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Stated Preferences for Sustainable Housing Development in Germany—A Latent Class Analysis

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Abstract

Despite enormous progress made in the resource-efficient housing construction as a result of technical innovation, market share of sustainable new housing development in Germany is still very low. There is a need for a demand-driven research approach to determine and exploit the potential for sustainable housing among private home buyers—the principal consumers of new housing in Germany. This study measures the preferences of German home buyers based on stated preferences survey data through the application of a discrete choice experiment. Using latent class analysis, the article identifies market segments of differing "environmental awareness" and corresponding preference heterogeneity. The results point to a latent demand for sustainable housing alternatives among private home buyers in Germany.

Keywords

sustainable housing development; stated preferences; discrete choice experiment; latent class analysis; housing economics

For more than a decade, the environmental impact of new housing development has been identified a global environmental problem (United Nations Conference on Environment & Development 1992; Enquete Commission 1994; Hesse 1996; German Federal Office for Building and Regional Planning 1999; Sieverts 2005). In Germany, for example, the housing sector is dominated by low-density single-family housing, which leads to high land and energy consumption. Furthermore, the proportion of greenfield land being used for housing and transport continuously increased in the decade from 1997 to 2007 and totaled up to 413 km² per day in 2007 (German Federal Statistical Office 2008, 12). If land used for new housing development continues at this rate, it is forecasted that 50 percent of all land in Germany will be built up before the year 2080, leaving future generations only limited opportunities for other types of land use. Built-up land causes negative ecological impacts, such as soil pollution, reduced habitat and biotope space, and decreasing water retention and filtering function of soil (German Federal Environment Agency 2004, 2).

"Ecological" and "sustainable" housing development concepts have been proposed to reduce the negative environmental effects of housing developments (Wolpensinger and Rid 2010). "Ecological housing" focuses on the reduction of the negative effects of new housing development, for instance by installing thermal insulation, solar energy use, or heat-exchange systems (Hartl and Lee 2003, 1; Hahn 1982). "Sustainable housing," in addition, addresses social and economic issues (World Commission on Environment Development 1987). According to sustainability objectives, resource consumption should not exceed a specified maximum level, to preserve enough resources to allow future generations to consume at similar levels (Enquete Commission 1994; German Federal Environment Agency 2000; Fuchs and Schleifnecker 2001; Hartl and Lee 2003). Sustainable housing concepts promote higher building densities, mixed-use developments, and sustainable construction techniques (Williams and Dair 2007, 135; Hartl and Lee 2003, 6).

Although sustainable housing development concepts arose in policy and academic literature in the early 1980s, the market share of "ecological" or "sustainable" new housing development in Germany, as in other European countries, remains very low (Hartl and Lee 2003, 5). In sustainability literature, the market share of sustainable housing developments is estimated to be well below 10 percent of all newly constructed residential buildings in Germany (Wolpensinger and Rid 2010, 122; Wolpensinger 2002; Bauer, Huber, and Lingelbach 2000, 1).

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Our hypothesis is that resource savings in the housing sector cannot be achieved, if sustainable housing development concepts are not adopted by the market (and consumers). There is a need for a demand-driven research approach to determine and exploit the potential for sustainable housing. Therefore, this study aims to measure the preferences of German home buyers toward sustainable housing options based on survey data through the application of a discrete choice experiment (DCE). Currently, there are no statistical data available on how private home buyers evaluate aspects of sustainable housing development.

In our analysis, we focus on people who are planning to invest in residential properties. In Germany, this group is often termed "private home buyers," the segment of households that aim to become home owners. In 2007, this group accounted for more than 70 percent of new housing developments in Germany, in contrast to 25 percent of new housing units built and leased by commercial real estate developers and 5 percent by the public sector (German Federal Statistical Office 2007). While new housing units built by the public sector are mainly used for social housing schemes, commercial real estate developers either sell the newly developed housing units to private home buyers or rent them to tenants. Preferences among private home buyers are expected to be heterogeneous (Opaschowski 2005). In this article, we used the DCE and latent class analysis (LCA) methods to measure home buyer preferences and identify market segmentation.

The article starts with a review of literature relevant to stated preferences approaches, that is, the DCE (second section) and the LCA (third section). The fourth section describes the survey and data collection method. The results of the econometric analysis are presented and discussed in the fifth section. Finally, in the sixth section, we present some implications for evaluating the market share of sustainable housing developments in Germany.

Using Stated Preferences and the Choice Experiment Method to Evaluate Sustainable Housing Development Characteristics

Stated preferences (SP) approaches have proven useful to understanding of consumer choices in various research applications (Adamowicz et al. 1998). Most commonly, SP research is aiming to elicit consumer preferences towards distinct aspects of an object or product under investigation and to predict market shares for "real" or hypothetical products. In this research, we used SP data to measure private home buyers' preferences on different aspects of sustainable housing development. SP models can be divided into compositional models and de-compositional models.

In housing research, SP models are most commonly associated with compositional models to measure housing preferences (Timmermans, Molin, and Noortwijk 1994), that is, to analyze home buyers' values as determinants of housing preferences (Bayern Labo 2007; Lindberg, Gärling, and Montgomery 1988), to evaluate perceptions of streets and public places (Mehta 2007), or to evaluate architectural design qualities (Purcel and Nasar 1992). In compositional models, housing preferences are estimated by recording separately and then measuring the relative importance of each attribute (Timmermans, Molin, and Noortwijk 1994). But the purchase decisions of households are usually influenced by a bundle of determining factors, such as budget restrictions, situational factors, and individual preferences (Ajzen 1991). Hence, choosing from two or more alternatives, in most cases, implies choosing the most preferred alternative by making trade-off decisions. Although compositional models are simpler to use, the validity of the compositional models is questionable, due to the trade-offs made (Timmermans, Molin, and Noortwijk 1994, 218).

To overcome these restrictions, de-compositional SP models, for example, the DCE method, have been developed in social-psychology and market research to investigate individual reactions to the entirety of a product rather than to single characteristics of a product (Timmermans, Molin, and Noortwijk 1994; Lancaster 1966). Another example of de-compositional models is the conjoint preference model (for an overview, see Timmermans, Molin, and Noortwijk 1994). The procedure is primarily characterized by its ability to consider a dependent variable with qualitative scale features, also called discrete variable, in a logistic regression model. In a DCE, the interviewee has to make a choice between alternatives that are defined as combinations of a set of attributes and presented in choice sets that combine two or more alternatives each. In the choice sets, each alternative is evaluated as a whole. In most cases, each respondent makes one choice per two or more choice sets that alter in terms of alternatives presented.

The DCE method has the advantage of accounting for the multiattribute nature that characterizes most behavioral decision-making processes. Also, choice set alternatives may include currently nonexisting alternatives and provide insights into the trade-off behavior of respondents (Morrow-Jones, Irwin, and Roe 2004). The DCE method avoids the problem of multicollinearity, as choice set alternatives are defined as combinations of a set of attributes, and each set is evaluated as a whole. The dependent variables are the choices made by respondents; the independent variables constitute the alternatives and the choices can be modeled as a function of the alternatives' attributes (McFadden 1974; Ben-Akiva and Lerman 1985).

A concrete example of this are purchasing or choice decisions where the consumer chooses a particular alternative (e.g., a sustainable housing variant) from a particular number of alternatives in a choice set (e.g., conventional vs. sustainable housing variants) that show differing characteristics (e.g., solar panels or not). In line with Lancaster's consumer theory, it is assumed that private home buyers evaluate the characteristics of different housing development models and then choose the one that best fits into their preference structures (Lancaster 1966).

The DCE method has been applied to complex management issues with considerable success. For summaries, see Timmermans and Golledge (1990), as well as choice model research undertaken by Bateman et al. (2009); Louviere, Hensher, and Swait (2000); or Hensher and Greene (2003). The DCE method has been applied to housing research to measure people's evaluations of housing alternatives in the context of residential choice (Timmermans, Molin, and Noortwijk 1994; Louviere 1979; Joseph, Smit, and McIlravey 1989). Also, discrete choice models have been used to evaluate preferences for neotraditional neighborhood characteristics (Morrow-Jones, Irwin, and Roe 2004), to analyze preferences for development planning alternatives (Johnston, Swallow, and Bauer 2002), and to evaluate design alternatives of workspace design for university architecture faculty (Dijkstra et al. 2003). In this article, we report on a DCE approach to elicit home buyers' preferences for sustainable housing development options.

Introducing the Latent Class Approach to the Analysis of Preference Heterogeneity

In the SP literature, consumer preferences are most commonly described as heterogeneous (Hunt et al. 2005), which means that diversity within the data makes average-based data analysis often misleading in terms of data interpretation and conclusions drawn. Originally used in market research, market segmentation is a fundamental tool for the identification of heterogeneous subgroups of consumers (market segments) and therefore for accounting for preference heterogeneity (Beane and Ennis 1987; Venugopal and Baets 1994). A market segment is defined as a group of consumers who are expected to exhibit similar purchasing responses (Smith 1956). The understanding of market segmentation is often developed from behavioral theories such as recreational specialization (Kim et al. 2008; Hunt et al. 2005, 297).

In most SP research, exogenous market segmentation is used to inquire into taste heterogeneity. Exogenous market segmentation methods require the researcher to have a priori knowledge of the elements of heterogeneity: (1) important segmenting variables such as age, income, and motivations, which are used to allocate each individual to a specific market segment; and (2) threshold values for these variables from which to derive the number of market segments (Hunt et al. 2005, 298; Boxal and Adamowicz 2002, 422). Most commonly, the multinomial logit model is applied to estimate respondents' preferences on the basis of DCE data (Morrow-Jones, Irwin, and Roe 2004). But the multinomial logit model assumes homogeneous preferences across respondents (Birol, Karousakis, and Koundouri 2006); hence market segmentation can only be carried out by making a priori assumptions about segmenting variables. The exogenous market segmentation approach has been widely criticized, as researchers in most cases cannot account for all sources of heterogeneity (Bhat 2002). The exclusive allocation of individuals to segments is not systematically linked to preference data but to rather weak a priori assumptions.

In contrast, LCA has attracted increasing interest from choice experiment researchers due to its accounting for preference heterogeneity in DCE data. LCA identifies market segments based on the concept of endogenous (latent) preference segmentation. This means that an individual's segment membership is not exogenously specified (e.g., by a priori assumptions about heterogeneity), but estimated from the structure of preferences itself and hence is directly linked to the choice data. In LCA, class or segment membership is probabilistic and assumed to be jointly affected by both respondents' choices and answers to attitudinal questions, such as data on environmental consciousness (Birol, Karousakis, and Koundouri 2006, 152; Morey, Thacher, and Breffle 2006). The number of market segments or the relative size of the segments, respectively, can be evaluated by test statistics, such as the Bayesian Information Criterion (BIC) or Akaike's Information Criterion (AIC).

Originally developed by Lazarsfeld and Henry (1968), LCA is well established in the social sciences (e.g., McLachlan and Peel 2000; Wedel and Kamakura 1998; Kamakura and Russell 1989). The latent class approach has been used in leisure and recreation studies (Hunt et al. 2005; Train 1998; Chen and Cosslett 1998) and in quantitative landscape analysis (Birol, Karousakis, and Koundouri 2006). Some of these studies explicitly tested the performance of different choice models and revealed that LCA indeed outperformed other analytical models in identifying substantial taste variation that could only be partially captured by other procedures (Birol, Karousakis, and Koundouri 2006; Boxall and Adamowicz 2002).

In this study, we identify segments of private home buyers with taste differences according to concepts of sustainable housing and additional attitudinal data. We report on our use of the latent class approach to identify the number of classes with homogeneous preferences in a sample of private home buyers and their relative probabilities of membership in each class. This is the first study, as far as we know, that uses finite mixing approaches to model discrete choices for sustainable housing development alternatives.

Survey and Data Collection

In understanding environmental choices, the alternatives to be evaluated by respondents are various development or policy options (Bennett and Adamowicz 2001) associated with changes in environmental quality. In this study, the first step was to define the good to be valued in terms of its attributes and attribute characteristics (Birol, Karousakis, and Koundouri 2006, 147). Here, the good to be valued was the housing

Table 1. Attributes and Attribute Levels

Attributes	Attribute characteristics
Attributes represented in visualizations	
1. Building density	1. Low (approx 80% EFH; 20% DH) 2. Medium (approx 40% RH and DH; 40% EFH) 3. High (approx 80% RH and DH; 10% GW)
2. Number of green spaces	1. Small number (few green areas; approx. 1 GB/1 KB on every second site) 2. Medium number (some green areas; approx. 1 GB/1 KB per site) 3. High number (large green areas; approx. 1 GB/1 KB per site and two streets additionally lined with trees)
3. Central plaza	1. No central plaza 2. Central plaza provided 3. Central plaza and nearby shopping facilities provided
4. Infrastructure provision	1. Auto-oriented (streets for cars and car parking directly at the buildings) 2. Pedestrian-oriented (cluster parking and walkways to the buildings)
Attributes represented as additional information to the housing models in textual format	
5. Public transportation	1. Low transit service frequency (1-2 services/day) 2. Medium transit service frequency (3-6 services/day) 3. High transit service frequency (7-9 services/day)
6. Technical installations for resource protection (e.g. solar panels)	1. No technical installations for resource protection provided 2. Technical installations provided (e.g. solar panels)
7. Representation of social classes	1. No social mixing (social structure of residents is homogeneous, e.g., with regard to income and age) 2. Mixed social structure (social structure of residents is heterogeneous, e.g. with regard to income and age)
8. Costs (the costs are represented as relative values compared to the other alternatives)	1. Same building costs 2. 10% higher building costs (housing development A costs 10% more than housing development B) 3. 10% lower building costs (housing development A costs 10% less than housing development B)

GW = apartments; RH = row house; DH = duplex/semidetached house; EFH = single-family home; GB = large tree; KB = small tree.

development scenario. The attributes needed to signify degrees of sustainability in housing development, in order to measure the differences in tastes towards sustainable or non-sustainable scenarios.

There is an extensive literature on concepts of sustainable housing development in Germany (German Federal Environment Agency 2000; German Federal Office for Building and Regional Planning 1999; Bavarian State Ministry of the Environment, Public Health and Consumer Protection 1998; Brandenburg State Ministry of Urban Development, Housing and Transport 2000; Enquete Commission 1994). Also, reviewed case studies can be accessed from the website www.oekosiedlungen.de to learn about concepts of sustainable housing in Germany. We analyzed both sources of data to select those criteria of sustainable housing development that are most commonly cited in literature and case studies. The specific attributes of sustainable housing developments that we studied are specified in Table 1.

To improve the ease of recognition and evaluation for attributes of the housing development alternatives, the attributes "building density," "quality of green spaces," "infrastructure provision," and "central plaza" were presented in form of 3D-CAD (computer-aided design) simulations (Figure 1). These four attributes pertained to the neighborhood layout, which was allowed to vary on three levels of building density and three levels of quantity of green spaces. The "low" building density level was calculated to equal 0.2 GFZ (German technical expression of gross floor area), the "medium" level to equal 0.4 GFZ, and the "high" level to equal 0.6 GFZ. The different levels of green spaces were designed using different levels of quantity of trees planted on each site or along two main roads, respectively (see Table 1 for details). The neighborhood layout was also allowed to show two different types of roads infrastructure: (1) auto-oriented street design, that is, streets designed for cars and parking within buildings; and (2) pedestrian-oriented design, that is, cluster parking and walkways to buildings. The neighborhood design was extended to allow for the comparison of housing alternatives with (1) no central plaza, (2) a central plaza built on site, and (3) a central plaza with additional nearby shopping facilities.

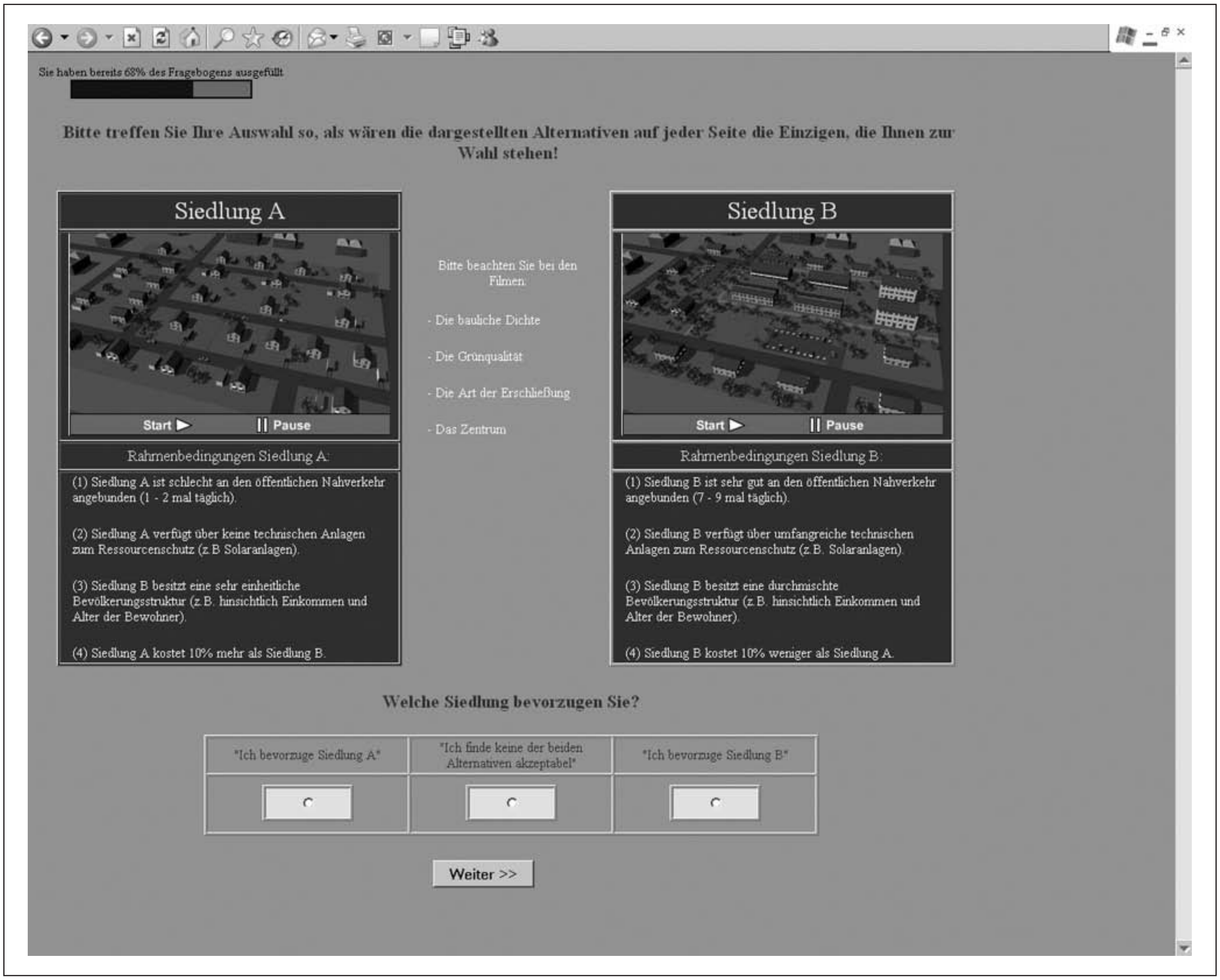


Figure 1. Sample choice set layout (taken as screenshot from the Internet questionnaire)
Choice set allows for three choices: (1) "I choose development A," (2) "I would choose neither A nor B," or (3) "I choose development B."

Four additional housing development characteristics were presented as textual information to the housing alternatives and were allowed to vary on two or three levels, respectively (see Table 1 for attributes presented visually in "3D film sequences" or as "textual presentations"). "Frequency of local public transportation" pertained to the quality of local transportation service provided at the housing development site and took on three different levels: "low" (one to two services per day), "medium" (three to six services per day), or "high frequency of transit" (seven to nine services per day). Also, housing profiles varied in terms of whether "technical installations for resource protection (solar panels)" are provided on site, and whether the social structure of residents was heterogeneous with regard to income and age. Also, a "cost" attribute was provided as a generic attribute, specified to account for same building costs (housing alternative A costs the same than housing alternative B) or different building costs (housing alternative A costs 10 percent less or more than B). The cost attribute was specified to measure relative cost differences rather than absolute cost measures in terms of euros, as we intended to account for cost constraints in the house buying decision of households but did not intend to measure willingness-to-pay for each attribute.

The method of collecting information was an Internet-based survey (see Figure 2). Each respondent was presented with four "choice sets," each containing two housing development profiles and a "neither" option, which was provided for respondents who felt that neither of the two housing development alternatives was acceptable (Figure 1). Respondents were asked to choose the most preferred alternative in each choice set.

A statistical experimental design plan was developed to control the composition of the housing profiles and the choice sets following a fractoral and orthogonal factorial design.[1] This is necessary to calculate regression parameters in compliance with the assumptions of regression theory (Louviere and Woodworth 1983; Louviere, Hensher, and Swait 2000).

In this study, thirty-six alternatives, each consisting of eight attributes with two or three attribute levels, were required to build eighteen choice sets to carry out the DCE (for attributes and attribute levels, see Table 1). Each respondent received only four choice sets, as literature shows that a higher number of choice tasks might "lead to fatigue of the respondents and unreliability of their answers" (Grêt-Regamey, Bishop, and Bepi 2007, 57). The four choice sets presented to each respondent were drawn randomly from the database of the total of eighteen choice sets.

The target group of our survey was the group of private home buyers (i.e., the segment of households) who wish to become homeowners. The average age of home buyers in Germany is about forty years (LBS 2004). Dutton, Helsper, and Gerber (2009, 18) report a high degree of Internet use for respondents of this age cohort; therefore we assumed an Internet survey appropriate to reach the target group of private home buyers. We first informally surveyed German Internet-discussion groups to identify home buyer forums. The web administrators of five Internet discussion groups were asked to forward an email that contained the web link to the Internet survey, which was hosted on the university's web server.[2] Also, two of the biggest southern German housing developers were asked to forward the email invitation to the target group of private home buyers, using their client e-mail databases.[3]

We conducted the survey for three months starting in January 2008. The survey database recorded 732 entries; 312 were incomplete and 420 complete. The high number of incomplete questionnaires ("survey dropout rate") is not unusual in Internet-based surveys (Vogt 1999). About 85 percent of the incomplete surveys were aborted after answering the third page of the questionnaire (see Appendix A). Pages one, two, and three of the questionnaire provided information including the survey's objectives, the university's name and address, and some incentives to be drawn by lottery among the respondents.[4] Because the first actual survey question was on page four, the large number of dropouts before page four were assumed to be Internet users with "initial curiosity" in the survey but no real intention of answering the questionnaire.

Of the 420 complete responses, 18 questionnaires had to be deleted from the database to avoid biased data as the recorded time for completion was below five minutes, which we believed was the minimum time required to answer the questionnaire. Thus, the database was reduced to 402 respondents. All the respondents answered four choice sets, making 1,608 responses available for the analysis. Unfortunately, it was not possible to calculate the response rate, as the e-mail invitation to the questionnaire was sent out by the Internet discussion groups' webmasters, who did not release any detailed information about their web-community, for example, the exact number of forum members.

The socioeconomic characteristics of the respondents are very similar to the characteristics of German home buyers as reported in other representative surveys: homebuyers in Germany are forty years old on average (LBS 2004), and the sample average age class in our study was thirty-six- to forty-five-year olds. The average household size of homebuyers is 2.8 persons per household in Germany (LBS 2004), while the sample average household size in this study was in the 2 to 3 persons per household class.

In our questionnaire, a question was provided to learn about the spatial distribution of the respondents. The respondents were asked to state the postal code of their place of current residence, which was analyzed and linked to the four "Basic Types of Spatial Structures in Germany" (German Federal Office for Building and Regional Planning 2007) as geographical structure: 35 percent of the respondents lived in "urban environments," another 35 percent in "sub-urban areas" ("urban fringe"), 25 percent in "semi-rural," and 5 percent in "rural areas." The distribution of the respondents' places of current residence reflects the actual current spatial distribution of the German population, as published by Schürt, Spangenberg, and Pütz (2005).[5]

Results and Discussion

The choice data analysis was carried out with Latent Gold Choice 4.0 software. The statistical analysis models used in this software are based on individual-specific choice frequencies (Louviere, Hensher, and Swait 2000); for technical details of the models underlying the analysis, see Appendix B. In this study, the choice options are housing development alternatives, with several attributes, for example, housing density, green spaces, car parking options, and so forth (Table 1). Attribute coefficients and p-values (Wald tests) were calculated, which demonstrate significant differences among respondent preferences.

Discrete Choice Analysis (DCA) with no Heterogeneity Assumed ("One-Class Model")

For the overall model or "one-class model" (in terms of LCA), all respondents are assumed to have homogeneous preferences regarding the housing development alternatives being evaluated. In this case, the analytical model reduces to the regular multinomial logit model as discussed above; for technical details, see equation (1) in Appendix B. The model adequacy was measured using Pseudo-$R^2(0)$, which reached a value of .22 (see Table 2). According to Constanzo et al. (1982), a Pseudo-$R^2(0)$ of .2 to .4 documents a good model fit.

We next discuss the parameters using the coefficient values from the estimation as shown in Table 2. A positive coefficient

Table 2. Choice Model—Results for the "Overall" or 1-Class Model (with Homogeneous Preferences Assumed across All Respondents; $n = 402$)

Attributes	Level (when applicable)	Coefficient	Z-value
Building density	Low	.17**	2.7757
	Medium	−.06	−0.8641
	High	−.11	−1.8069
Green spaces	Small number	−.12*	−1.9635
	Medium number	−.03	−0.4533
	High number	.15**	2.6022
Central plaza	No central plaza	−.07	−1.0837
	Central plaza	−.03	−0.5294
	Central plaza and shop	.10	1.5825
Infrastructure provision	Auto-oriented	.13**	3.1936
	Pedestrian-oriented	−.13**	−3.1936
Public transportation (transit service frequency)	Low	−.91***	−13.0491
	Medium	.35***	5.9426
	High	.56***	9.2597
Technical installations for resource protection	Technical installations provided (e.g. solar panels)	.50***	11.4975
Representation of social classes	Mixed social structure	.17***	3.8943
Costs	Costs	−.10	−1.8378
None	Alternative A or B chosen	.27***	5.9764
	Neither A nor B chosen	−.27***	−5.9764
Log-likelihood = 1078,55			
$R^2(0) = .2173$			

The attributes are coded in effects coding (except for the cost attribute, which is linear coded). Effects coding means that the attributes will sum to zero over the categories of the nominal attribute concerned. For two-level variables, here, only one level is shown, as the other is the negative equivalent (except for the infrastructure provision attribute, where coefficient-values for both levels are shown for explanatory reasons). Latent GOLD Choice 4.0 computes the required design vectors using effects coding (ANOVA type) for nominal dependent variables.
Note: *** 1% significance level, ** 5% significance level, * 10% significance level.

value indicates that the attribute level has a positive effect on the choice of an alternative, whilst a negative coefficient displays a negative effect. Almost all of the housing development attributes are significant and have the expected sign. For example, it is probable that a housing development alternative would be preferred as costs decrease and as transit frequency increases. The "central plaza" attribute is the only attribute in the one-class model analysis without statistical significance, suggesting that this variable does not make a difference to the respondents" choice of housing development options in the one-class model.

For the density parameter, three levels were provided for analysis. The positive value for the low building density parameter (represented by single-family houses in Table 1) shows that this was preferred by the respondents to the two levels of higher building densities (represented by row houses and apartments). This means that the more row houses and apartments and the less single-family homes there are in a housing development alternative, the less likely respondents will choose it. This is consistent with other studies (Morrow-Jones, Irwin, and Roe 2004; Gordon and Richardson 1997), where results showed that people preferred lower building densities.

A "large number of green spaces" has a positive impact on the probability of a housing development alternative being chosen. To the extent that any style of housing development can provide large green areas (represented by approximately one small tree and one large tree per site and two streets additionally lined with trees; Table 1), people would prefer to live in such "green" neighborhoods. Morrow-Jones, Irwin, and Roe (2004) conducted a conjoint analysis using the common multinomial logit method and found that in general and all else being equal, the presence of any kind of green spaces (parks or agricultural land) positively affects the likelihood of a housing alternative being chosen.

The "infrastructure provision" attribute showed a positive parameter value for the auto-oriented infrastructure development, represented by streets for cars throughout the neighborhood and car parking provided directly in front of each building (Table 1). An alternative infrastructure development was conceptualized as a variant with cluster parking and connected walkways to the houses. But the negative value for the cluster parking variant and the positive value for the auto-oriented infrastructure indicate that the preferred option was the conventional auto-oriented infrastructure development.

The highest coefficient values in the one-class model were recorded with respect to the "public transport" attribute, which took on the values of "low," "medium," and "high" frequency of transit services available to the residents (Table 1). "Medium" as well as "good local transport connections" were rated positively by the respondents, suggesting that the marginal value of local transit services increases as the frequency of transit services increases. The high approval of "public transit" could reflect the reliance of many German households not only on personal means of transport but also on public transport: in Germany, around two-thirds of all households reliant on public transport also have one household member using a car on a typical working day (Franz 2006, 63).

With regard to the use of technical installations for the conservation of energy resources, the respondents evaluated the installation of solar panels positively. A housing development with solar panels is more likely to be chosen than a conventional housing development that does not make use of photovoltaic or solar thermal systems. The approval of "solar panels" could be attributed to the current federal subsidies attached to solar thermal and photovoltaic panels in Germany and the resulting market dynamics (Asendorpf 2006).

Socially mixed housing development alternatives were preferred to homogeneous resident social structures, in regard to income and age. In general and all else being equal, the respondents would like to live in socially diverse neighborhoods rather than in communities with residents of equal age and income.

The value of the cost attribute indicates that the effect of choosing a housing alternative with a higher building cost level is negative. This corresponds to economic theory (Boxall and Adamowicz 2002, 435; Bergmann, Hanley, and Wright 2006, 1010). The cost attribute, like all other attributes in the statistical design of the choice experiment, was assigned to each alternative at random. Cost levels have not been specifically attributed to any other independent variable by means of the statistical design, and no willingness-to-pay measures are reported in this article. The negative value and statistical significance of the cost attribute, however, indicate that it was perceived as an effective measure of cost constraints by the respondents.

Finally, the "none" attribute was specified to equal 1 when either housing development option A or B was selected in a choice set, and 0 when neither the A nor B option was selected. The positive and significant value of the "none" parameter implies that the respondents showed interest in comparing both and choosing one of the two housing development options and the housing development characteristics.

The results of the one-class model analysis show that the target group of private home buyers preferred more conservative developments. This means that respondents preferred low building density—that is, single-family homes linked to a standard auto-oriented infrastructure—to a more dense development with cluster parking and pedestrian-oriented infrastructure development. These results support the common assumption that low building densities and single-family homes with large private green spaces are the dominant lifestyle model. Recent studies suggest that almost 80 percent of all young Germans aspire to a life in a single family home or duplex/semidetached house with its own garden (Hassenpflug 2000, 35; Bayern Labo 2005, 27).

Preference Heterogeneity Identified from Latent Class Analysis (LCA) ("Three-Class Model")

Following the one-class-model calculations, two-, three-, and four-class models were calculated in Latent Gold Choice 4.0. This was done to inquire into market segments ("latent classes") with homogeneous preferences without using a priori segmentation criteria such as socioeconomic status. The determination of the number of market segments (c) appropriate to the characterization of a given population is not part of the maximization procedure from which the parameter estimates are derived. The standard procedure is to sequentially estimate model parameters for increasing values of segments c ($c = 1, 2, 3, 4, \ldots$) until the point at which an additional segment does not improve model fit as measured by some statistical criterion, such as log-likelihood (LL), Pseudo-$R^2(0)$, BIC, AIC, and AIC3 (see Table 3). The lower the statistics, the better the fit of the model (Boxall and Adamowicz 2002).[6]

In comparing the four-class model statistics to the three-class model statistics, the AIC improves very little in the three-class model, while the AIC3 and the BIC both increase considerably. Hence, the four-class model was excluded from further analysis. But the three-class model shows some improvement with respect to AIC and AIC3 over the two-class model. In addition, a *bootstrap* procedure was carried out that gave a significant p-value for the preference of the three-class model as opposed to the two-class model. From the analysis of the model statistics, as well as from the bootstrap procedure, the three-class solution was chosen as the best estimation of unobserved data heterogeneity.

The Pseudo-$R^2(0)$, as a measure of model adequacy, reached a value of .45 for the three-class model as compared to the Pseudo-$R^2(0)$ value of .22 for the one-class model. In other words, the latent class model, which accounts for preference heterogeneity (in this case, three market segments), showed a much better model fit than the one-class model, which assumed preferences to be homogeneously distributed among respondents.

To investigate preference heterogeneity in more detail, we used attitudinal data to measure the environmental awareness of each respondent: in the questionnaire, four Likert scale variables were provided to form an additive index as a measure of the degree of "environmental awareness" (see Table 4).[7]

In latent class modeling, attitudinal data or other household characteristics can be directly incorporated into equation (4) as covariate (see Appendix B). This means that class or segment membership is jointly affected by both respondents' choices and individual households' characteristics (Birol, Karousakis, and Koundouri 2006, 152; Morey, Thacher, and Breffle 2006). Accordingly, the index variable on "environmental awareness" was introduced as covariate into equation (4).

Table 3. Latent Class Model Statistics

	LL	BIC(LL)	AIC(LL)	AIC3(LL)	R^2 (0)
1-Class choice	−1,078.5542	2,235.0622	2,183.1083	2,196.1083	.2173
2-Class choice	−1,036.2943	2,240.4892	2,128.5886	2,156.5886	.3456
3-Class choice	−1,003.7008	2,265.2491	2,093.4016	2,136.4016	.4447
4-Class choice	−985.2262	2,318.2467	2,086.4525	2,144.4525	.5291

Table 4. Variables Selected to Calculate an "Environmental Awareness Index"[a,b,c]

Variable 1 (see questionnaire, Q.5): "In my house, I want to use as much energy as possible from renewable sources."
Variable 2[a] (see questionnaire, Q.5): "In my opinion, there is little point putting solar panels onto a building"
Variable 3 (see questionnaire, Q.5): "I don't believe that heating a house really uses as much energy as is often claimed in the press or media."
Variable 4 (see questionnaire, Q.12): "Technical installations are installed in the housing development to save resources."

The index was calculated as an additive index, and all four variables were assigned equal weights in calculating the index. All variables included to the index were measured along a 5-point Likert-type scale. For variables 1-3, the scale was 1, *I strongly disagree*; 2, *I tend to disagree*; 3, *I have no opinion on this*; 4, *I tend to agree*; 5, *I strongly agree*. For variable 4, the scale was 1, *not at all important*; 2, *not very important*; 3, *I have no opinion on this*; 4, *quite important*; 5, *very important*.

[a]Variable 2 has been recoded prior to adding its values to the index.

As regards the covariate parameter ("environmental awareness"), the parameter reaches statistical significance for all three classes (see Table 5). Accordingly, the sample can be divided up into one segment with a negative attitude towards the index variable (as this segment shows a negative coefficient value on the covariate) and two segments with a positive attitude towards the index variable (as these two segments show positive coefficient values at different levels) (Table 5). Using the environmental awareness index as covariate, segment one included respondents with "low environmental awareness" (or "non-ecos"), segment two respondents with "high environmental awareness" (or "high ecos"), and segment three respondents with "some environmental awareness" (or "ecos").

Wald statistics were used to test for the statistical significance of taste differences among the three segments with regard to the housing development attributes. The results showed that the majority of attributes differed significantly between the three segments with the exception of the "central plaza," "green spaces," and "cost" attributes (Table 5, last column, for Wald statistics on statistical significance of differences between classes).

Analyzing the preferences within the three segments, we found all attributes to have at least one level showing statistical significance in at least one segment. For example, the "central plaza" attribute shows statistically significant parameter estimates in the first ("non-ecos") and third segment ("ecos"). In contrast, the "central plaza" attribute did not show any statistically significant parameter estimates in the one-class model. In other words, by means of latent class analyses, it was possible to identify more detailed statistically significant differences in tastes from the sample (Table 5).

As for the statistically significant parameter estimates of the housing development attributes, the differences in respondents' choices can be attributed to class memberships as follows: in a similar way to the one-class model results, respondents with "low environmental awareness" preferred single-family homes over row houses and apartment houses. In contrast, the two "ecos" segments would prefer to live in higher building densities. This finding indicates a high potential for significant resource savings: for example, higher building densities with row and apartment houses instead of single family homes or duplex/semidetached houses could reduce the present amount of land consumption for new housing developments in Germany by approximately 50 percent (Sieverts 2005).

The two segments of the "environmentally awareness" did not express statistically significant approval or disapproval with regard to green spaces. But the "nonenvironmentalist" segment of respondents (segment one) significantly disapproved of a "small number of green spaces" within the development site.

Both the "non-ecos" and "ecos" segments had positive preferences for the "central plaza with shop" parameter. In other words, respondents preferred to live in neighborhoods that offer nearby shopping facilities. This finding is consistent with other analyses: Kuckarts (2006) carried out a nationwide household survey in Germany to investigate preferences for "neighborhood quality," among other things. The author reports that "nearby shopping facilities" were evaluated as one of the most important criteria for "neighborhood quality." Similarly, Hartloff et al. (2002, 243) report of a survey in which proximity of shopping facilities and housing units significantly added to the residents" willingness to pay for groceries.

The segment of the "non-ecos" shows a significant value for the "central plaza" parameter, which represents a central plaza with no shopping facilities but with additional public open space to residents. The parameter has a negative value, which means that respondents in this segment disapprove of

Table 5. The Latent Class Model Results for Respondents of Different "Environmental Awareness"

		Segmentation models for respondents of different environmental awareness (3-class model)			
		Segment 1: Non-ecos	Segment 2: Ecos (high)	Segment 3: Ecos	
	Class size (share)	197 (0.49)	117 (0.29)	88 (0.22)	
Attributes	Level (when applicable)	Coefficient	Coefficient	Coefficient	Wald-test[a] p-value
Density	Low	0.50***	−1.62*	−0.14	.001
	Medium	−0.13	2.08*	−0.44	
	High	−0.37**	−0.46	0.58*	
Green spaces	Small number	−0.14	0.33	0.10	.83
	Medium number	−0.01	−0.68	−0.09	
	High number	0.13	0.35	−0.01	
Central plaza	No central plaza	0.01	−0.02	−0.38	.52
	Central plaza	−0.24*	−0.68	−0.26	
	Central plaza and shop	0.23*	0.66	0.64*	
Infrastructure provision	Auto-oriented	0.23**	−0.21	−0.29	.06
	Pedestrian-oriented	−0.23**	0.21	0.29	
Public transportation (transit service frequency)	Low	−0.75***	−3.80***	−1.18***	.03
	Medium	0.37***	1.51*	0.30	
	High	0.38***	2.29*	0.88**	
Technical installations for resource protection	Technical installations provided (e.g. solar panels)	0.19*	2.56*	1.29**	.01
Representation of social classes	Mixed social structure	0.08	2.16	0.39	.06
Costs	Costs (linear coded)	−0.02	−1.02	0.13	.34
None	Alternative A or B chosen	0.52***	1.31*	−0.93**	.001
	Neither A nor B chosen	−0.52***	−1.31*	0.93**	
Model for classes					
Covariate	Environmental awareness index (factor loadings)	−0.71***	+0.45*	+0.26	.001
Log-likelihood = −1,003.70					
$R^2(0)$ = 0.4447					

The attributes are coded in effects coding (except for the cost attribute, which is linear coded). Effects coding means that the attributes will sum to zero over the categories of the nominal attribute concerned. For two-level variables, here, only one level is shown, as the other is the negative equivalent (except for the infrastructure provision attribute, where coefficient-values for both levels are shown for explanatory reasons). Latent GOLD Choice 4.0 computes the required design vectors using effects coding (ANOVA type) for nominal dependent variables.
[a]The Wald test's p-value shows significant differences among the three segments.
Note: *** 1% significance level, ** 5% significance level, * 10% significance level.

living in a neighborhood where a central plaza (without shops) is located. This is what could be expected from the "non-ecos," who preferred lower building densities over higher building densities: living in single-family homes and associated large private green spaces reduces the preferences for additional public open space in the "non-ecos" segment. Unfortunately, the "central plaza" (without shops) parameter did not reach statistical significance in either of the "ecos" segments. As a result, we cannot report on how additional public open space can compensate for living in higher building densities. Morrow-Jones, Irwin, and Roe (2004), however, reported from a survey of home owners and found that reduced private open spaces associated with higher building densities were compensated by increasing nearby open spaces. To sum up, the analysis of the "central plaza" attribute leads to the conclusion that the importance of nearby shopping facilities is rated more highly than having a central plaza.

The parameter estimates for the "infrastructure provision" attribute illustrate some contrasting opinions among the segments (Table 5): "non-ecos" respondents chose the auto-oriented option over the pedestrian-oriented infrastructure development. In contrast, both "ecos" segments would prefer cluster parking and pedestrian-oriented development over auto-oriented development. This finding contrasts with some literature, where "pedestrian-oriented" infrastructure is said to be difficult to implement, as residents would not want to live in a neighborhood that does not provide on-site parking facilities (Fuchs and Schleifnecker 2001). In this study, however, we found that a segment of respondents prefer pedestrian- over auto-oriented development.

With regard to "public transportation services," "technical installations for resource protection," and "representation of social classes," all respondent segments shared relatively similar preferences, as the parameters show the same signs across: the "ecos," however, judged a high local transit frequency much more positively than the "non–environmentally aware." This is in line with other research: Zhang, Herzog, and Hauser (2006, 323) conclude that pedestrian-oriented urban design (which was preferred by the "ecos" segment of respondents in this study) makes transit services more likely to be considered by travelers.

The "technical installations (e.g., solar panels)" parameter also shows the same sign for all three segments. Here, too, it was the two "ecos" groups that showed higher coefficient values than the "non-ecos" group. This finding indicates that solar panels are more important to more environmentally aware respondents, although even the "non-ecos" rated having solar panels over not having solar panels. The "representation of social classes" attribute also shows higher positive parameter estimates among the two "ecos" segments. This means that living in a diverse neighborhood with regard to different age and income groups is more important to respondents with higher environmental awareness. This finding contrasts with other analyses, in which households are found to prefer more homogeneous neighborhoods with regard to the social structure of residents (Opaschowski 2005), or a rising number of "prestige" and "lifestyle" communities is attributed to preferences for socially homogeneous neighborhoods (Genis 2007; Leisch 2002). Accordingly, our results were somewhat unexpected, as the positive evaluation of a heterogeneous population structure in the neighborhood does not offer a direct benefit, whereas a good public transportation system does; it shows a fundamental openness towards a planning subject that is often talked about but seldom put into practice (Rohr-Zänker 2005, 10; Ministry of the Environment Baden-Württemberg et al. 2005, 46). Contrary to the one-class model, the "level of building costs" attribute received neither significant coefficient values nor a significant separation between classes according to the Wald *p*-values.

To sum up, the results of LCA can be interpreted in line with the assumed preferences of people with "high environmental awareness" and people with "low environmental awareness." The group of respondents with "high environmental awareness" approved of all attributes relating to sustainability as defined in this study, such as "higher densities" and "pedestrian-oriented" infrastructure. In contrast, respondents in the "non–environmentally aware" segment preferred more conventionally designed housing developments, especially with regard to lower building densities and auto-oriented infrastructure. Surprisingly, however, positive attitudes towards some aspects of sustainability can also be seen among the "non–environmentally aware": the integration of "technical installations (e.g., solar panels)," "high frequency of public transportation," and a "socially mixed development" were positively judged by all respondent segments.

Implications for the Evaluation of the Possible Market Share of Sustainable Housing Development

The results of LCA showed a much higher potential for sustainable housing development among different segments of private home buyers than one would assume when only looking at the results of the one-class model. Through LCA, the segment of respondents with "high environmental awareness" was identified, which makes up around 29 percent of all respondents and could be labeled the "green" segment in the market for new housing. Given the "high ecos" segment's positive evaluations of all criteria of sustainable housing development and taking preferences as indicators to evaluate market potential, we conclude that the market potential for sustainable housing development is higher than reported in other studies, which claim that sustainable housing development in Germany is restricted only to a small segment of "ecological extremists" (Fuchs and Schleifnecker 2001, 66). Our finding is in line with other research that found preferences for higher building densities in a significant part of the sample (Mayer and Gearin 2001). From the preferences identified in this study, we conclude that the marketplace still has room to exploit the overlap between sustainability and the choices of housing investments made by private home buyers, as the present market share of sustainable housing development is estimated to be well below 10 percent (Wolpensinger and Rid 2010).[8]

The group of respondents with "low environmental awareness" constitute 49 percent of the sample and take a rather critical view of sustainable aspects of housing development planning, such as higher building densities and pedestrian- instead of auto-oriented infrastructure. Given this, the demand for a broader concept of sustainability is dependent on the development of "environmental awareness" among households and private home buyers. Recent studies have reported a growing level of "environmental awareness" among the German population since the 1980s (cf. Kuckarts 2006; Dröge 1997; Dittmann 1998, 20), but the degree of "environmental consciousness" is subject to high fluctuations and therefore difficult to forecast (Kuckarts 2006, 13).

From the size of the "green" market segment (29 percent of the sample) identified through LCA, however, we conclude that market factors other than low demand must be considered to explain the low market share of sustainable housing in Germany. One could argue that private home buyers are not opting for sustainable housing development alternatives because these forms of housing are more expensive than "conventional" housing developments, and private home buyers' decisions are limited by budget restrictions. In the United States, this seems to be true: Palmeri (2007, 67) write that sustainable forms of housing are on offer, yet "buyers are clearly put off by higher up-front costs." In Germany, the literature points in a different direction: Fuchs and Schleifnecker (2001, 249) investigated the cost-benefit ratio for selected "ecological" construction techniques, such as improved insulation, energy efficient heating, and solar panels, and concluded that investments in "ecological" construction techniques pay off quickly and lead to reductions in building lifecycle costs. In a recent study, Prehal and Poppe (2003) reported on an investigation into reducing the construction costs of energy-efficient housing developments in Austria: although initial construction costs of sustainable housing do not yet match those of "standard" housing, the cost gap will narrow in the near future through further innovation and standardization of construction processes.

Other aspects of sustainable housing developments might be more difficult to evaluate in terms of costs; building costs, for example, are subject to site peculiarities; models do exist, however, to describe some cost-related factors with regard to other sustainable housing criteria (see Siedentop et al. [2006] for a review of the related literature). While increasing green spaces or transit service frequencies certainly add to costs, sustainable housing development also offers opportunities for significant savings (Wolpensinger and Rid 2010). Higher densities can lead to building cost savings, *ceteris paribus*, due to lower land costs per housing unit or lower costs for water, electricity, and road infrastructure per housing unit (Siedentop et al. 2006). A more pedestrian-oriented infrastructure development can help to reduce building costs, as at least some roads within the development site can be designed as walkways (and hence save on paving and other roadwork costs) and as costs for car parking and garages can be reduced (Bavarian Ministry of the Interior 2001, 41). This is especially significant in the case of cost savings for expensive subterranean garages. Including a central plaza in housing developments, however, is often associated with higher costs, as the site cannot be developed in as commercially efficient a manner as would otherwise be possible. In contrast, proximity to shopping facilities reduces travel costs to some degree and, thus, ecologically and economically adds to sustainability.

For these reasons, we conclude that the high market potential for sustainable housing might be limited by slightly higher initial construction costs. This might explain the reduced current demand to some extent. Because the present market share of sustainable housing is well below 10 percent in Germany, follow-up studies can investigate market inefficiencies in the German housing market, to explain the discrepancy between the latent demand identified in this study and the low market share of sustainable housing. A recent study by Levine, Inam, and Torng (2005) suggests that there indeed exist market inefficiencies in the housing and transport markets in the metropolitan areas of Boston and Atlanta—insufficient accounting for heterogeneous preferences and hence insufficient choices for diverse populations and households.

If market inefficiencies can explain the low market share of sustainable housing developments in Germany, we also recommend further investigating housing development planning regulations. In Germany, housing developments are regulated by municipal planning offices, which set the framework for parameters such as building density, quantity and quality of green spaces, and infrastructure provision, through zoning and planning regulations. More research is necessary to find out whether current zoning regulations actually add to market inefficiencies regarding sustainable housing developments and how local planning guidelines can be modified to best meet the high market potential identified for sustainable housing development.

Conclusion

Our results confirm that an empirical approach involving the application of a DCE and LCA is suitable for analyzing the complex choice decisions of private home buyers. We found the LCA approach well suited to the analysis of our data, because (1) the LCA model showed a much better model fit compared to the one-class model according to the statistical criterion of Pseudo-$R^2(0)$, and (2) the LCA model results allowed for a richer and more detailed analysis of home buyers' preferences through the identification of three distinct market segments.

Analyzing various market segments based on empirical data, in particular, allows us to demonstrate possible market volume for sustainable housing development planning, which cannot be observed from data on present or past individual behavior. Here, our results show that the differences between the respondents with "high environmental awareness" or "low environmental awareness" can be plausibly interpreted.

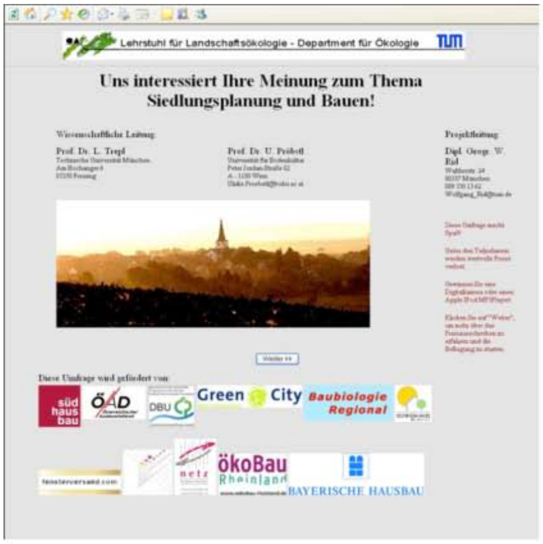
Lastly, some limitations of this study need to be mentioned. The study used eight housing development characteristics that we believed to be central to the concept of sustainable housing development. There are, however, other housing characteristics that can be included to empirically test models of sustainable housing development. Some housing characteristics discussed in connection with improving the environment or the degree of sustainability are used throughout various international empirical research applications, such as a higher building density or pedestrian-oriented neighborhood layout (Bramley and Power 2009; Lin and Yang 2006). Some housing development characteristics might be related to housing development concepts more popular in the United States, for example, neotraditional or New Urbanist neighborhoods and associated characteristics such as grid street patterns or smaller block sizes (Morrow-Jones, Irwin, and Roe 2004, 172); while others might be more popular in Europe, for example, the concept of sustainable housing development and associated characteristics such as sustainable communities (Bramley and Power 2009, 32-34). Further research needs to be carried out to empirically investigate which housing development characteristics indeed lead to environmental improvements in every local context and which are only applicable in specific regional settings.

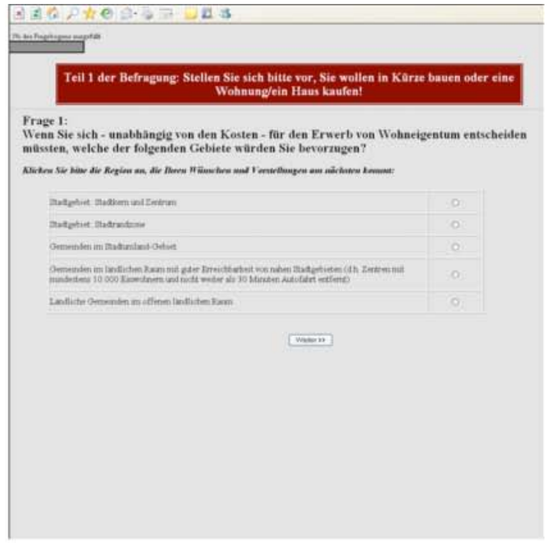
Another limitation of this study is that we did not account for correlation between the parameters, for example, to what extent preferences for public transit are connected to preferences for a pedestrian-oriented neighborhood layout. To better understand the correlations among parameters, further analyses should be undertaken, perhaps with the help of random parameter logit models.

Appendix A
The Internet Questionnaire—Translation

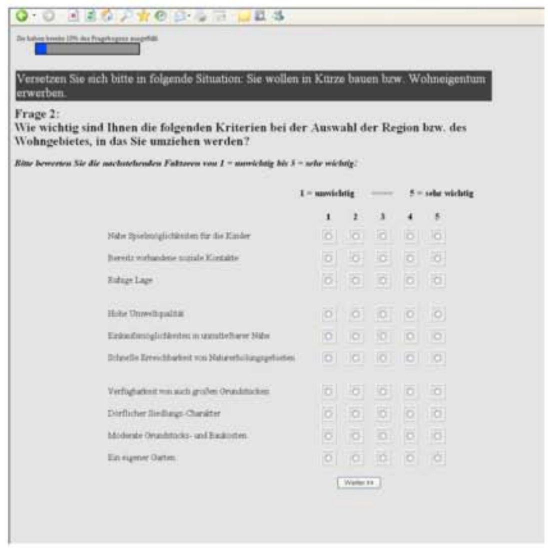
Page 1—Information about project hosts and addresses
Page 2—Information about incentives for completing the survey
Page 3—Introduction
Page 4—Q.1: In which areas would you prefer to purchase a housing property (if costs did not matter)? (City center, city; urban fringe, or rural communities within 30 minutes of a city of more than 10,000 inhabitants)
Page 5—Q.2: Please evaluate the following housing development characteristics on a scale ranging from 1 = *unimportant* to 5 = *very important*. (E.g., playgrounds for kids, high environmental quality, nearby shopping facilities, etc.)
Page 6—Q.3: Please indicate how important it would be for you to be involved in the planning process with regard to the following housing development characteristics (on a scale ranging from 1 = *unimportant* to 5 = *very important*). (E.g., size and location of green spaces; individual design of the building's façade and entrance; infrastructure provision [auto-oriented or pedestrian-oriented development])
Page 7—Q.4: Please evaluate the following statements on a scale ranging from 1 = *I strongly disagree* to 5 = *I strongly agree*. (E.g., "My choice of residential location is very much dependent on the social status of that residential location"; "I would prefer to live in a neighborhood of reasonable size"; "For me, it is important to have clear boundaries of a plot")
Page 8—Q.5: Please evaluate the following statements (attitudes towards housing energy-efficiency measures) on a scale ranging from 1 = *I strongly disagree* to 5 = *I strongly agree*.
Page 9—Q.6: Please consider a scenario, where technical installations, such as solar panels, help to save resources but lead to higher initial building costs. After some time, however, the investment pays off through cost savings, e.g. for energy consumption. Under this condition, please indicate your most preferred scenario. ("Technical installations lead to 2 percent higher initial building costs, and the additional investment pays itself off in 30 years"; "Technical installations lead to 5 percent higher initial building costs, and the additional investment pays itself off in 20 years"; "Technical installations lead to 10 percent higher initial building costs, and the additional investment pays itself off in 10 years"; "I am not interested in technical installations to save resources.")
Page 10—Q.7: Please indicate your house buying preferences. (E.g., "I want to buy a house" or "I want to buy an apartment"; "I am planning to buy this housing property for a household of "more than 4 persons", "2-4 persons", "2 persons" or for "1 person")
Page 11—Q.8 (learning task, part 1): Please evaluate different characteristics of a housing development with regard to a "central plaza." ("No central plaza," "central plaza provided," or "central plaza and shopping facilities provided")
Page 12—Q.9 (learning task, part 2): Please evaluate different characteristics of a housing development with regard to the infrastructure provision. ("Pedestrian-oriented development" or "auto-oriented development")
Page 13—Q.10 (learning task, part 3): Please evaluate different characteristics of a housing development with regard to the quality of green spaces. ("Low quality of green spaces," "moderate quality of green spaces," or "high quality of green spaces")
Page 14—Q.11 (learning task—part 4): Please evaluate different characteristics of a housing development with regard to the building density. ("Low building density," "moderate building density," or "high building density")
Page 15—Q.12 (learning task—part 5): Please evaluate different characteristics of a housing development with regard to the "frequency of local public transport," "technical installations to save natural resources," and "mixed social structure of residents (age, income, etc.)" on a scale ranging from 1 = *not at all important* to 5 = *very important*.
Page 16: Introduction and explanation of how to answer the choice sets.
Pages 17-20: A sequence of four choice sets.
Page 21—Q.13 (A): How old are you?
Page 21—Q.13 (B): How close are you to actually making a house buying decision? ("I have already purchased a housing property"; "I am not planning to buy a housing property in the next future")
Page 21—Q.13 (C): How would you describe your actual residential location? (City center, city; urban fringe, rural communities within 30 minutes of a city of more than 10,000 inhabitants)
Page 21—Q.13 (D): How much are you intending to spend to buy a housing property?
Page 22: Respondents are given the opportunity to leave their email-address to have the chance of winning one of the prizes introduced before.
Page 23: End of the questionnaire.

Pages 11-15 (learning task): In the learning tasks, the respondents are introduced to the attributes and attribute levels of the choice sets.

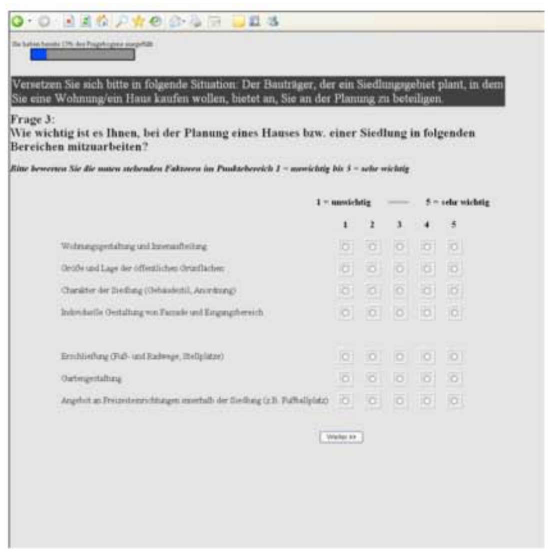

Lehrstuhl für Landschaftsökologie - Department für Ökologie
Uns interessiert Ihre Meinung zum Thema
Siedlungsplanung und Bauen!
Diese Umfrage wird gefördert von:
Green City
Baubiologie Regional
ökoBau Rheinland
BAYERISCHE HAUSBAU


Teil 1 der Befragung: Stellen Sie sich bitte vor, Sie wollen in Kürze bauen oder eine Wohnung/ein Haus kaufen!
Frage 1:
Wenn Sie sich - unabhängig von den Kosten - für den Erwerb von Wohneigentum entscheiden müssten, welche der folgenden Gebiete würden Sie bevorzugen?


Jeder Befragte, der den Fragebogen komplett bearbeitet, hat die Möglichkeit, an einem Preisausschreiben teilzunehmen!
Am Ende des Fragebogens können Sie sich zur Teilnahme anmelden. Da diese Befragung anonym erfolgt, bitten wir Sie, dort nur Ihre Handy-Nummer bzw. Telefon-Nummer zu hinterlassen.
Wenn Sie an den Ergebnissen der Studie Interesse haben, senden wir Ihnen diese nach Auswertung aller Daten gerne per Email zu. Die Email Adresse zum Anfordern der Studie finden Sie ebenfalls am Ende des Fragebogens.
Sie können folgende wertvolle Preise gewinnen!
(1) Eine Digitalkamera "Pentax S45"
(2) Zwei "IPOD Shuffle"
(3) Vier Geschenk-Gutscheine von "Amazon"

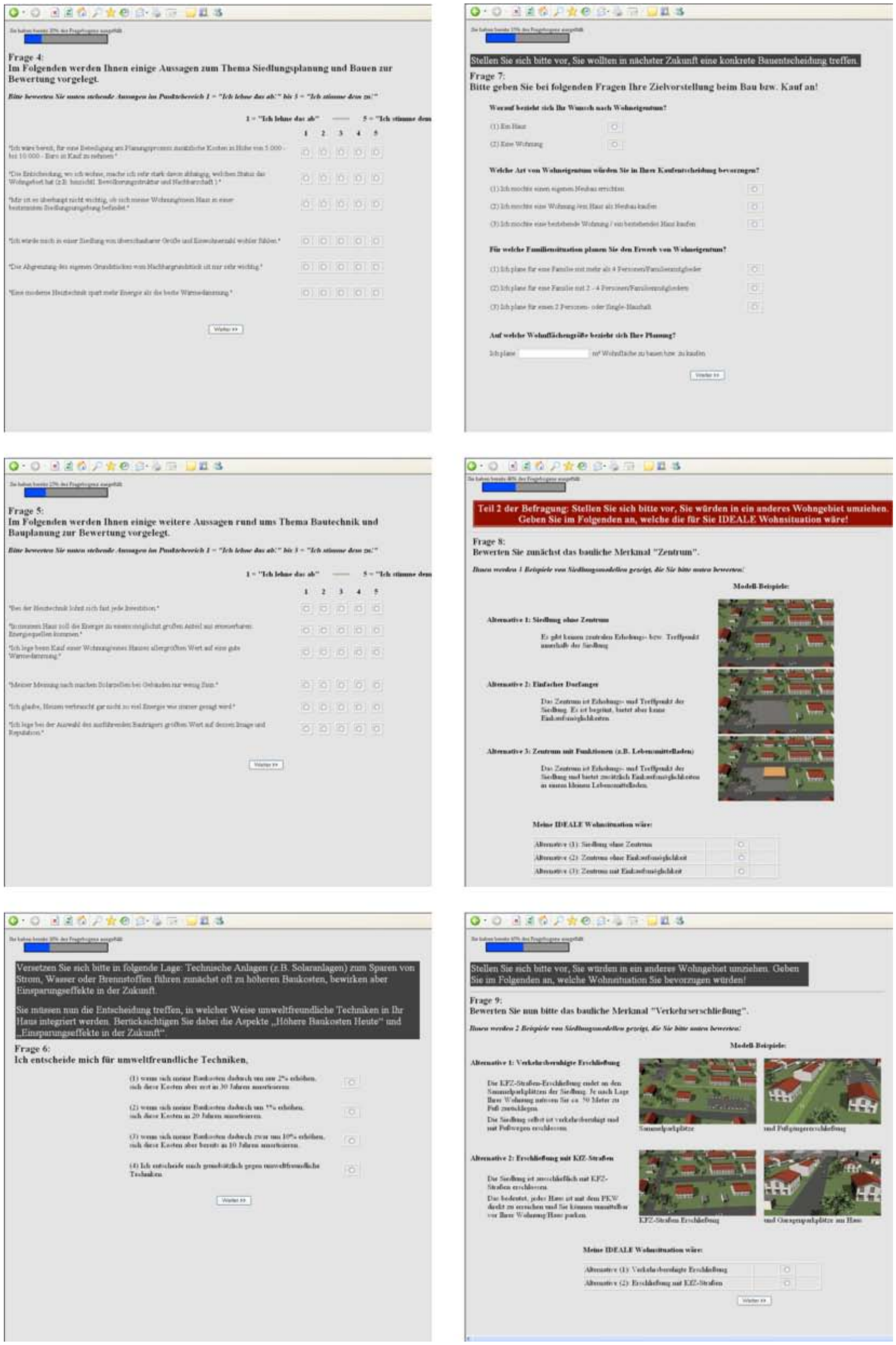

Versetzen Sie sich bitte in folgende Situation: Sie wollen in Kürze bauen bzw. Wohneigentum erwerben.
Frage 2:
Wie wichtig sind Ihnen die folgenden Kriterien bei der Auswahl der Region bzw. des Wohngebietes, in das Sie umziehen werden?


Wohnen ist ein Grundbedürfnis jedes Menschen, aber...
Prof. Dr. habil. U. Pröbstl,
Dipl. Geogr. W. Rid


Versetzen Sie sich bitte in folgende Situation: Der Bauträger, der ein Siedlungsgebiet plant, in dem Sie eine Wohnung/ein Haus kaufen wollen, bietet an, Sie an der Planung zu beteiligen.
Frage 3:
Wie wichtig ist es Ihnen, bei der Planung eines Hauses bzw. einer Siedlung in folgenden Bereichen mitzuarbeiten?

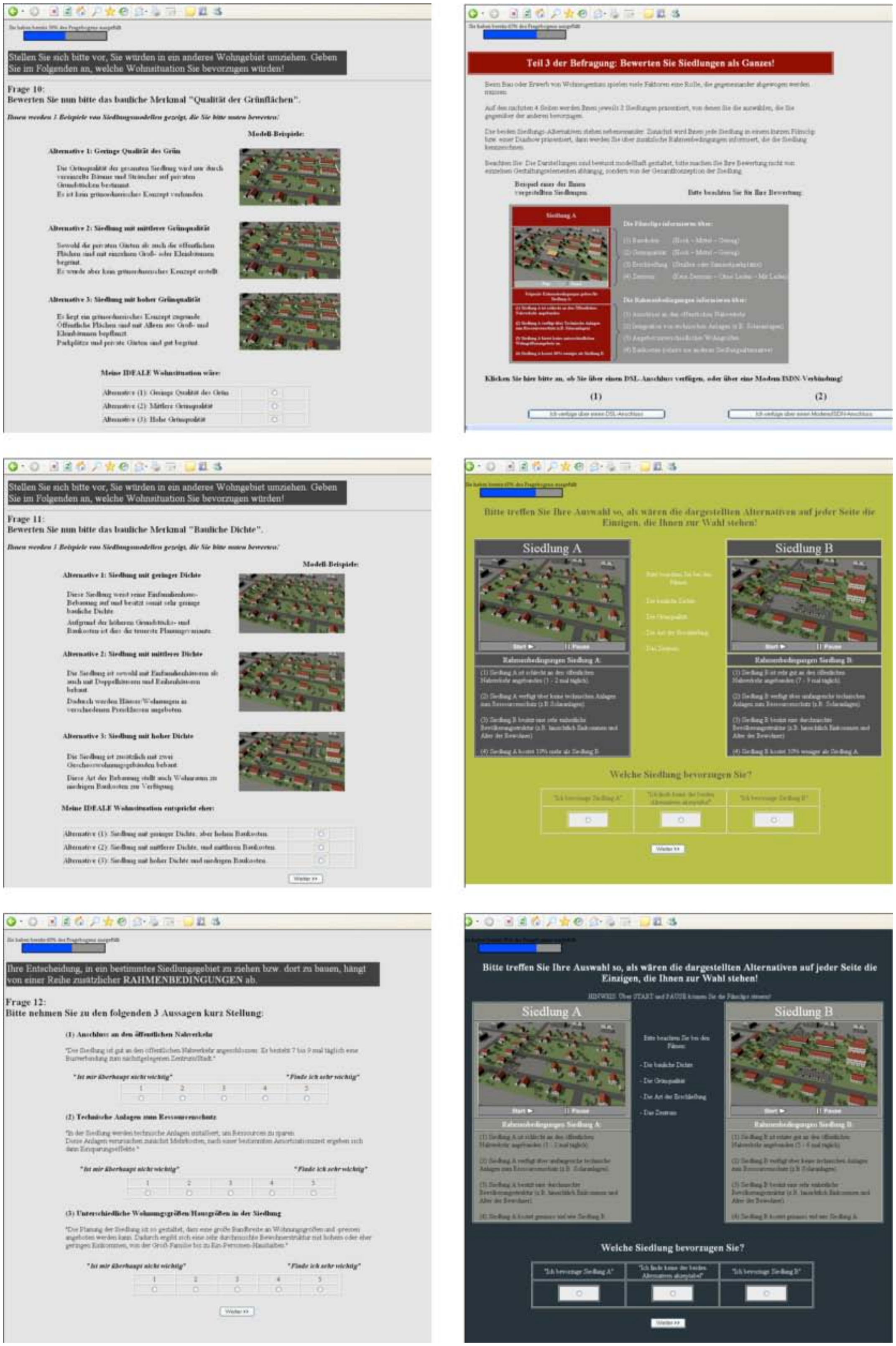
(continued)

Figure 2. (continued)



(continued)

Figure 2. (continued)



(continued)

Figure 2. (continued)

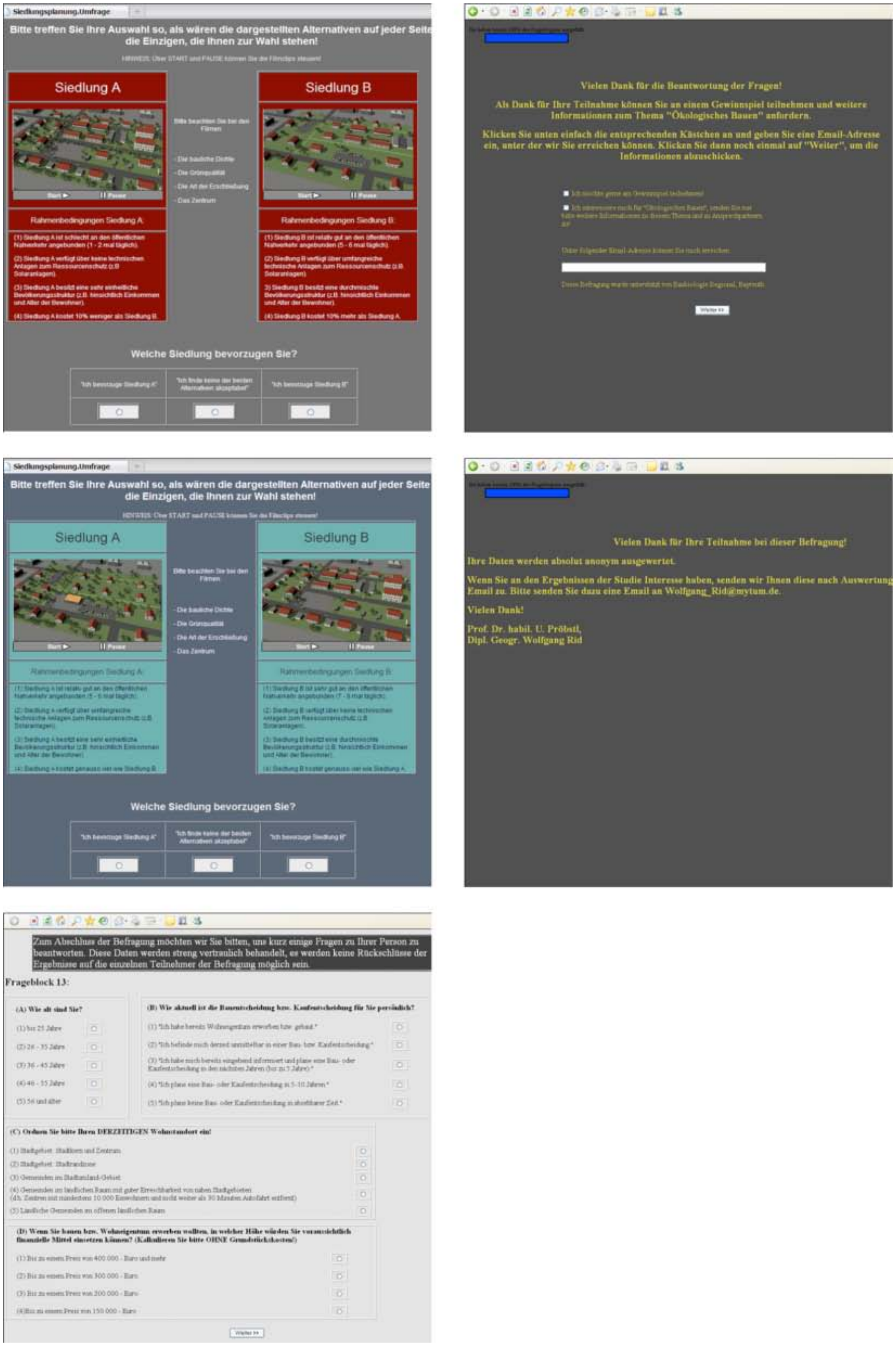


Figure 2A. The questionnaire

Appendix B

In the multinomial logit model, the predicted probability of observing outcome m is given by

$$\mathrm{PR}(y_n = m \mid X_n) = \frac{\mathrm{EXP}(\nu_{nm})}{\sum_{j=J}\mathrm{EXP}(\nu_{nj})} = \frac{\mathrm{EXP}(X_{nm}\beta)}{\sum_{j=J}\mathrm{EXP}(X_{nj}\beta)} \text{ FOR } m = 1 \text{ TO } J. \quad (1)$$

$\Pr(y_n)$ is the probability of individual n choosing alternative m (out of the total of J alternatives) and v_{nm} is the systematic (measurable) utility, which is a function of X_{nm} and the vector β. X_{nm} defines a matrix of attributes that pertain to choice options and β contains the parameters indicating the effects of the independent attributes of choosing one alternative over another. In most applications v_{nm} takes a linear-in-parameters additive form. In our study, the vector v_{nm} is defined as follows:

$$\begin{aligned} v_{nm} = \beta_{density} {*} X_{density\ nm} + \beta_{green} {*} X_{green\ nm} + \\ \beta_{center} {*} X_{center\ nm} + \beta_{parking} {*} X_{parking\ nm} + \\ \beta_{public} {*} X_{public\ nm} + \beta_{installatins} {*} X_{installatins\ nm} + \\ \beta_{social} {*} X_{social\ nm} + \beta_{costs} {*} X_{costs\ nm} \end{aligned} \quad (2)$$

In our case, for example, $X_{density\ nm}$ is the housing density of a housing alternative m presented to respondent n and $\beta_{density}$ is a single parameter indicating the effect of the housing density variable on the probability of choosing one housing alternative over another. In general, for each variable X there are J values of the variables for each individual but only a single parameter β. In other words, the β parameter is the same across all individuals.

In a latent class or finite mixture variant of the conditional model, it is assumed that individuals belong to different latent classes that differ with respect to (some of) the parameters appearing in the linear model for v_{nm} (Kamakura and Russell 1989). To indicate that the choice probabilities depend on class membership c, the logistic model is now of the form

$$\mathrm{PR}(y_n = m \mid c, X_n) = \frac{\mathrm{EXP}(\nu_{nm})}{\sum_{j=J}\mathrm{EXP}(\nu_{nj})} = \frac{\mathrm{EXP}(X_{nm}\beta_c)}{\sum_{j=J}\mathrm{EXP}(X_{nj}\beta_c)}. \quad (3)$$

The only difference to the aggregate model shown in (1) is that the logit regression coefficients are allowed to be class specific.

We introduced a covariate into the model to allow choice attribute data and individual consumer characteristics (i.e., the degree of "environmental awareness") to jointly explain choice behavior (Boxall and Adamowicz 2002, 426). When covariates are included in the model, the probability structure changes slightly compared to equation (3). It becomes

$$\mathrm{PR}(y_n = m \mid c^{Z_n}, X_n) = \sum_{C=1}^{C}\left[\frac{\mathrm{EXP}(\lambda_C Z_n)}{\sum_{C=1}^{C}\mathrm{EXP}(\lambda_C Z_n)}\right]\left[\frac{\mathrm{EXP}(x_{nm}\beta_c)}{\sum_{j=J}\mathrm{EXP}(x_{nj}\beta_c)}\right]. \quad (4)$$

Class membership of individual n is now assumed to depend on a set of covariates denoted by Z_n. In this context λ_c indicates the impact of the covariates on the class membership probability. This model permits choice attribute data and individual consumer characteristics to simultaneously explain choice behavior.

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Notes

1. A fractoral statistical design does not allow for all possible combinations of attributes and attribute levels, but only for the minimum needed to be able to estimate main effects in the analysis model. In an orthogonal design, the dependent variables (i.e., the housing attributes respectively attributes characteristics) are not correlated with each other.
2. The following Internet discussion groups/websites were asked to forward the e-mail containing the link to the web questionnaire: www.baunetz.de; www.oekobau-rheinland.de; www.baukosten .com; www.baulinks.de; and www.baumarktforschung.de.
3. The following housing developers forwarded the e-mail containing the link to the web questionnaire: "Suedhausbau, Munich" and "Bayerische Bau und Immobilien Gruppe, Munich."
4. The incentives included one digital camera, two iPods, and four Amazon gift certificates; the winners of the incentives were randomly drawn from all respondents who entered an email address for this purpose on the last page of the questionnaire. The winners were contacted via e-mail and the names of the winners published on the university's website.
5. Schürt, Spangenberg, and Pütz (2005) specified the distribution of places of current residence of the German population as 39 percent of Germans living in "urban environments" (*Zentralräume*) another 30 percent in "suburban areas" (*Zwischenräume*), 23 percent in "semirural" (*Peripherraum mit Verdich-*

tungsansätzen), and 8 percent in "rural areas" (*Peripherraum sehr geringer Dichte*).

6. Research carried out by Andrews and Currim (2003) indicates the value of the minimum Akaike's Information Criterion (AIC) with a per-parameter penalty factor of 3 (AIC3) for the evaluation of the appropriate number of latent classes in regression-based marketing models. Boxall and Adamowicz (2002, 433) recommended using the AIC as well as the minimum Bayesian Information Criterion (BIC) to select the "optimal" number of segments but also point out that these criteria should be used as guidelines and "judgement and simplicity play a role in the final selection of the size of S [=number of segments]."
7. The four "environmental awareness" variables were taken from a study conducted by Schahn et al. (1999).
8. These estimates are based on a consideration of all German housing developments that claim to be "sustainable" or "ecological" (Wolpensinger and Rid 2010). Wolpensinger and Rid (2010) also commented that only in very rare cases have concepts of sustainability been adopted that do not only account for ecological but also for economic and social aspects of sustainable housing development. Therefore, the market share with regard to the broad concept of sustainability (i.e., accounting for ecological, economic, and social housing development characteristics) as defined in this study is most likely to be even lower than Wolpensinger and Rid's estimate of less than 10 percent of all housing developments in Germany.

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