Analyzing heterogeneity in conjoint estimates of residential preferences

Citation for published version (APA):

Molin, E. J. E., Oppewal, H., & Timmermans, H. J. P. (2001). Analyzing heterogeneity in conjoint estimates of residential preferences. *Journal of Housing and the Built Environment*, 16(3-4), 267-284.
<https://doi.org/10.1023/A:1012539415696>, <https://doi.org/10.1007/s10924-008-0111-x>

DOI:

[10.1023/A:1012539415696](https://doi.org/10.1023/A:1012539415696)
[10.1007/s10924-008-0111-x](https://doi.org/10.1007/s10924-008-0111-x)

Document status and date:

Published: 01/01/2001

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Analyzing heterogeneity in conjoint estimates of residential preferences

ERIC J.E. MOLIN¹, HARMEN OPPEWAL² and HARRY J.P. TIMMERMANS³

¹Assistant Professor of Transport Policy and Logistics Organization, Delft University of Technology, The Netherlands; ²Professor of Retail Management, School of Management Studies, University of Surrey, U.K.; ³Professor of Urban Planning, Eindhoven University of Technology, The Netherlands

Received September 2000; Accepted June 2001

Abstract. Conjoint estimates of residential preferences are typically based on aggregate responses. For reasons of segmentation or to differentiate between non-significant housing attributes and attributes that are characterized by conflicting preferences, further analysis is required. In this paper, the heterogeneity in the conjoint estimates of residential preferences of families is analyzed. It is examined how the estimated part-worth utilities of the housing attributes are related to the socio-economic variables and current housing attributes by applying regression analysis. Although the explained variance was rather low, suggesting that residential preferences of families are highly idiosyncratic, the relationships that were significant could be interpreted well.

Key words: conjoint analysis, group decision-making, heterogeneity, hierarchical information integration, residential preferences

1. Introduction

Insight in residential preferences of (potential) dwellers is often of crucial importance for local planning authorities, housing associations, and development companies to assess or predict the likely consequences of their policies, plans, or investments. If this point of view is accepted, the question then becomes how to measure residential preferences in such a way that stakeholders in the housing market can ex-ante evaluate their actions. To that effect, various modeling approaches have been proposed and applied in housing research (e.g., Timmermans et al., 1994), one of the most promising of which is the conjoint analysis approach (e.g. Knight and Menchik, 1976; Louviere, 1979; Boag and Sarkar, 1984; Phipps and Carter, 1984, 1985; Veldhuisen and Timmermans, 1984; Joseph, et al., 1989; Phipps, 1989; Louviere and Timmermans, 1990; Timmermans et al., 1992; Timmermans

and van Noortwijk, 1995; Timmermans et al., 1996; van de Vyvere et al., 1998; Molin, 1999; Molin et al., 1996, 1997, 1999, 2000).

Conjoint analysis is an approach that attempts to describe and predict preferences of decision-makers (dwellers) from their responses to hypothetical residential profiles that can be viewed as integral descriptions of housing situations (characteristics of the house, the environment, etc.). Typically, respondents are requested to express a rating for the overall attractiveness of each residential profile (e.g., Molin et al., 1997). Because each respondent provides judgment responses to a series of profiles that are carefully constructed, one can statistically estimate a model of residential preference. The parameters of this estimated utility function indicate the (part-worth) utility the respondent derives from each attribute characterizing potential housing.

Conjoint estimates of residential preferences are typically based on aggregate responses. One of the main reasons for this practice is that the experimental task soon becomes too demanding for individual respondents. To address this problem of information overload, the residential profiles are typically allocated across respondents in some balanced way, and an *aggregate* model is estimated. As long as the interest is focused on average responses, there is nothing wrong with this practice. However, if the stakeholders are interested in possible segmentation, this practice represents a potential problem. There is also a theoretical issue. Reliance on aggregate responses implies that the researcher cannot differentiate between non-significant housing attributes and attributes that are characterized by conflicting preferences. What would be required is an additional analysis that explores heterogeneity in the estimated part-worth utilities of the housing attributes.

This line of research is pursued in the present article. To the best of our knowledge, this is the first attempt of this line of analysis, trying to find out whether conjoint estimates of residential preferences are strongly associated with socio-demographic variables or whether they are idiosyncratic. This study also differs in another important respect from most conjoint-based studies of residential preferences. Conjoint models are typically estimated from *individuals'* responses to hypothetical residential profiles. However, this practice ignores the fact that many households consist of more than one person, who may have conflicting or at least diverging residential preferences. Several studies (e.g. Davis and Rigeaux, 1974; Munsinger et al., 1975) have shown that in a large majority of families members make joint decisions on important issues such as housing. Thus, conventional conjoint analysis as typically applied in housing studies may have the potential drawback that the unit of observation in the data collection process is not the actual unit of

decision-making, which may result in invalid measurements. An alternative measurement approach that reflects the joint decision-making process is to bring family members together and ask them to jointly respond to residential profiles. In these group tasks, family members have the opportunity to exchange information about the interpretation of the questions, learn about mutual preferences, and if relevant, try to change particular preferences. Hence, group tasks potentially simulate interaction processes that typically occur in real-world decision-making processes, and hence may result in higher validity.

Hence, in this article the possible relationships between residential preferences as derived from a group-based conjoint analysis and background variables are analyzed. To that effect, the estimated parameters of each individual family are treated as the dependent variables in multiple regression analysis.

This article is organized as follows. First, the conjoint group modeling approach is discussed. This is followed by a description of the research design and measurement procedures. Then, the average family model of residential preference is presented and discussed. We then continue by presenting the main results of the present study, the results of the regression analysis that examines whether the variation in family residential part-worths is systematically related to their socio-demographic characteristics. Finally, some conclusions are drawn.

2. The conjoint group modeling approach

2.1 Principles of conventional conjoint analysis

Conjoint analysis has been developed as an alternative to direct measurement of preferences or utility in which respondents are asked to express their preference or evaluation of separate attributes of the choice alternatives of interest and possibly also to express the relative importance weights of the selected attributes. Although this measurement approach has been and in fact still is quite popular, evidence has been accumulated over the years suggesting that this simple approach likely produces invalid and biased estimates of residential preferences (e.g., Green et al., 1982; Akaah and Korgaonkar, 1983; Timmermans, 1984). The essence of conjoint analysis is that overall preferences are measured, not calculated or composed, for bundles of attributes, called profiles. That is, respondents have to trade-off the attributes to arrive at an overall evaluation of a profile. Because the profiles are constructed according to the principles of the design of statistical experiments, the overall evaluations can be easily and efficiently decomposed into the part-worth

utility contributions of the attribute levels. These part-worth utilities express the preference or utility of the attribute levels and the range of these estimated utilities is used as an estimate of the importance of the corresponding attribute.

The construction of conjoint models involves the following steps. First, the attributes assumed to influence housing preference are elicited. Next, the levels or categories for each attribute are identified. For example, let us assume, for the sake of simplicity, that tenure, costs, number of rooms, and size of the backyard are influencing housing choice. Tenure can be operationalized as owner-occupied and rent. We could identify four categories for costs (say Nlg 600, 900, 1200, 1500 per month); similarly we could differentiate between 2, 3, 4 and 5 rooms, and between a backyard that is 5, 10, 15, 20 meters deep.

The next step involves combining these attribute levels according to some experimental design to create housing profiles. For example, one combination would be: rent, two bedrooms, Nlg 600, and 5-meters deep backyard. The total number of combinations in this example would be $2 \times 4^3 = 128$. It should be evident that the total number of possible profiles rapidly increases with an increasing number of attributes and/or attribute levels. A full factorial design involves all possible combinations and allows one to estimate all contributions of (combinations) of attribute levels to housing preference. However, it will often not be feasible or it would be too demanding for a respondent to present all combinations of attribute levels. Therefore, typically a fractional factorial design, involving an orthogonal subset of all combinations, is presented to respondents. (For an introduction to constructing fractional factorial designs we refer to Steenkamp, 1985, in Dutch.) For example, one could present only 16 profiles (1/8 fraction). While the use of a fractional factorial design increases the feasibility and reliability of the task, it comes at a cost: one has to assume that all higher-order interaction effects are negligible. That is to say, one assumes that the overall preference for a housing or residential profile is the sum of the effects of the individual attributes only; any combination of attribute levels is assumed not to have any significant effect beyond the contributions of the individual attribute levels.

Once the profiles are constructed, individuals are requested to evaluate each profile in a ranking or rating task, often in terms of the overall preference. The preference function can then be estimated, for example, by using regression analysis (Timmermans, 1984). Examples of conjoint models based on rating or ranking tasks can be found in Knight and Menchik (1976), Louviere (1979), Boag and Sarkar (1984), Phipps and Carter (1984, 1985), Veldhuisen and Timmermans (1984), Joseph et al. (1989), Phipps (1989), Molin (1999), and Molin et al. (1997, 1999, 2000).

2.2 A conjoint group modeling approach based on integrated HII experiments

The principles described in the previous section refer to a standard, basic conjoint model of residential preferences. As stated in the introduction, in this study we developed a group-based conjoint model. More specifically, the estimated model can be viewed as an extension to group preference formation of Integrated Hierarchical Information Integration (IHII; Oppewal et al., 1994) which is based on the Hierarchical Information Integration (HII) approach (Louviere, 1984). HII assumes that if decision-makers are confronted with complex decision problems, involving a large number of attributes, they group the attributes that belong together into higher-order decision constructs. They first form evaluations for each decision construct and then integrate these evaluations to arrive at overall preferences for decision alternatives. IHII is also based on these assumptions but requires the construction of a subexperiment for each decision construct, which varies the attributes that define a decision construct, to which the summarizing construct evaluations of the other decision constructs are added.

Figure 1 presents our extension of the IHII model. In particular, it describes the structure of these subexperiments for the case of two decision constructs. In this Figure, X_{kij} denotes the k -th attribute level belonging to decision construct i of decision alternative j , G_{nij} denotes the evaluation of decision construct i of individual group member n , and V_j is the overall utility of decision alternative j . The figure makes it clear that in subexperiment one, the profiles are formed by attribute level combinations of the first decision construct, to which group member construct evaluations of the second decision construct are added. Likewise, in subexperiment two, group member evaluations of the first construct are added to the attribute level combinations describing construct two. Furthermore, it becomes clear that the dependent evaluation in both subexperiments is the final group evaluation for the choice alternative.

Because each profile potentially describes all I aspects of an alternative that one assumes to be relevant to the respondents, their overall evaluations should provide information about their utilities and preferences regardless of which construct experiment they experience. Hence, as the response to any profile provides an evaluation of the total decision alternative, the responses can be pooled across all subexperiments to estimate the following model:

$$V_j = \beta_o + \sum_{i=1}^I \left(\sum_{k=1}^{K_i} \beta_{ki} X_{kij} + \sum_{n=1}^N \tau_{ni} G_{nij} \right) + \varepsilon_j$$

Figure 1. The structure of the IHII group experiments (the case of two decision constructs).

where β_o is the constant, β_{ki} is the part-worth utility of level k of the attributes defining decision construct i , τ_{ni} is the individual influence parameter of group member n with respect to decision construct i , ε_j is an error term, and all other terms are as discussed before.

3. Methodology

3.1 Experimental design

The construction of the experiments applied in this study involved the following steps. First, based on some preliminary tests and a literature search (see introduction) the attributes influencing residential preferences and their levels were elicited. Consistent with the IHII approach, the attributes were assigned to two decision constructs: *housing* or *location*. Attributes and their levels are listed in Figure 2.

To combine the attribute levels into residential profiles, an orthogonal fraction of the full factorial design was selected involving 16 profiles for each subexperiment. This design allows us to estimate a main-effects-only model, which implies that all interaction effects are assumed to be zero. Examples of profiles for both subexperiments are presented in Figure 3.

The measurement task required group members to express their overall preference for each of the 16 profiles on a 0 to 20-point scale. The extremes of this scale were labeled as ‘very unattractive’ (0) and ‘very attractive’ (20).

HOUSING CONSTRUCT ATTRIBUTES	LOCATION CONSTRUCT ATTRIBUTES
<i>dwelling type</i> - flat / apartment - row house - semidetached dwelling - detached dwelling	<i>type of buildings in neighborhood</i> - mainly row houses or apartments - mainly (semi)detached
<i>number of bedrooms</i> - three - four - five	<i>frequency of public transport</i> - once each hour - four times an hour
<i>size of bedroom for children</i> - 7.5 m ² - 16 m ²	<i>travel time to work for father</i> - 5 minutes - 30 minutes - 55 minutes
<i>monthly costs</i> - Nlg 600 - Nlg 1000 - Nlg 1400	<i>travel time to work for mother</i> - 5 minutes - 30 minutes - 55 minutes
<i>tenure</i> - rent - own	<i>travel time to work or school for child</i> - 5 minutes - 30 minutes - 55 minutes
<i>evaluation of location by father</i> - marginally sufficient (5½) - good (8)	<i>evaluation of housing by father</i> - marginally sufficient (5½) - good (8)
<i>evaluation of location by mother</i> - marginally sufficient (5½) - good (8)	<i>evaluation of housing by mother</i> - marginally sufficient (5½) - good (8)
<i>evaluation of location by child</i> - marginally sufficient (5½) - good (8)	<i>evaluation of housing by child</i> - marginally sufficient (5½) - good (8)

Figure 2. Selected attributes and their levels.

3.2 Measurement procedure and sample

Families participating in the present study were all residents of Eindhoven, a medium-sized city in the Netherlands, or residents of its smaller neighbor, the municipality of Veldhoven. All families consisted of a father, a mother, and at least one child of 14 years of age or older. Families were contacted through the children's school or through their previous participation in a consumer study. They received a letter that explained the purpose of the project and asked them to participate in the study. Families could indicate their willingness to participate by filling out a participation form, which they were asked to return to the university in a pre-stamped envelope. This resulted in 147 families that completed the tasks reported in this paper.

The data were collected by 36 trained student interviewers. As the questionnaires were all self-explanatory, the interviewers mainly had an organ-

HOUSING	apartment rent 4 bedrooms bedrooms for children: 16 m ² monthly costs: Nlg 1000	
LOCATION	evaluation of location by FATHER: evaluation of location by MOTHER: evaluation of location by CHILD:	good (8) marginally sufficient (5½) good (8)

LOCATION	mainly houses in a row / apartments travel time to work or school for FATHER: 55 minutes for MOTHER: 5 minutes for CHILD: 30 minutes public transport: once an hour in each direction	
HOUSING	evaluation of housing by FATHER: evaluation of housing by MOTHER: evaluation of housing by CHILD:	good (8) marginally sufficient (5½) good (8)

Figure 3. Example profiles of the housing subexperiment (upper) and of the location subexperiment (lower).

izational task. In particular, they made appointments with the families and recorded the responses to avoid that one of the family members would be in control of the reporting and hence could exert more influence. To assure that all family members were equally able to read the profiles, each member was given a copy of the questionnaire.

The questionnaires started by describing the goal of the research project and defining the attributes and their levels. Then, the family members became acquainted with the attributes and their levels by scoring their current housing situation on the selected attribute levels. They then familiarized themselves with the experimental task by rating six profiles that were not part of the experimental design. After these introductory tasks, the main experiment of interest started. Finally, the family members were requested to provide answers to a set of socio-economic questions. An overview of the selected residential attributes, the socio-economic characteristics, and their response format is provided in Figure 4.

To be included in the regression analysis, the following modifications and assumptions with respect to the measured variables were made. The categorical attributes *tenure*, *dwelling type*, *type of building in neighborhood*, and *most important daily activity* were recoded as dummy variables. *Educational level* and the attributes for which category classes were used as response format were assumed to be interval-level variables. The mid-value of the categories was used to represent these variables.

Current housing attributes	(number of categories) response format
monthly costs	(12) < 400, 400-500, 500-600, ..., 1400-1500, >1500 in Nlg per month
tenure	(2) rental, owner-occupied
number of rooms	(4) 2, 3, 4, 5 or more bedrooms
size of children's bedrooms	(6) > 6, 6-9, 9-12, 12-15, 15-18, 18+ in square meters
dwelling type	(4) flat or apartment, row house, semidetached, detached
Current location attributes	
type of buildings in neighborhood	(2) mainly houses in a row or apartments, mainly (semi)detached houses
frequency of public transport	(6) 0, 1, 2, 3, 4, 5 or more per hour
travel time to work or school of husband	(12) < 5, 5-10, 10-15, ..., 75-80, 80 or more minutes
travel time to work or school of wife	(12) < 5, 5-10, 10-15, ..., 75-80, 80 or more minutes
travel time to work or school of child(ren)	(12) < 5, 5-10, 10-15, ..., 75-80, 80 or more minutes
Socio-economic characteristics ¹	
most important daily activity	(2) work, other
age	in years
educational level	(4) elementary school & lower vocational, secondary school; middle vocational, higher vocational & university
net personal income per month	(13) 0, 0-250, 250-500, 500-1000, 1000-1500, ..., 4500-5000, > 5000
number of weekly working days	in days per week
number of weekly working hours	(6) < 10, 10-20, 20-30, 30-40, 40-50, > 50
number of children	(5)

¹ measured separately for both husband and wife, except for number of children

Figure 4. Current residential attributes and socio-economic characteristics (number of categories in parenthesis).

4. Results

4.1 The average residential preference function

Before analyzing differences in estimated utilities, we need to estimate the conjoint preference models. The results of the estimates are discussed in this section. As each family evaluated all the profiles implied by the selected experimental design, a residential preference function could be estimated for each family separately. A simple main-effects-only model was assumed to represent residential preferences. This model was estimated using multiple regression analysis, an appropriate statistical technique because the dependent variable of the model involves the rating of the attribute profiles. The independent variables of the model are formed by the effect-coded attribute levels. Consequently, the estimated regression coefficients can be interpreted as the part-worth utility contributions of the corresponding attribute levels expressed as deviations from the regression intercept. The regression intercept is equal to the mean overall profile evaluation.

To assess model fit, we calculated the R^2 's for all separate family models. The mean of the R^2 's was 0.91 and the standard deviation was 0.06. Only five families had a model with an R^2 lower than 0.80; one outlier with a fit of 0.60 was observed; 48 models had an R^2 between 0.80 and 0.90, while 94 models had an R^2 higher than 0.90. Thus, the models appear to predict the observed preference ratings quite well.

Table 1 presents the means of the estimated part-worth utilities and the associated standard deviations. It indicates that the estimated regression intercept is equal to 9.33. As a rating scale ranging from 0 to 20 was used, the intercept is slightly lower than the middle scale value (= 10). We now describe the estimated part-worth utilities, starting with those of the housing attribute levels.

The part-worth utilities estimated for housing type indicate that the total utility increases as the dwelling type becomes more 'detached'. Families especially derive a low part-worth utility from flats/apartments, and, albeit to a lesser extent, from houses in a row. Families prefer semidetached and detached dwellings, the difference in utility between the latter two levels being relatively small. Utility also increases with increasing 'number of bedrooms'. This relationship is almost perfectly linear. Furthermore, families prefer larger sizes of Children's bedrooms to smaller bedroom sizes. As expected, utility decreases with increasing monthly costs. Although this relationship is almost linear, the negative value for Nlg 1000 shows that the incremental decrease in utility is somewhat larger between the values Nlg 600 to 1000 than between the larger values. Finally, families prefer owner-occupied dwellings to rented dwellings.

The location-related attribute levels covary as follows with total utility. Families prefer neighborhoods with mainly (semi)detached dwellings to neighborhoods with mainly row houses and apartments. The latter means that they prefer living in suburban neighborhoods above living in urban neighborhoods. Not surprisingly, families prefer higher to lower frequencies of public transport, although the part-worth utilities are rather low indicating that the importance attached to this attribute is rather low. As expected, utility decreases with increasing travel time, which applies to all family members. This relationship is about linear for both fathers and mothers, while for children a relatively high negative value for the level '55 minutes' is estimated. This indicates that especially the longer travel times for children cannot be easily compensated for. Regarding the range in part-worth utilities, families on average attach most importance to the child's travel time, followed by the mother's travel time, while they attach least importance to father's travel time.

Table 1. Mean estimated part-worth utilities of attribute levels¹ of the concatenated family model

	mean	std. dev.
<i>dwelling type</i>		
– flat/apartment	–2.37	1.85
– row house	–0.63	1.12
– semidetached dwelling	1.36	1.11
– detached dwelling	1.64	1.27
<i>number of bedrooms</i>		
– three	–1.26	1.18
– four	0.07	0.70
– five	1.19	1.13
<i>size of children's bedroom</i>		
– 7.5 m ² (versus 16 m ²)	–1.05	0.76
<i>monthly costs</i>		
– Nlg 600	2.13	1.37
– Nlg 1000	–0.23	0.78
– Nlg 1400	–1.90	1.26
<i>tenure</i>		
– rent (versus owner-occupied)	–0.55	0.68
<i>building type in neighborhood</i>		
– mainly row houses or apartments (versus mainly (semi)detached dwellings)	–0.54	1.03
<i>frequency of public transport</i>		
– once an hour (versus four times)	–0.24	0.61
<i>father's travel time to work or school</i>		
– 5 minutes	0.68	0.99
– 30 minutes	0.16	0.72
– 55 minutes	–0.84	1.01
<i>mother's travel time to work or school</i>		
– 5 minutes	1.07	1.27
– 30 minutes	0.02	0.82
– 55 minutes	–1.09	1.01
<i>child's travel time to work or school</i>		
– 5 minutes	1.30	1.04
– 30 minutes	0.31	0.64
– 55 minutes	–1.61	1.14
<i>intercept</i>	9.33	1.79
<i>number of cases</i>	147	

¹Mean estimated part-worth utilities of the decision constructs are presented in Table 2.

Table 2. Mean estimated part-worth utility of the decision constructs for the concatenated family model

	mean	std.dev.
evaluation of location by father ¹	0.38	0.47
evaluation of location by mother	0.54	0.61
evaluation of location by child	0.61	0.58
evaluation of housing by father	0.75	0.59
evaluation of housing by mother	0.52	0.68
evaluation of housing by child	0.64	0.53

¹ All part-worth utility estimates are based on the levels good (8) versus marginally sufficient ($5\frac{1}{2}$).

Table 2 presents the mean part-worth utilities estimated for the construct evaluations of each family member. These part-worth utilities may be interpreted as the relative influence of the family members on the final decision outcome. Table 2 indicates with respect to the housing construct that fathers had the highest influence, followed by children and mothers. As for the location construct, children had the highest influence, followed by mothers and fathers. Two-sided paired *t*-tests showed that the differences in relative influence are significant at the $\alpha = 0.05$ level, except for the difference between fathers and children for the housing construct and the difference between mothers and children for the location construct.

In conclusion, the estimated part-worth utilities are all in the anticipated directions, providing face validity to the estimated model at the aggregate level.

4.2 Analyzing heterogeneity

Standard applications of conjoint preference models stop with these results. A potential problem here is that a low range can be caused by low importance throughout a homogeneous sample, or by counterbalancing, conflicting preferences (heterogeneity) across the sample, or a combination of these effects. Therefore, it is preferable to further analyze the variation in estimated attribute utility range. Such an analysis was pursued in this study. The standard deviations of the estimated part-worth utilities are relatively large, indicating that such an additional analysis may be valuable. In this section, we examine whether the part-worth utilities are systematically related to the socio-economic characteristics of the families and the variables that describe their current housing situation that were introduced in Section 3.2.

To that effect, we applied multiple regression analysis in which the estimated part-worth utilities are treated as the dependent variable.

Analysis of the separate levels of the interval-level attributes 'monthly costs', 'number of bedrooms', and the 'father's travel time' revealed that the first and the third level had the same but opposite significant relationships with predictor variables, while the middle levels had no significant relationships with predictor variables. Therefore, we decided to choose for these attributes the range between the lowest and highest levels as the dependent variable instead of the separate part-worth utilities. The range calculated in this way may be interpreted as the importance attached to the attribute. Furthermore, as analyzing both part-worth utilities of the two-level attributes would reveal the same results except for opposing signs, we present only the results for one of both attribute levels. Finally, in the regression analysis we checked for outliers and influential cases. With respect to the variable 'number of children' it turned out that only one family had five children and this family had extreme part-worth utilities for several attribute levels, influencing the regression lines severely. Therefore, this family was excluded from the analysis. The effect was that one relationship vanished completely while the explained variance of some other relationships decreased significantly.

The results of these analyses are presented in Table 3, which reports only the significant regression coefficients. This means that the estimates for size of children's bedrooms as well as for the children's and mothers' travel time are not related to any of the predictor variables. This also implies that the current residential and socio-demographic variables not mentioned in the table do not significantly explain variation of the part-worth utility ranges. The highest R^2 value of 0.19 indicates that the variance of the estimates cannot be accounted for by the socio-demographics. Hence, utilities attached to the residential attribute level seem highly idiosyncratic. Notwithstanding the fact that the explained variance is rather low, the analysis offers some interesting insights, which are now discussed in more detail.

Column one indicates that the importance families attach to monthly costs is only dependent on the current monthly costs. As may be expected, the higher the current monthly costs, the less importance is attached to monthly costs. Hence, contrary to expectations, income did not have a significant direct effect on monthly costs importance. Further analysis involving the estimation of a simple Structural Equation Model (a path model) showed that income has a significant effect on current monthly costs, and thereby an indirect effect on the range of monthly costs, while the direct effect appeared not to be significant. The explanation for this finding is that all families of the response group are in the housing market for quite some time and therefore probably have had plenty of time to find a house that matches their

Table 3. Regression analysis of conjoint estimates (significant standardized regression coefficients)

predictor variables	ranges of part-worth utilities			part-worth utilities			
	monthly costs	number of bedrooms	father's travel time	dwelling type: row house	tenure: owner-occupied	neighborh.: mainly detached	public transport: freq. 4x/h.
income father			-0.26				
number of children		0.34				0.33	
mother's travel time					0.20		
number of bedrooms		0.20					
row house				0.20			
monthly costs	-0.36			-0.26			
owner-occupied house					0.20		
mainly (semi)detached					0.19		-0.27
dwellings in neighborhood							
R ² – adjusted	0.12	0.19	0.06	0.16	0.07	0.10	0.07
N	144	146	130	144	140	147	140

income. Hence, income affects current monthly costs, which in turn affects the importance attached to monthly costs.

The second column of Table 3 shows that the importance attached to the number of bedrooms is related to the number of children in the household and to a lesser extent also to the current number of bedrooms. For the sake of completeness, we should mention that the current size of the children's bedrooms had about the same explanatory power as the current number of bedrooms, but due to their correlation (0.50), only one of both turned out to be significant. We choose the current number of bedrooms as the more plausible predictor for this analysis.

The importance attached to father's travel time is only related with father's income: the higher the father's income, the less do families mind that fathers have to travel for a longer time to their work. This relationship is not explained away by the father's current travel time, as this attribute was one of the potential predictors, but this relationship did not turn out to be significant.

The part-worth utility for a row house is negatively related with current monthly costs, while the fact that families now live in row houses positively affects this part-worth utility. Hence, the higher the current monthly costs, the less families are willing to live in a row house, while families currently living in row houses have a higher preference for this dwelling type. The utility derived from detached dwellings is not affected by monthly costs, only by type of neighborhood. That is, families currently living in a neighborhood with mainly semidetached and detached dwellings prefer detached dwellings.

The utility for owner-occupied dwellings is higher for families currently living in a owner-occupied dwelling and increases when the mother's travel time to work increases. It is not quite clear why the mother's travel time would directly influence tenure preference. This relationship may be spurious; it might be explained away by a variable not measured in this study.

The part-worth utility of the attribute level 'mainly detached dwellings in neighborhood', more freely interpreted as a suburban environment, is solely affected by the number of children in the family. The more children in the family, the stronger families prefer to live in a suburban neighborhood. The current type of neighborhood, in turn, affects the importance attached to public transport frequency: families living in a more urban environment value frequent public transport more highly than families living in a suburban neighborhood.

5. Conclusion

Conjoint analysis is a widely applied approach to estimate residential preference models. Reports on these kind of models usually only present the

estimated utility functions averaged across all respondents, whereas heterogeneity may exist between the respondents. In this paper we therefore examined to what extent heterogeneity in residential preferences of families can be explained by socio-economic background variables and characteristics of the current housing situation.

To that effect, the standard conjoint approach was extended. We first estimated residential preference models for each individual family. These models were estimated from conjoint experiments that were completed by all family members in joint deliberation. The estimated part-worth utilities were then treated as the dependent variables in a multiple regression analysis. It was examined to what extent the variation in attribute importance could be explained by the socio-economic family characteristics and families' current housing situation.

The estimated individual family models appeared to fit the data well. Moreover, the averaged part-worth utilities were all in anticipated directions, which gave face validity to the model. The analysis of attribute variation could also be interpreted well. The explained variance was rather low however, suggesting that a family's residential preferences are highly idiosyncratic, or at least not systematically related to the selected socio-demographics, at least in the present study.

This is not to say that heterogeneity is irrelevant in other studies. To prevent the problem associated with traditional conjoint analyses – whereby the analyst cannot differentiate between irrelevant attributes and heterogeneous preferences – the approach suggested in this paper may be helpful. In particular, it allows the researcher to analyze the estimated residential preference functions for systematic relationships with socio-demographic variables. If such relationships were to result, one could create consumer segments based on the perceived importance of attributes.

Acknowledgment

This research was financially supported by the Foundation for Economic, Social-Cultural, Geographical and Environmental Sciences (E.S.R), which is part of the Netherlands Organization for Scientific Research (N.W.O.).

References

- Akaah, I.P. and Korgaonkar, P.K. (1983) An Empirical Comparison of the Predictive Validity of Self-Explicated, Huber-Hybrid, Traditional Conjoint, and Hybrid Conjoint Models, *Journal of Marketing Research*, 20, 187–197.

- Boag, D.A. and Sarkar, A.K. (1984) Housing Affordability and Acceptability as Influenced by Consumer Trade-off Perceptions, Canada Mortgage and Housing Corporation, Ottawa.
- Davis, H.L. and Rigeaux, B.P. (1974) Perception of Marital Roles in Decision Processes, *Journal of Consumer Research*, 1, 51–61.
- Green, P.E., Goldberg, S.M. and Wiley, J.B. (1982) A Cross-Validation Test of Hybrid Conjoint Models, *Advances in Consumer Research*, 10, 147–150.
- Joseph, A.E., Smit, B. and McIlravey, G.P. (1989) Consumer Preferences for Rural Residences: A Conjoint Analysis in Ontario, Canada, *Environment and Planning A*, 21, 47–65.
- Knight, R.L. and Menchik, M. (1976) Conjoint Preference Estimation for Residential Land Use Policy Evaluation. In: *Spatial Choice and Spatial Behavior* (Eds, Golledge, R.G. and Rushton, G.), Ohio State University Press, Columbus, pp. 135–155.
- Louviere, J.J. (1979) Modeling Individual Residential Preferences: A Totally Disaggregate Approach, *Transportation Research A*, 13, 373–384.
- Louviere, J.J. (1984) Hierarchical Information Integration: A New Method for the Design and Analysis of Complex Multi-attribute Judgment Problems. In: *Advances in Consumer Research*, vol. 11 (Ed, Kinnear, T.C.), Association for Consumer Research, Provo, Utah, pp. 148–155.
- Louviere, J.J. and Henley, D.H. (1977) An Empirical Analysis of Student Apartment Selection Decisions, *Geographical Analysis*, 9, 130–141.
- Louviere, J.J. and Timmermans, H.J.P. (1990) Hierarchical Information Integration Applied to Residential Choice Behavior, *Geographical Analysis*, 22, 127–145.
- Molin, E.J.E. (1999) Conjoint Modeling Approaches for Residential Group Preferences, *Bouwstenen 53*, Faculteit Bouwkunde, Technische Universiteit Eindhoven (dissertation).
- Molin, E., Oppewal, H. and Timmermans, H. (1996) Modeling Consumer Response to New Housing: A Stated Choice Experiment, *Netherlands Journal of Housing and the Built Environment*, 11, 297–312.
- Molin, E., Oppewal, H. and Timmermans, H. (1997) Modeling Group Preferences Using a Decompositional Preference Approach, *Group Decision and Negotiation*, 6, 339–350.
- Molin, E., Oppewal, H. and Timmermans, H. (1999) Group-based versus Individual-based Conjoint Preference Models of Residential Preferences: A Comparative Test, *Environment and Planning A*, 31, 1935–1947.
- Molin, E., Oppewal, H. and Timmermans, H. (2000) A Comparison of Full Profile and Hierarchical Information Integration Conjoint Methods to Modeling Group Preferences, *Marketing Letters*, 11, 165–175.
- Munsinger, G.M., Weber, J.E. and Hansen, R.W. (1975) Joint Home Purchasing Decisions by Husbands and Wives, *Journal of Consumer Research*, 1, 60–66.
- Oppewal, H., Louviere, J.J. and Timmermans, H.J.P. (1994) Modeling Hierarchical Conjoint Processes with Integrated Choice Experiments, *Journal of Marketing Research*, 31, 92–105.
- Phipps, A.G. (1989) Residential Stress and Consumption Disequilibrium in the Saskatoon Housing Market, *Papers of the Regional Science Association*, 67, 71–87.
- Phipps, A.G. and Carter, J.E. (1984) An Individual Level Analysis of the Stress-Resistance Model of Household Mobility, *Geographical Analysis*, 16, 176–189.
- Phipps, A.G. and Carter, J.E. (1985) Individual Differences in the Residential Preferences of Inner-city Households, *Tijdschrift voor Economische en Sociale Geografie*, 16, 32–42.
- Steenkamp, J. (1985) De Constructie van Profielensets voor het Schatten van Hoofdeffecten en Interacties bij Conjoint Meten. In: *Jaarboek van de Nederlandse Vereniging van Marktonderzoekers*, pp. 125–155.

- Timmermans, H.J.P. (1984) Decompositional Multi-attribute Preference Models in Spatial Choice Analysis, *Progress in Human Geography*, 8, 189–221.
- Timmermans, H.J.P. (1987) Hybrid and Non-Hybrid Evaluation Models for Predicting Outdoor Recreation Behavior: A Test of Predictive Ability, *Leisure Sciences*, 9, 67–76.
- Timmermans, H.J.P., Borgers, A.W.J., van Dijk, J. and Oppewal, H. (1992) Residential Choice Behaviour of Dual-Earner Households: A Decompositional Joint Choice Model, *Environment and Planning A*, 24, 517–533.
- Timmermans, H., Molin, E. and van Noortwijk, L. (1994) Housing Choice Processes: Stated versus Revealed Modeling Approaches, *Netherlands Journal of Housing and the Built Environment*, 9, 215–227.
- Timmermans, H.J.P. and van Noortwijk, L.E. (1995) Context Dependencies in Housing Choice Behavior, *Environment and Planning A*, 27, 181–192.
- Timmermans, H.J.P. and van Noortwijk, L.E., Oppewal, H. and van der Waerden, P. (1996) Modeling Constrained Choice Behavior in Regulated Housing Markets by Means of Discrete and Universal Logit Models: An Application to the Residential Choice Behavior of Divorcees, *Environment and Planning A*, 28, 1095–1112.
- Veldhuisen, K.J. and Timmermans, H.J.P. (1984) Specification of Individual Residential Utility Functions, *Environment and Planning A*, 16, 1573–1583.
- Vyvere, Y. van de, Oppewal, H. and Timmermans, H. (1998) The Validity of Hierarchical Information Integration Choice Experiments to Model Residential Preference and Choice, *Geographical Analysis*, 30, 254–272.