of choice. Psychol Rev 79: 281-299

Waddell, P. (1996) Accessibility and residential location: the interaction of workplace, residential mobility, tenure and location choices. Presented at the Lincoln Land Institute TRED Conference, Boston, USA.

Weisbrod, G.E., Lerman, S.R., Ben-Akiva, M.E. (1980) Trade-offs in residential location decisions: transportation versus other factors. Transp Policy Decis Mak 1: 13-26

Williams H., Ortúzar J. (1982) Behavioral theories of dispersion and misspecification of travel demand models. Transp Res B 16B, PP. 167-219

Yates, J., Mackay, D.F. (2006) Discrete choice modeling of urban housing markets: a critical review and an application. Urban Stud 43: 559-581

Zheng, J., Guo, J.Y. (2008) A destination choice model incorporating choice set formation. Proceedings of the 87th Transportation Research Board Annual Meeting, Washington, D.C., USA.

Table 1

Sample characteristics

VARIABLE	CATEGORIES (%)				
GENDER	Male	Female			
	60.7	39.3			
MARITAL STATUS	Married	Single			
	29.8	70.2			
DEGREE OF STUDIES	B.Sc.	M.Sc.	Ph.D.		
	46.8	34.2	19.0		
AGE	≤ 21	22-24	25-29	30-34	35-44
	7.4	21.4	49.3	18.2	3.6
INCOME SOURCE	Scholarship	Full-time	Part-time	None	
	44.8	12.2	23.9	19.0	
MONTHLY EXPENSES	≤ $500	$500-$1000	$1000-$1500	≥ $1500	No response
	39.1	28.8	15.4	12.8	3.8
RESIDENTIAL ARRANGEMENT	Dorms	Rent alone	Rent with roommates	Co-habit with spouse	Parent's house
	33.4	5.9	12.7	36.8	11.3
APARTMENT SEARCH EXPERIENCE	None	Once	2-3 times	≥ 4 times	
	17.0	34.4	41.0	7.6	
PLACE OF RESIDENCE	Haifa	Northern Israel	Central Israel	Other	
	75.1	13.8	7.9	3.2	
CAR AVAILABILITY	Everyday	2-3 times a week	Once a week	2-3 times a month	Rarely
	42.5	11.6	11.6	7.1	27.3

Table 2

Proposed semi-compensatory model estimation results

VARIABLE	DESCRIPTION/CATEGORIES	SEMI COMPENSATORY MODEL WITHOUT INTERACTION TERMS		SEMI COMPENSATORY MODEL WITH INTERACTION TERMS	
		parameters	t-statistic	parameters	t-statistic
APARTMENT'S SHARING THRESHOLD					
Marital status	Single (base category)	-	-	-	-
	Married	1.257	5.21	1.257	5.13
Gender	Female (base category)	-	-	-	-
	Male	-0.518	-3.45	-0.517	-3.41
Age	Years	0.020	1.83	0.020	1.82
Car availability	Monthly/weekly (base category)	-	-	-	-
	Daily	0.391	2.48	0.391	2.44
Trip frequency to campus	Monthly/weekly (base category)	-	-	-	-
	Daily	-0.414	-2.76	-0.415	-2.74
On-campus studying to benefit from teacher-student communication		-0.124	-2.63	-0.124	-2.63
Monthly expenses	< $750 (base category)	-	-	-	-
	$750- $1000	0.503	2.06	0.504	2.07
	$1000-$1750	0.605	2.79	0.606	2.75
Current residential arrangement	Dormitories (base category)	-	-	-	-
	Parents	-	-	-	-
	Roommates	-0.646	-3.14	-0.647	-3.12
	Alone	0.793	2.64	0.792	2.63
	Spouse	0.986	5.15	0.986	5.17
Current residential location	City of Haifa	-	-	-	-
	Suburban cities of Haifa	-0.610	-1.75	-0.610	-1.71
	Northern outskirts of Haifa	-0.917	-3.84	-0.918	-3.81
	Center of Israel	-	-	-	-
LOCATION THRESHOLD					
Price-quality ratio consciousness		-0.290	-4.44	-0.290	-4.41
Age	Years	0.031	1.92	0.031	1.91
Car availability	Monthly/weekly (base category)	-	-	-	-
	Daily	0.410	2.45	0.410	2.43
Faculty location	Main campus (base category)	-	-	-	-
	Medicine campus	0.472	1.70	0.472	1.66
Monthly expenses	< $750 (base category)	-	-	-	-
	$750 – $1500	0.243	1.70	0.244	1.29
	> $1500	0.479	2.20	0.479	2.15
Income source	No income / Scholarship (base category)	-	-	-	-
	Part time job	-0.385	-1.92	-0.385	-1.90
	Full time job	-	-	-	-
Difference in job opportunities between Carmel and Neveshanan		0.083	1.99	0.083	1.96

Difference in green space availability between Carmel and Neveshanan		0.211	4.15	0.211	4.12
Preference to study on campus in order to increase the study efficiency		-0.133	-3.21	-0.133	-3.16
Trip frequency to campus	Monthly/weekly (base category)	-	-	-	-
	Daily	-0.286	-1.87	-0.286	-1.80
Dummy variable for retaining only vacant apartments		0.639	3.21	0.638	3.21
PRICE THRESHOLD					
Marital status	Single (base category)	-	-	-	-
	Married	0.388	2.57	0.377	2.47
Monthly expenses	< $500 (base category)	-	-	-	-
	$500– $750	0.288	2.33	0.313	2.52
	$750-$1500	0.366	2.66	0.363	2.59
	>$1500	0.640	3.45	0.641	3.51
Price-knowledge factor		0.124	3.78	0.120	3.67
Apartment search experience	None (base category)	-	-	-	-
	1-3 apartment changes	-	-	-	-
	More than 4 apartment changes	-0.508	-2.32	-0.427	-1.91
Trip frequency to campus	Monthly/weekly (base category)	-	-	-	-
	Daily	-0.342	-3.41	-0.376	-3.63
Current residential arrangement	Dormitories (base category)	-	-	-	-
	Roommates	-	-	-	-
	Alone / parents	-	-	-	-
	Spouse	0.339	2.46	0.348	-2.55
Current residential location	City of Haifa	-	-	-	-
	Suburban cities of Haifa	-	-	-	-
	Northern outskirts of Haifa	-	-	-	-
	Center of Israel	0.476	3.40	0.460	3.32
Dummy variables for retaining a combinations of location and apartment sharing	Shared apartment in Neveshanan (base category)	-	-	-	-
	Vacant apartment in Carmel	1.885	9.08	1.844	8.89
	Vacant apartment in Neveshanan	1.355	9.65	1.315	9.43
	Shared apartment in Carmel	1.193	4.41	1.097	3.77
Cut-off points	$200 (base category)	-	-	-	-
	$250	-0.235	-1.788	-0.527	-3.83
	$350	0.263	2.002	0.182	1.35
	$350	0.601	4.45	0.540	3.91
	$400	0.860	6.40	0.793	5.68
	$450	1.375	9.85	1.250	8.72
	$500	1.891	13.26	1.798	12.22
	$550	2.551	17.85	2.443	16.39
	$600	2.802	19.28	2.731	18.13
	$650	3.187	21.24	3.113	20.30
	$700	3.340	21.75	3.264	20.72
CHOICE STAGE					
APARTMENT ATTRIBUTES					
Price		-0.004	-4.56	-0.014	-5.50

Size (square meters)		0.034	9.23	0.036	9.44
Number of roommates		-0.740	-4.36	-0.890	-5.09
Walking time to campus		-0.073	-8.08	-0.073	-7.95
Quiet apartment		1.438	13.89	1.387	13.03
Parking		0.398	3.03	0.370	2.76
Floor		-0.194	-4.16	-0.145	-3.00
Gallery		0.177	2.54	0.126	1.78
Smoking allowed		-0.345	-2.25	-0.285	-1.83
Bars		0.331	3.45	0.380	3.78
View		0.465	4.13	0.431	3.77
Renovated		0.751	6.93	0.729	6.62
Air condition		0.617	5.81	0.681	6.31
Solar water heater		0.606	4.10	0.539	3.55
INTERACTION WITH PRICE (VARIABLE * PRICE)					
Marital status	Single (base category)	-	-	-	-
	Married	-	-	0.002	1.28
Monthly expenses	< $500 (base category)	-	-	-	-
	$500– $750	-	-	0.008	3.54
	$750-$1500	-	-	0.004	1.58
	>$1500	-	-	0.008	3.35
Price-knowledge factor		-	-	0.002	4.24
Apartment search experience	None (base category)	-	-	-	-
	1-3 apartment changes	-	-	-	-
	More than 4 apartment changes	-	-	-0.002	4.24
Trip frequency to campus	Monthly/weekly (base category)	-	-	-	-
	Daily	-	-	-0.004	-2.81
Current residential arrangement	Dormitories (base category)	-	-	-	-
	Roommates	-	-	-	-
	Alone / parents	-	-	-	-
	Spouse	-	-	0.005	2.88
Current residential location	City of Haifa	-	-	-	-
	Suburban cities of Haifa	-	-	-	-
	Northern outskirts of Haifa	-	-	-	-
	Center of Israel	-	-	-0.001	-0.64
Number of observations		631		631	
Number of parameters		61		70	
Log-likelihood at zero		-6831.62		-6831.62	
Log-likelihood at estimates		-3498.54		-3474.47	
McFadden’s adjusted R^2		0.479		0.481	

Table 3

MNL Model estimation results

VARIABLE	DESCRIPTION/CATEGORIES	MNL WITHOUT INTERACTION TERMS		MNL WITH INYERACTION TERMS 1		MNL WITH INYERACTION TERMS 1	
		parameter	t-statistic	parameter	t-statistic	parameter	t-statistic
INTERACTION WITH APARTMENT SHARING (VARIABLE * VACANT)							
Marital status	Single (base category)	-	-	-	-	-	-
	Married	-	-	-0.337	-1.14	-	-
Gender	Female (base category)	-	-	-	-	-	-
	Male	-	-	-0.176	-0.35	-	-
Age	Years	-	-	0.053	2.77	0.037	2.47
Car availability	Monthly/weekly (base category)	-	-	-	-	-	-
	Daily	-	-	0.007	0.02	-	-
Trip frequency to campus	Monthly/weekly (base category)	-	-	-	-	-	-
	Daily	-	-	-0.544	-1.00	-	-
On-campus studying to benefit from teacher-student communication		-	-	-0.204	-2.66	-0.172	-2.34
Monthly expenses	< $750 (base category)	-	-	-	-	-	-
	$750- $1000	-	-	-0.128	-0.34	-	-
	$1000-$1750	-	-	-0.203	-0.60	-	-
Current residential arrangement	Dormitories (base category)	-	-	-	-	-	-
	Parents	-	-	-	-	-	-
	Roommates	-	-	-0.204	-2.66	-	-
	Alone	-	-	-0.213	-0.54	-	-
	Spouse	-	-	0.128	0.34	-	-
Current residential location	City of Haifa	-	-	-	-	-	-
	Suburban cities of Haifa	-	-	0.544	0.99	-	-
	Northern outskirts of Haifa	-	-	-0.213	-0.54	-	-
	Center of Israel	-	-	-	-	-	-
INTERACTION WITH LOCATION (VARIABLE * CARMEL)							
Price-quality ratio consciousness		-	-	-0.359	-3.17	-0.365	-3.28
Age	Years	-	-	0.164	3.55	0.182	4.60
Car availability	Monthly/weekly (base category)	-	-	-	-	-	-
	Daily	-	-	0.842	2.95	0.890	3.21
Faculty location	Main campus (base category)	-	-	-	-		
	Medicine campus	-	-	0.873	1.93	0.925	2.10
Monthly expenses	< $750 (base category)	-	-	-	-	-	-
	$750 – $1500	-	-	0.196	0.59	-	-
	> $1500	-	-	0.168	0.42	-	-
Income source	No income / Scholarship (base category)	-	-	-	-	-	-

	Part time job	-	-	-0.438	-1.14		
	Full time job	-	-	-	-	-	-
Difference in job opportunities between Carmel and Neveshanan		-	-	0.173	2.33	0.169	2.32
Difference in green space availability between Carmel and Neveshanan		-	-	0.373	4.28	0.384	4.52
Preference to study on campus in order to increase the study efficiency		-	-	-0.184	-1.93	-0.190	-2.69
Trip frequency to campus	Monthly/weekly (base category)	-	-	-	-	-	-
	Daily	-	-	-0.226	-0.80	-	-
INTERACTION WITH PRICE (VARIABLE * PRICE)							
Marital status	Single (base category)	-	-	-	-	-	-
	Married	-	-	0.006	4.58	0.006	4.62
Monthly expenses	< $500 (base category)	-	-	-	-	-	-
	$500– $750	-	-	0.004	3.92	0.004	3.89
	$750-$1500	-	-	0.006	3.52	0.006	3.48
	>$1500	-	-	0.006	3.45	0.006	4.47
Price-knowledge factor		-	-	0.001	1.43	0.001	1.52
Apartment search experience	None (base category)	-	-	-	-	-	-
	1-3 apartment changes	-	-	-	-	-	-
	More than 4 apartment changes	-	-	-0.002	-0.77	-	-
Trip frequency to campus	Monthly/weekly (base category)	-	-	-	-	-	-
	Daily	-	-	-0.002	-2.09	-0.002	-2.44
Current residential arrangement	Dormitories (base category)	-	-	-	-	-	-
	Roommates	-	-	-	-	-	-
	Alone / parents	-	-	-	-	-	-
	Spouse	-	-	0.006	5.78	0.007	6.24
Current residential location	City of Haifa	-	-	-	-	-	-
	Suburban cities of Haifa	-	-	-	-	-	-
	Northern outskirts of Haifa	-	-	-	-	-	-
	Center of Israel	-	-	0.002	1.24	-	-
INTRINSIC PREFERENCES FOR COMBINATIONS OF LOCATION AND APARTMENT SHARING							
Shared apartment in Neveshanan (base category)		-	-	-	-	-	-
Vacant apartment in Carmel		7.121	6.76	5.057	2.67	4.468	2.57
Vacant apartment in Neveshanan		0.717	1.79	1.006	2.38	1.000	2.46
Shared apartment in Carmel		4.954	4.77	3.453	1.80	2.832	1.62
APARTMENT CHARACTERISTICS							
Price		-0.011	-12.67	-0.021	-12.03	-0.025	-12.76
Size (square meters)		0.035	9.98	0.036	9.99	0.036	10.08
Number of roommates		-0.748	-4.70	-0.953	-5.53	-0.949	-5.75
Walking time to campus		-0.071	-8.01	-0.070	-7.23	-0.070	-7.86
Quiet apartment		1.414	14.32	1.352	13.23	1.351	13.44
Parking		0.343	2.74	0.296	2.23	0.294	2.28
Floor		-0.188	-4.19	-0.114	-2.38	-0.114	-2.44

Gallery	0.173	2.61	0.104	1.46	0.100	1.48
Smoking allowed	-0.293	-1.98	-0.233	-1.43	-0.225	-1.41
Bars	0.368	4.02	0.420	4.21	0.417	4.29
View	0.392	3.65	0.373	3.33	0.370	3.36
Renovated	0.700	6.75	0.661	5.83	0.663	6.22
Air condition	0.634	6.23	0.698	6.63	0.696	6.72
Solar water heater	0.551	3.87	0.493	3.06	0.484	3.06
Number of observations	631		631		631	
Number of parameters	17		50		33	
Log-likelihood at zero	-3343.24		-3343.24		-3343.24	
Log-likelihood at estimates	2717.87		-2470.40		-2476.48	
McFadden’s adjusted R^2	0.182		0.246		0.249	

Figure 1

Proposed semi-compensatory model framework vs. the traditional compensatory approach

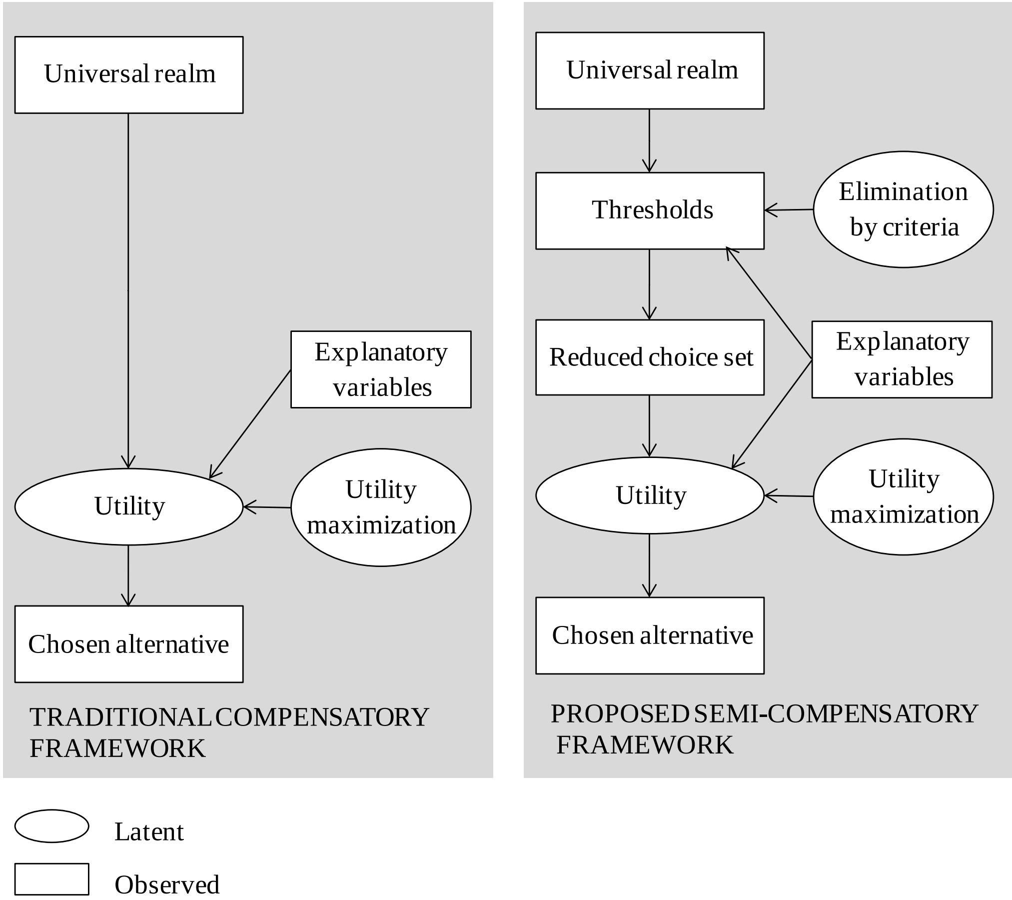
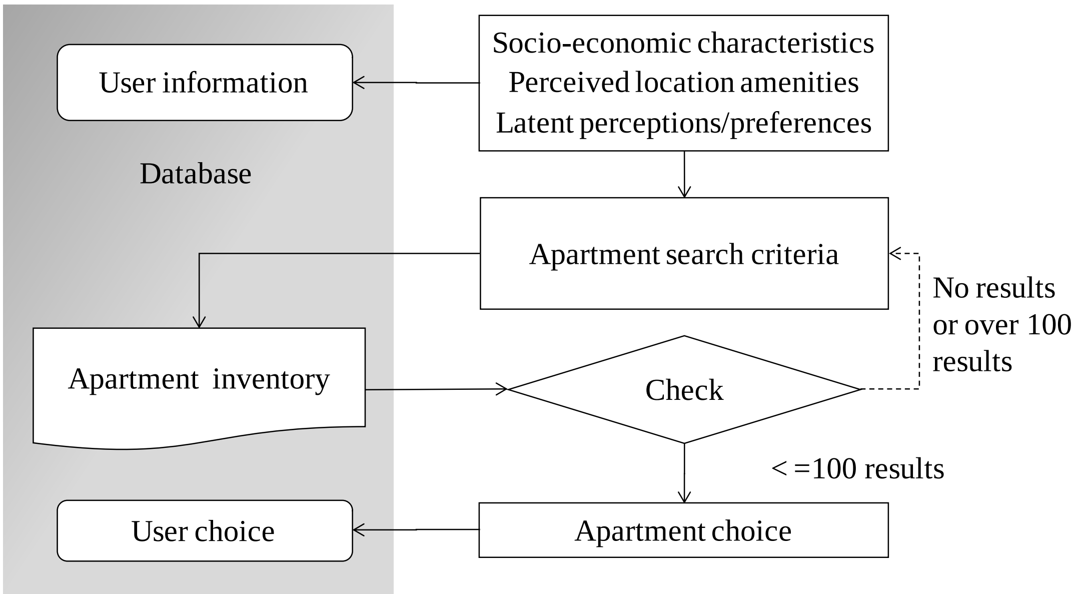


Figure 2

Internet website structure



The figure is not consistent with the text.

Figure 3

Web-page for the database search task in the Survey

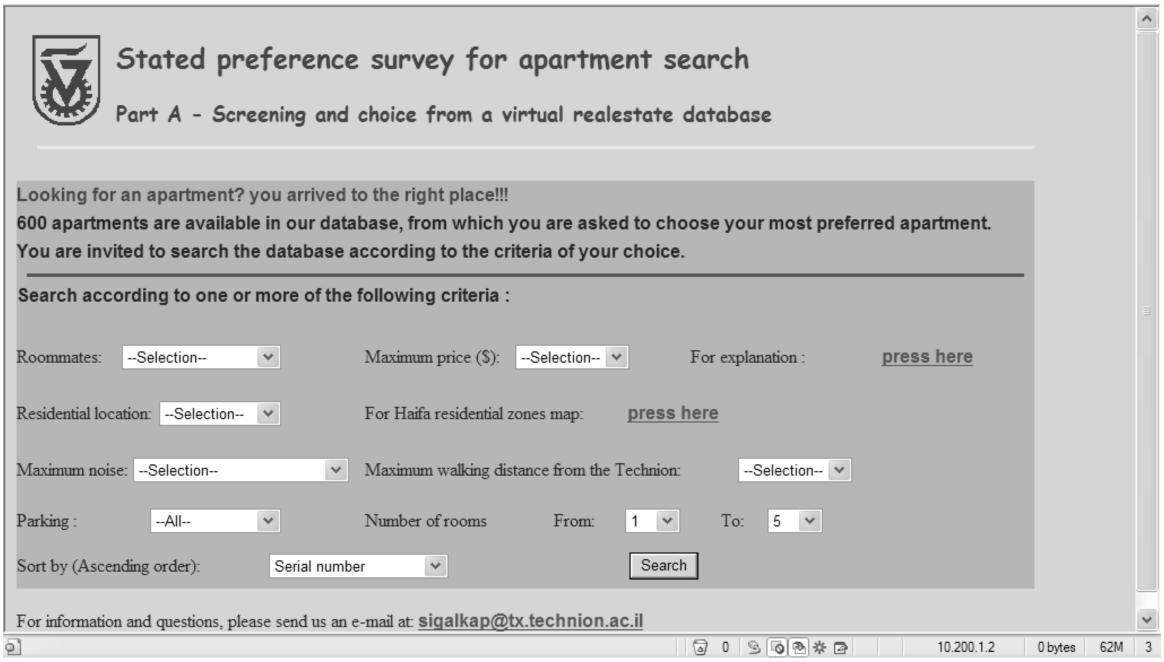


Figure 4

Price threshold distribution