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Winslott Hiselius, Lena

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LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

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Using Choice Experiments to Assess People's Preferences for Railway Transports of Hazardous Materials

Lena Winslott Hiselius*

This article investigates whether the choice experiment approach can be used to assess people's preferences and the determinants of these preferences in order to estimate the costs and benefits of different configurations of the transport of hazardous materials by rail. Changes in the exposure to hazardous materials that people are subjected to are used rather than changes in accident risk. To the best knowledge of the author, this has not been done before in a study of people's preferences toward hazardous materials. A mail survey, carried out in two cities in Sweden, is used to obtain tentative estimates of the willingness to pay for a reduction in exposure as well as the willingness to accept an increase in exposure. Special attention is given to viability, since the complexity of the activity studied, transport of hazardous materials, and the method used pose particular challenges. The response rate and tests of validity and consistency indicate that this method can be applied. Moreover, the results suggest that studies of this kind may provide guidance on changes in the transport of hazardous materials, especially because policymakers may influence the attributes presented here. Referring to the exposure of hazardous materials highlights the importance of providing the respondents with adequate information regarding hazardous transports. An important finding is that the amount of background information may have some effect on the stated preferences.

KEY WORDS: Choice experiments; hazardous materials; transportation; risk

1. INTRODUCTION

The transport of hazardous materials (hazmat) is an economic activity of concern to society. In Sweden, 12–15 million tons of hazmat are transported by road and 2 million tons by rail on a yearly basis.[1,2] Although the probability of a hazardous material accident is very small, the consequences could be severe for humans and environment. Thus, the level of risk should be taken into account in decisions regarding such transports,[3] and in determining the costs and benefits of various transport configurations. In decisions concerning transports, there is an interest in the value of a marginal change in the risk of an accident, and this value may be obtained by studying individuals' preferences toward changes in accident risk. However, in discussing the transportation of hazmat we are dealing with very small probabilities that may be hard to understand and relate to other risks. Furthermore, outcomes in the case of an accident involving hazmat may be quite diverse depending on the specific circumstances around the accident. Consequently, it may be an awkward task to estimate people's willingness to pay (WTP) for, or willingness to accept (WTA), a specific change in the risk of an accident. Since the risk faced by people is closely related to the degree of exposure to hazmat, a more suitable approach may be to investigate preferences with respect to changes in this kind of exposure.

Two main instruments are available for determining individual preferences, contingent valuation (CV) and choice experiments (CEs). For long, the CV method has been the standard procedure for

* Department of Economics and Department of Technology and Society, Lund University, PO Box 118, SE-221 00 Lund, Sweden; Lena.Hiselius@tft.lth.se.

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eliciting individuals' preferences by asking respondents to state their WTP for different goods and scenarios.[4] Recently, there has been increasing interest in the CE method, though.[5,6] Using this method, subjects are asked to choose between two or more scenarios in a sequence of choice sets. Each scenario is described by a number of attributes and their associated levels. Since the individuals reveal their preferences by their choices, it is possible to estimate the relative weight of each attribute, i.e., the marginal rate of substitution (MRS). Furthermore, given that a cost attribute is included, the marginal WTP or WTA can also be calculated for the selected attributes.

There are weaknesses in all methods analyzing individual preferences. Problems often discussed are, e.g., hypothetical biases, sensitivity to study design or so-called framing effects, and insensitivity to scope.[7,8] The CE approach has been argued to possess some advantages relative to the CV method by being more informative, avoiding yeah-saying behavior, and simulating a real life choice context in a better way.[9,10] Furthermore, from a management/policy perspective, tradeoffs between the attributes of a transport configuration may be of particular interest. The CE approach is then well suited since it separates and values the different attributes of a scenario directly. However, the choice task within a CE study can be seen as cognitively demanding, since the research from experimental economists and psychologists suggests that there is a limit to how much information respondents can meaningfully handle while making a decision.[14] Studying people's preferences toward the transport of hazmat poses particular challenges since this activity may be seen as complex and unfamiliar, and connected with feelings of unease. These circumstances may lower the respondents' inclination to participate and to carefully imagine the scenarios presented.

The main purpose of this article is to investigate the potential of CE for modeling preferences for changes in the exposure to hazmat transported by rail in order to assess the costs and benefits of different transport configurations. To the best knowledge of the author, this is the first time a CE study, using exposure as a proxy for probabilities and accident outcomes, has been carried out.[1] Due to the novelty of this method and the complexity of the activity studied, special attention is given to the viability of the approach. The response rate and a test of consistency are discussed to assess whether the CE method can be usefully applied. Furthermore, the preferences of people exposed to the transportation of hazmat and the determinants of these preferences are estimated and compared with *a priori* theoretical expectations, giving an indication of internal validity. The values people place on changes in their exposure are also tentatively calculated. Referring to the exposure to hazmat highlights the importance of providing the respondents with adequate information in order to help them understand the consequences of an accident and the size of the accident risk. A further objective of this article is then to study the effect of background information on the preferences being stated.

[1] There are some CE studies from various areas that include risk in the choice sets but do not express exposure as a source of risk.[11–13]

2. THE SURVEY

Since people's preferences for a change in the exposure to hazmat may be influenced by numerous factors such as former experiences of accidents and the amount of hazmat being transported, the survey is conducted in two cities, Lund and Borlänge in Sweden. These two cities are characterized by rail traffic with transport of hazmat through the city center. The City of Lund has no experience of accidents involving hazmat. Transports mainly pass through and there is an ongoing debate concerning a new rail track outside the city. Seventy railway wagons with hazmat pass through the city center per day. On the other hand, the City of Borlänge experienced an accident involving hazmat in the year 2000. There was no leakage but people living in the city center were evacuated for a week. Local industries are dependent on the supply of liquefied petroleum gas and other materials classified as hazardous. There are no plans for a new rail track in the near future. One hundred and forty wagons with hazmat pass through the city center per day.

A postal survey was conducted with a questionnaire consisting of four parts. The first part contained various attitudinal questions, and questions regarding the respondent's socioeconomic status, as well as distance to the railway from their homes. In the second part of the questionnaire, information was given on the likelihood of accidents involving hazmat and the possible consequences. The information also stressed that even if there was no leakage people could still be affected and evacuated for a couple of days. A short description was also given of the transport of hazmat on the railway nearby, together with a city map with the railway marked out. The third part contained the

	Alternative 1	Alternative 2	Current situation
Number of wagons with hazardous materials	No wagons	70 wagons/day	70 wagons/day
Time of transport		Nighttime	Daytime and nighttime
Classification of hazardous materials		Class 1	Class 2
Altered housing cost per month	30 SEK higher	200 SEK lower	Unaltered
Which alternative would you prefer?	☐ **Alternative 1**	☐ **Alternative 2**	☐ **Current situation**

Fig. 1. Example of choice set for the Lund subsample.

CE and the fourth part had questions regarding costs and consequences to be considered when stating their answers.

Six hundred individuals in Lund and 400 in Borlänge were randomly selected. In order to test whether the amount of information on hazmat that a respondent received affected his or her preferences, 200 individuals living next to the railway in Lund and 200 living next to the railway in Borlänge received a questionnaire with little information regarding hazmat. Correspondingly, 200 individuals living next to the railway in Lund and 200 living next to the railway in Borlänge received substantial information regarding hazmat. Furthermore, in Lund, respondents living at two different distances from the railway were also randomly selected: living near but not next to the railway (100), living on the outskirts of the city and not within earshot of the train traffic (100). The respondents received a reminder card after two weeks. After another two weeks, those who did not respond to the questionnaire were sent a new one. A "dropout" questionnaire was finally sent out to those not responding in order to collect information regarding socioeconomic status and general attitude toward the transportation of hazmat and the questionnaire itself.

3. THE CHOICE EXPERIMENT

The effect of hazmat transports may be seen as a passive use value arising from a change in environmental quality that is not necessarily reflected in any observable behavior. In the CE method used in this study, the respondents are asked to choose one preferred alternative from two hypothetical transport configurations of hazmat and the current transport situation. See Fig. 1 for an example of a choice a respondent is asked to make. The respondents are asked to make six such choices and, based on these answers, people's preferences for changes in the exposure to hazmat are analyzed.

3.1. Attributes and Levels

The hypothetical alternative that is preferred by a respondent is assumed to depend on the attributes of the alternatives and the levels of these attributes. The first three attributes of this CE study jointly describe exposure to the hazmat being transported, whereas the fourth attribute is a cost variable. Everything else is assumed to be unaltered compared to today's situation. See Appendix C for exact wording.[2]

Attribute 1: Number of wagons per day transporting hazardous materials. Based on the number of wagons transporting hazmat today, three alternative levels are defined: twice as many as today, half as many as today, and none at all. In total four levels including the status quo.

Attribute 2: Classification of hazardousness. To facilitate the description of the hazmat being transported, we employ a simplistic representation of its hazardousness. The current mix of hazmat is assumed to be of Class 2, hazardous. Two other levels are defined, Class 1, less hazardous than today's mix, and Class 3, more hazardous than today's mix. With the purpose of minimizing the amount of information given and its complexity, limited information is given on the hazardousness of the goods. Instead, a number of follow-up questions are asked in order to control for effects that the respondents may be considering, e.g., damages to personal health and property and the environment. There are thus three levels of the hazardousness attribute. In a way, there is also a fourth level, no danger at all. This level appears in those cases where the

[2] In the questionnaire it was especially mentioned that the frequency of trains was assumed to be unaltered and thereby the level of noise that the railway causes would not change.

presented alternative describes a situation with no transport of hazmat at all.

Attribute 3: Time of transport. In the current situation, hazmat is being transported both day and night. Two other levels are defined, transport of hazmat in either daytime or nighttime only. Thus, there is a total of three levels. However, in the same way as the previous attribute, there is also a fourth level, no transport of hazmat at all.

Attribute 4: Housing cost per month. The text section preceding the choice sets states that the value of houses located near the railway is assumed to be affected by the transport of hazmat. For instance, a change in the number of wagons transporting hazmat is supposed to affect the market value. This change in the value of the property is in its turn assumed to affect the property taxation, expressed as an increase or decrease in the housing cost per month. The text also states that the housing cost is assumed to be altered for all types of housing. The following eight levels are used, where decreases in housing cost per month are defined as negative values: −200, −100, −40, ±0, 30, 50, 150, 250 SEK (108 SEK equals 10 EUR, November 2004).

3.2. Design of the Choice Sets

When designing a CE, it is important to combine the levels of the attributes into different alternatives in an optimal way. Limited sample sizes and the use of large numbers of attributes and levels have led the vast majority of CE studies to use fractional factorial designs as opposed to full factorial designs. In the task of designing a CE, there is also an important aspect in the way alternatives are combined into choice sets. For most combinations of attributes, levels, and alternatives, it is difficult to create a design that is optimal in every way, though. The design of this study is consequently a mix of fractional factorial design recommendations found in Louviere *et al.*,[(15)] two pilot studies, and simulations based on pilot data. Within each choice set, the respondent is asked to choose one of the three alternatives (see Fig. 1): two hypothetical transport alternatives (defined by varying levels of the four attributes presented in the previous section) and a constant comparator, the current transport situation (defined by current attribute levels). Some alternatives describe a situation where there is no transport of hazmat, see Alternative 1 in Fig. 1. In these cases, there is no data on time of transport and classification of the material, for obvious reasons. These conditions, together with the use of a constant comparator (the current situation), complicate the task of creating and combining the scenarios, without one alternative dominating another. As a result, full orthogonality, i.e., independent variation of all attribute levels, could not be achieved. No major imbalances were detected in the scenarios, though.[3] Furthermore, since respondents of the first pilot study generally expressed difficulties answering the questionnaire, the choice sets were reconstructed so that the level of one attribute was always identical for two of the alternatives presented. Given the complexity of the choices, it was decided that each respondent would be presented with six choice sets in the main study. Thirty-six choice sets were created and separated into six blocks of questionnaires, each consisting of six choice sets.[4]

3.3. Internal Consistency and Validity

When using the CE method it is of importance to include tests to study whether individuals appear to understand the technique and are taking it seriously. Internal consistency is often tested with a given *a priori* theory on which alternative is best. If an alternative is chosen in one choice set, an even better alternative should be chosen in another choice set. The test for internal consistency is carried out within one of six blocks of questionnaires, since an overall inclusion reduces the efficiency of the choice design. Carried out this way, the test gives an indication of the problem and cannot be used as a tool for sorting out irrational responses.

We use regression techniques to estimate a utility function with presented attributes as explanatory variables. Since there is no secondary data to compare real and stated behavior, the results of the regression analysis are used to study the internal validity of this study, i.e., the extent to which the results are consistent with *a priori* theoretical expectations. Assuming diminishing marginal utility of income, we would expect higher income groups to have a lower marginal valuation of cost. The disutility of an increased housing cost is therefore assumed to be lower for higher

[3] See Fig. A1. in Appendix for cross-plots of the three attributes describing exposure versus altered housing cost per month.

[4] Due to limited space, only 1 out of the 36 choice sets is presented (Fig. 1). A complete presentation, including a questionnaire in English, can be obtained from the author on request.

income groups. Given that reduced exposure is to be preferred, we would expect levels describing less (more) exposure than the current situation to have a positive (negative) sign in the regression analysis. Furthermore, it may be reasonable to expect the preferences of a household to be influenced by distance to the railway, so that households living next to the railway are expected to place a higher value on reduced exposure. Preferences and choices may also be affected by the information given.[16] In order to test the effect of information on the transport of hazmat, two types of questionnaires were created, one with substantial information regarding the consequences of an accident with hazmat and the size of the accident risk, and one with considerably less information. See Appendix B for exact wording. According to Slovic *et al.*,[17] people tend to overrate the risk of low probability events. Under the assumption that substantial information partly corrects this attitude, we expect the value of a reduction in exposure to hazmat to be higher for those respondents receiving little information than for those respondents receiving substantial information. Householders owning their residences may have stronger incentives to accept an increased housing cost in exchange for reduced exposure to hazmat than people renting their housing, since the increase in cost for residence owners is compensated for by an increased price once the property is sold. Consequently, we would expect higher values of reduced exposure for residence owners. However, other factors may correlate with owning one's residence, e.g., age, number of persons in the household, and the number of years the occupants expect to live at the same address. These factors may also increase the incentive of the household to accept higher housing costs in exchange for reduced exposure. Optimally, one would like to control for all other factors correlated with owning one's residence. The number of observations in this study, however, is too limited. Segmenting the data on owning one's residence will reveal whether this is a factor of relative importance. Finally, there are no *a priori* assumptions made about time of transport. At first glance, one may argue that people living close to the railway only prefer transport of hazmat in the daytime, since they are likely to spend their days at another location further away from the railway. Their exposure would then decrease compared to the current situation if transportations were restricted to the daytime only. Accordingly, transport of hazmat at nighttime would increase their exposure. However, one may also argue that the railway traffic is generally less heavy at night, which lowers the risk of an accident involving hazmat. Transportations at nighttime only are then to be preferred.

4. EMPIRICAL SPECIFICATION

4.1. Theoretical Framework

CEs, like many other environmental valuation approaches, share a common theoretical framework in the random utility model.[18] The representative individual is assumed to have an indirect utility function of the form:

$$U_{in} = U(Z_{in}, S_n),$$

where for any individual n, a given level of utility will be associated with the choice of any alternative i. Alternative i will be chosen over some other option j if $U_i > U_j$. Utility derived from any option is assumed to depend on the attributes, Z, of that option. These attributes may be viewed differently by different agents whose socioeconomic characteristics, S, will also affect utility.

While the individual knows the nature of his or her utility function, the researchers do not. This introduces the concept of random utility, where an error term, ε, is included in the utility function to reflect unobservable factors. Assume now that the utility function can be partitioned into two parts, one deterministic and in principle observable, and one random and unobservable. The indirect utility function can then be rewritten as

$$U_{in} = V_{in}(Z_{in}, S_n) + \varepsilon_{in}(Z_{in}, S_n).$$

The probability that individual n will choose option i over option j is given by

$$\text{Prob}(i \mid C) = \text{Prob}\{V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}, \text{ all } j \text{ in } C\},$$

where C is the complete choice set. Depending on the analysis model used, ε can be specified to take into account multiple observations from the same respondent as well as heterogeneity among respondents and correlation between alternatives, see, e.g., Reference 19. Assumptions must also be made about the distribution of the error term. The usual assumption is that the errors are Gumbel-distributed and independently and identically distributed. This implies that the probability of choosing alternative i is given by

$$\text{Prob}(i) = \frac{\exp^{\mu V_i}}{\sum_{j \in C} \exp^{\mu V_j}}.$$

Here, μ is a scale parameter, which is set to be equal to 1 (implying constant error variance).

4.2. Model

The multinomial logit model (MNL) is frequently used to estimate the utility function. There is, however, a debate concerning the use of this model since it assumes that selections from the choice set follow the independence from irrelevant alternatives (IIA) property, i.e., the relative probabilities of two options being selected are unaffected by the introduction or removal of other alternatives. This property follows from the independence of the error terms across different options contained in the choice set. Violations of the IIA hypothesis are often observed, resulting in the need for more complex statistical models. In this study, the data are analyzed using both the MNL and the random parameter logit model (RPL). The RPL model is a less restrictive model and is often used when the MNL is shown to violate the IIA property. Even if there is no violation of IIA property, there may be arguments for the use of a RPL model since taste variation among individuals is explicitly treated, as are correlations between parameters and repeated choices from each respondent.[(19)] Using the MNL and the RPL models, the following linear and additive utility function is estimated with a common alternative-specific intercept α for Alternatives 1 and 2 and k independent variables, x (see Table I):

$$U = \alpha + \beta_l x_l + \varepsilon \quad \text{for } l = 1, \ldots, k.$$

Altered housing cost/month is treated as a continuous variable for which negative values correspond to decreases in the housing cost. In order to study the way in which income affects the parameter for this cost variable, separate parameters are estimated for population segments based on monthly household income per consumption unit.[5] Three income groups are used for the Lund subsample. Since household income is less spread in the Borlänge subsample, two income groups per consumption unit are defined in this case.[6] Variables for number of wagons, classification of hazardousness, and time of transport are dummy coded with the levels of the current situation as reference category. In order to study how individual characteristics affect the preferences for a change in the exposure to hazmat, the respondents are segmented using dummy variables for (1) the respondent owns his/her residence, (2) the respondent received a questionnaire with substantial information regarding hazmat, and (3) the respondent is not living next to the railway. Interaction variables are thereafter created between the dummy variables for segmentation and each variable for the number of wagons, classification of hazardousness, and time of transport. The interaction variables give the effect of the characteristics mentioned, in addition to the estimated parameters of the baseline segment, i.e., respondents not owning their residences, receiving limited information in the questionnaire, and living next to the railway. In the model, there are no interactions included between the number of wagons, the classification of hazardousness, and the time of transport, assuming additive parameters. This can be discussed since people are likely to regard, for instance, twice as many wagons differently, depending on whether the materials being transported are classified as Class 1, less hazardous than today, or as Class 3, more hazardous than today.

Table I. Independent Variables

Continuous variable	
Altered housing cost/month:	Ranging from −200 to 250 SEK, segmented by Income L, Income M,[a] and Income H
Dummy variables describing attributes	
Number of wagons:[b]	Twice
	Half
	None
Hazardousness:[b]	Class 1
	Class 3
Time of transport:[b]	Daytime
	Nighttime
Segmentation of respondents, interacting with dummy variables presented above:[c]	
	Owning one's residence
	Receiving substantial information in the questionnaire
	Not living next to the railway

[a]Not defined for the Borlänge subsample.
[b]The reference category equals: the number of wagons of today, hazardousness of Class 2, and transports both daytime and nighttime.
[c]The baseline segment of respondents is: not owning one's residence, receiving limited information in the questionnaire, and living next to the railway.

[5] The consumption units used by Statistics Sweden are applied: single = 1.16, married/cohabitants = 1.92, additional adult = 0.96, and children = 0.66.

[6] In the Lund subsample, income groups are defined by Income L (<10,000 SEK per month), Income M (>10,001 and <20,000), and Income H (>20,001 SEK per month), and in the Borlänge subsample, Income L (<15,001 SEK per month) and Income H (>15,001 SEK per month).

The number of observations of this study is limited, however, and we therefore concentrate on estimating main effects, which should indicate viability of the method.[7]

One common alternative-specific intercept term is estimated for Alternatives 1 and 2, reflecting the preferences for these alternatives over the current situation when all attributes included in the model are the same. This coefficient can also be regarded as an endowment effect or status quo effect.[(20)] According to this theory, we are most likely to find a negative intercept, which may be interpreted as a disutility of moving away from the current state due to strong preferences for an unaltered situation. Individuals may also choose the current situation when the task of selecting options is considered too complex or when they are uncertain about the tradeoffs they would be willing to make. Choosing the current situation could also be a form of protest response. In some studies, the CE analysis is carried out both on a full sample, including respondents constantly choosing one alternative, and a reduced sample excluding these respondents.[(20,21)] This study will, however, include respondents constantly choosing the current situation due to uncertainty regarding their underlying motives. Important information may then be lost if these answers are disregarded.

When using the RPL model, assumptions are made regarding the distribution of the random coefficients. The cost parameters are treated as nonrandom in that the distribution of the marginal WTP for an attribute is then simply the distribution of that attribute's coefficient. To simplify the model the intercept term is also treated as nonrandom. Variables estimated for the baseline segment and describing the number of wagons and the classification of hazardousness are assumed to be log-normal distributed, restricting all respondents to the same sign of the coefficient. Remaining variables are assumed to be normally distributed since we have no prior knowledge regarding their preference structures. As the log-normal distribution gives positive coefficients, variables whose coefficients are necessarily negative are entered as the negative of the variable. Models using log-normal distributions often fail to converge, though.[(22)] In this study, as a second best solution, we also use the normal distribution for all variables of the RPL model. To the extent that the model converges, correlations between parameters and multiple observations from respondents are accounted for. Regression analyses using the MNL and the RPL model are conducted with Nlogit 3.0.[8] Due to limitations in the data set, the full model, i.e., all variables presented in Table I, is only estimated using the MNL model. Excluding insignificant parameters, a final estimation is made using both models.

Once parameter estimates have been obtained, a compensating variation measure is derived. The monetary value of a marginal change in any attribute is expressed as the ratio between the coefficient of the attribute and the coefficient of the cost parameter. The levels presented in the CE range from above to below the situation of today for all attributes, which allows us to examine situations where people are willing to pay for improvements as well as situations where people are willing to accept deteriorations for which they are compensated.

5. RESULTS

In the Lund subsample, the response rate was 45–60% depending on selection area, which is admirable given the complexity of the survey. The response rate was lower in the Borlänge subsample, however, 45%. This may have been a result of an older population (average age of 46 in Borlänge compared to 39 in Lund), and lower level of education (32% with academic education in Borlänge compared to 80% in Lund). There is a possibility that the response rate of Borlänge was also negatively affected by an incorrect questionnaire being sent out.[9] The response rate in the dropout study was 27%. The individuals were asked to state the reasons for not responding to the main questionnaire. The most common reasons for not answering were that they were too busy, forgot to answer, or just did not want to participate. The dropouts were generally younger.

7 Even if main effects can be argued to explain the major part of respondent behavior, disregarded interactions may bias the variables, possibly leading to incorrect estimates.[(15)] However, the design of this study does allow interactions to be studied between the number of wagons, classification of hazardousness, and time of transport. Analyses (not presented here) do not suggest any differences in sign when such parameters are included in the model.

8 When estimating the RPL model, Halton draws with 250 replications are used.

9 The first version of the questionnaire that was sent to the Borlänge subsample contained an error in the CE, so a revised questionnaire was sent to the whole sample the same week. Fifty-nine individuals answered both versions of the questionnaire, making comparisons possible. The majority answered the second questionnaire in the same way as the first incorrect one and there were no signs of an increasing rate of protest answers.

As discussed in Section 3.3, a test of internal consistency was carried out within one of six block choice sets in order to study whether the respondents understood the questions and answered them consistently. The test analyzes whether a respondent who chooses an alternative in one choice set also chooses an even better alternative in another choice set. In the Lund subsample, all 25 respondents answered consistently, whereas 3 of 12 respondents answered inconsistently in the Borlänge subsample. One of the respondents answering inconsistently chose Alternative 1 in all questions, which may be a sign of protest, whereas the other two varied the chosen alternatives and no pattern could be detected.

5.1. Estimates

Results of the regression analysis are presented in Table II. For the Lund subsample, the coefficient of cost is significantly lower for the segments of average and high income per consumption unit compared to the segment of low income, suggesting that respondents with higher income have a lower marginal valuation of cost, i.e., a diminishing marginal utility of income. This effect cannot be found when comparing the results for the segments of average and high income, though. There is also a slight indication of diminishing marginal utility of income in the Borlänge subsample, albeit not significant. In the Lund subsample, the majority of the estimated coefficients for the baseline segment are significant at the 5% level (two-tailed), suggesting that the chosen attributes have been taken into account. In the Borlänge subsample, 2 out of 7 coefficients are significant. For both subsamples, the coefficients of the number of wagons and classification of hazardousness have the theoretically expected sign, confirming internal validity within the study. However, in the baseline segment, the estimated coefficients of time of transportation differ from the other coefficients in that they are all but one insignificant and of different sign when comparing the results of the Lund and Borlänge subsamples. In Lund, the estimated coefficients are positive, suggesting that any change from the current situation, i.e., transport of hazmat both daytime and nighttime, increases utility, whereas in Borlänge the coefficients are negative, suggesting that any change is considered a disutility.

Turning to the additional parameters for the segments of respondents owning their residences, respondents receiving substantial information, and respondents living next to the railway, the level of significance is much lower. Indeed, in the Lund subsample only 6 out of these 21 parameters are significant at the 5% level (two-tailed) and 2 out of 7 in the Borlänge subsample. There is no apparent pattern to the significant coefficients and there is no similarity in the pattern of significant coefficients between the two subsamples. These parameters are presented nevertheless, since they, when studied all together, add to the general picture. The parameters of distance, information, and residence-owning are generally of expected sign, in favor of the internal validity test. The study suggests that individuals owning their residences have a stronger preference for reducing the exposure to hazmat than individuals not owning their residences.[10] In Table II it is also suggested that, in the Borlänge subsample, utility increases for individuals owning their residences if the time of transport is changed to daytime only. The result implies, furthermore, that if the respondent receives more information regarding the probabilities and outcomes of accidents involving hazmat, reducing the exposure may become less important. In Lund, the value of a reduction in the exposure to hazmat is lower for those respondents receiving substantial information than for those receiving little information. In the Borlänge subsample, there were no significant effects of information whatsoever, and these parameters were excluded from this presentation.[11] The study also suggests that people living close to a railway transport route with hazmat benefit more from a reduction in their exposure to hazmat than people living further away and vice versa.

Though the IIA restriction is not rejected by the Hausman and McFadden statistic,[23] there is still an

10 As mentioned previously, there are incentives for people owning their residences to answer this way since any increase in housing cost is compensated for when the house is sold. A telephone survey was therefore carried out of respondents that fulfilled the following criteria: answering within two weeks, owning their residences, not choosing the current situation in all choices, having the use of a telephone. Excluding 7 individuals in Lund and 5 in Borlänge who we could not get in touch with, the sample consisted of 30 respondents in Lund and 34 in Borlänge. The question that was asked was "When you made your choices in the questionnaire, did you consider changes in the market value of your estate?" In Lund the figure was 20% and in Borlänge 23%. This gives us an indication of this strategic problem. We have no information, however, on the degree to which this strategic behavior affects the results of this study.

11 The effect of substantial information as opposed to little may be limited in Borlänge since it has experienced an accident with hazmat. People living near the railway, in areas from which the random selection for this study were made, were affected by evacuations and roped-off areas.

Table II. Multinomial Logit Estimates for the Lund and Borlänge Subsamples

Parameters	Lund Coefficient	Lund *p*-Value	Borlänge Coefficient	Borlänge *p*-Value
Intercept	−0.807	0.000	−0.496	0.022
Altered housing cost/(month × 100)				
Cost (Income L)	−0.543	0.000	−0.374	0.000
Cost (Income M)	−0.350	0.000		
Cost (Income H)	−0.397	0.000	−0.366	0.000
Baseline segment[b]				
Number of wagons				
Twice	−1.061	0.000	−0.655	0.008
Half	0.568	0.002	0.158	0.444
None	2.035	0.000	0.441	0.164
Classification				
Class 1	0.645	0.001	0.348	0.110
Class 3	−1.911	0.000	−0.579	0.034
Time of transport				
Daytime	0.631	0.003	−0.372	0.112
Nighttime	0.302	0.150	−0.244	0.294
Additional for segments				
Own residence				
Twice	−0.192	0.451	−0.514	0.073
Half	0.452	0.028	0.053	0.830
None	0.983	0.000	0.091	0.715
Class 1	0.448	0.027	−0.200	0.409
Class 3	−0.073	0.808	−0.951	0.004
Daytime	−0.137	0.556	0.663	0.016
Nighttime	0.123	0.604	0.204	0.475
Substantial information				
Twice	0.142	0.543	–[a]	
Half	−0.286	0.132	–[a]	
None	−0.782	0.000	–[a]	
Class 1	−0.436	0.020	–[a]	
Class 3	0.124	0.663	–[a]	
Daytime	0.105	0.623	–[a]	
Nighttime	0.085	0.702	–[a]	
Not next to				
Twice	−0.246	0.310	n.a.	
Half	−0.132	0.512	n.a.	
None	−0.680	0.001	n.a.	
Class1	−0.198	0.314	n.a.	
Class 3	0.436	0.134	n.a.	
Daytime	−0.232	0.500	n.a.	
Nighttime	−0.121	0.606	n.a.	
N	1,914		1,049	
Log-likelihood	−1,841		−1,052	
Likelihood ratio index	0.12		0.09	

[a]Excluded parameters due to overall insignificance.
[b]Not owning one's residence, receiving limited information in the questionnaire, and living next to the railway.
Note: n.a. = not available.

interest in using the RPL model since we have repeated choices from the same respondents. Moreover, we may have heterogeneous preferences and correlation within preferences. Two restricted MNL and RPL models are then estimated, excluding the interaction variables that are highly insignificant in the full MNL model. For the Lund subsample, the estimates of altered housing cost per month, segmented for average and high monthly household income per consumption unit, are not significantly different in the MNL model. Segment Income M and Income H are consequently pooled into Income MH. In the Borlänge subsample, there is no significant difference between the two segmentation groups used for the cost parameter. Altered housing cost per month is therefore estimated without segmentation for this subsample. A likelihood ratio test for the restricted models implies that we cannot reject the null hypothesis that the coefficients are jointly zero. Furthermore, the IIA restriction cannot be rejected according to the Hausman and McFadden statistic. As mentioned in Section 4.2, models using the log-normal distribution often fail to converge and the regression models of this study are no exception. In addition, the regression models allowing for correlations between parameters fail to converge. Consequently, the resulting RPL models for the Lund and Borlänge subsamples are estimated taking repeated choices and normally distributed heterogeneous preferences into account, using the normal distribution for all parameters except the cost parameters and the intercept term. The results are presented in Table III for Lund and Table IV for Borlänge. There is an increase in the likelihood ratio index compared to the MNL models (Column 1), suggesting a better fit for the RPL models (Column 2). The estimates are generally lower for the MNL compared to the RPL models, which corresponds to the results of other studies.[24] The significance of the estimated standard deviations in the RPL models (Column 3) is a sign of heterogeneity in the preferences of the respondents. The standard deviation for variables interacting with owning one's residence is generally insignificant, though, indicating more homogenous preferences within this segment. The standard-deviation coefficients in the RPL models are unreasonably large, indicating problems that may be due to disregarded correlations in the heterogeneity of preferences.

5.2. Marginal Rate of Substitution

The interpretation of the coefficient values is not straightforward, except for significance and relative size. We therefore calculate the MRS between the attributes using the coefficient for cost as a numeraire. This implies that we can interpret the ratios as the average marginal WTP and WTA per household and month. The marginal rates of substitution based on the estimates of the MNL (Column 4) and the RPL (Column 5) models are presented in Tables III and IV. MRS totals, including the baseline values for respondents owning their residences, receiving substantial information, and living next to the railway, are given within brackets.[12] The ratios of estimated parameters in the MNL model are similar to those of the RPL model. The same result is found in, for instance, Train.[25]

Using the results in Tables III and IV, different transport configurations can be analyzed. For example, based on the results from Table III, Column 4, and using the estimates for Income L and the baseline segment, the total MRS for reducing the number of wagons by half, lowering the degree of dangerousness to Class 1, and transporting hazmat in the daytime only suggests a WTP per household and month of: 147 SEK (Intercept) − 88 SEK (Half) − 131 SEK (Class 1) − 97 SEK (Daytime) = −169 SEK.[13]

The intercept term is a determining factor for the result of a proposed transport configuration. In this study, the intercept is negative, which indicates that any change from the current situation is negative. Since there is uncertainty regarding this behavior, the inclusion of the intercept can be discussed. Adamowicz *et al.*[20] argue that such an inclusion is a reasonable option for models estimated for samples not containing individuals who constantly choose the current situation. They state that the intercept effect may be more of a real phenomenon in this case, since individuals who may have protested are excluded. In our point of view, it may also be reasonable to include the intercept term when carrying out the CE analysis on a full sample in order to limit the risk of neglecting interesting information. The question of how to deal with behavior concerning the current situation and the inclusion of the intercept term, which is beyond the scope of this study, ought to be discussed and analyzed more thoroughly in future research.

5.3. Estimates Constitute an Upper Bound?

It is plausible that the estimates presented here represent an upper bound for a number of reasons. A bias may arise since the survey is focused on one problem, transport of hazmat, exaggerating the importance of this problem without relation to other

[12] For instance, using the estimates of the MNL model for the Borlänge subsample, in this case residence owners, the change in MRS due to twice as many wagons as today is given by 163 SEK + 158 SEK = 321 SEK per household and month. Consequently, the households have to be compensated by this amount in order to maintain their utility.

[13] The total MRS is calculated under the assumption that the proposed transport configuration is the only one realized, i.e., a "state-of-the-world" model.[26]

Table III. Estimates Using MNL and RPL Models and MRS for Income L and Income MH, SEK—Lund Subsample

	MNL Coefficient (p-Value)	RPL Coefficient (p-Value)	RPL Coefficient Std (p-Value)	MNL, MRS[a] Income L/Income MH	RPL, MRS[a] Income L/Income MH
Parameters (nonrandom)					
Intercept	−0.802 (0.000)	−0.597 (0.047)	–	147/213	37/42
Altered housing cost/(month × 100)					
Cost (Income L)	−0.545 (0.000)	−1.606 (0.000)	–	n.a.	n.a.
Cost (Income MH)	−0.376 (0.000)	−1.416 (0.000)	–	n.a.	n.a.
Parameters (random RPL)					
Baseline segment[b]					
Number of wagons					
Twice	−1.173 (0.000)	−3.943 (0.000)	2.472 (0.000)	215/312	246/278
Half	0.480 (0.001)	1.201 (0.000)	1.395 (0.000)	−88/−128	−75/−85
None	2.031 (0.000)	2.688 (0.002)	7.313 (0.000)	−372/−540	−167/−190
Classification					
Class 1	0.713 (0.000)	0.986 (0.016)	2.091 (0.000)	−131/−190	−61/−70
Class 3	−1.594 (0.000)	−6.145 (0.000)	4.459 (0.000)	292/424	383/434
Time of transport					
Daytime	0.527 (0.000)	0.745 (0.011)	2.780 (0.000)	−97/−140	−46/−53
Nighttime	0.335 (0.006)	0.191 (0.432)	1.561 (0.000)	−61/−89	−12/−13
Additional for segments					
Half (own res)	0.401 (0.007)	1.040 (0.012)	0.403 (0.703)	−73/−107 (−161/−235)	−65/−73 (−140/−158)
None (own res)	0.100 (0.000)	5.061 (0.007)	2.617 (0.016)	−183/−266 (−555/−806)	−315/−357 (−482/−547)
Class 1 (own res)	0.461 (0.003)	1.542 (0.006)	1.094 (0.160)	−85/−122 (−216/−312)	−96/−109 (−157/−179)
Half (subst. info)	−0.258 (0.077)	−0.628 (0.082)	1.936 (0.000)	47/68 (−41/−60)	39/44 (−36/−41)
None (subst. info)	−0.807 (0.000)	−1.573 (0.001)	10.294 (0.000)	148/214 (−224/−326)	98/111 (−69/−79)
Class 1 (subst. info)	−0.362 (0.011)	−0.544 (0.253)	2.479 (0.000)	66/96 (−65/−94)	34/38 (−27/−32)
None (not next to)	−0.651 (0.001)	−1.727 (0.165)	2.001 (0.348)	121/176 (−251/−364)	108/122 (−59/−68)
Class 1 (not next to)	−0.414 (0.003)	−0.722 (0.132)	1.903 (0.002)	76/110 (−55/−80)	45/51 (−16/−19)
Log-likelihood	−1,847	−1,541			
Likelihood ratio index	0.12	0.25			

[a]Negative sign = WTP, positive sign = WTA.
[b]Not owning one's residence, receiving limited information in the questionnaire, and living next to the railway.
Note: n.a. = not available.

Table IV. Estimates Using MNL and RPL Models, and MRS, SEK—Borlänge Subsample

	MNL Coefficient (p-Value)	RPL Coefficient (p-Value)	RPL Coefficient Std (p-Value)	MRS[a] MNL	MRS[a] *RPL*
Parameters (nonrandom)					
Intercept	−0.494 (0.023)	−0.296 (0.437)	–	133	26
Altered housing cost/(month × 100)					
Cost	−0.372 (0.000)	−1.147 (0.000)	–	n.a.	n.a.
Parameters (random RPL)					
Baseline segment[b]					
Number of wagons					
Twice	−0.607 (0.010)	−2.094 (0.001)	3.359 (0.000)	163	182
Half	0.194 (0.181)	0.129 (0.713)	2.254 (0.000)	−52	−11
None	0.494 (0.078)	1.256 (0.149)	7.120 (0.000)	−133	−109
Classification					
Class 1	0.227 (0.157)	0.176 (0.635)	2.501 (0.000)	−61	−15
Class 3	−0.646 (0.013)	−3.653 (0.000)	3.436 (0.000)	174	318
Time of transport					
Daytime	−0.332 (0.118)	−1.356 (0.012)	2.159 (0.000)	89	118
Nighttime	−0.127 (0.439)	−0.623 (0.067)	1.841 (0.000)	34	54
Additional for segment					
Twice (own res)	−0.589 (0.021)	−1.469 (0.041)	0.457 (0.646)	158 (321)	128 (310)
Class 3 (own res)	−0.849 (0.006)	−1.303 (0.166)	1.997 (0.228)	228 (402)	114 (432)
Daytime (own res)	0.589 (0.007)	1.362 (0.022)	0.011 (0.990)	−158 (−69)	−119 (−1)
Log-likelihood	−1,053	−894			
Likelihood ratio index	0.09	0.19			

[a]Negative sign = willingness to pay, positive sign = willingness to accept.
[b]Not owning one's residence, receiving limited information in the questionnaire, and living next to the railway.
Note: n.a. = not available.

hazards. It is also possible that the survey suffers from a budget constraint bias since the respondents may not consider that increases in expenditure mean that less money is available for other expenditures. These biases suggest that the estimates constitute an upper limit on the value attached to transport of hazmat. A bias may also arise since the respondents are faced with hypothetical alternatives, giving cause to stated choices that are hypothetical as well. The obtained estimates may then be overstated. However, studies carried out on differences between actual and hypothetical preferences and using the CE approach differ in that some indicate a difference and others do not.[27,28] Furthermore, in Wheeler and Damania,[29] it is argued that the accuracy of responses is improved when respondents are asked to value real-world scenarios. Although the respondents know that they are not actually being asked to pay here and now, the situation should be realistic enough for them to believe that this could happen. In this study, we try to minimize the problem of hypothetical bias by presenting a realistic and familiar payment vehicle and realistic alternatives describing the transport of hazmat. Besides, we are addressing an affected population.

6. DISCUSSION

This article suggests that the CE approach can be used to estimate people's preferences for different configurations of transport of hazmat by rail despite the complexity in the activity studied and in the CE method used. The response rate, 45–60%, was admirably high given the difficulty of the study. A test carried out within one of the six blocks of questionnaires indicated internal consistency. In the Lund subsample, all 25 respondents answered consistently, whereas 3 of 12 respondents answered inconsistently in the Borlänge subsample. This discrepancy may be due to differences in age and education, affecting motivation and ability to respond. The application of this method is also supported by the internal validity, i.e., the estimated parameters are of expected sign. Some parameters are insignificant, though. We have nevertheless chosen to discuss these results since they may, when studied all together, add to the general picture. A reduction in the number of wagons with hazmat and a reduction in the degree of hazardousness increase utility and people are thus willing to pay for these improvements or they demand compensation for changes for the worse. The overall finding suggests that level of information and distance to the railway may affect valuations and so does owning one's residence. The effect of time of transportation is inconclusive. This is not necessarily surprising, as a change in the time of transportation of hazmat can be interpreted as affecting people's exposure and safety both negatively and positively, leaving the summed effect insignificant. In this situation, we can only speculate on the origin of the differences between the subsamples. One explanation may be differences in the background data such as daytime distance to the railway and prior experiences of incidents with hazmat.[14]

The estimates can be seen as contextual, i.e., being time- and site-specific, even though objective information is given concerning the transport of hazmat. Characteristics of the city and the socioeconomic parameters of the subsamples are likely to affect the results and the appropriateness of an application of the results to other areas even if the settings are similar. Are the respondents able to understand the questions? Are their answers valid and consistent? According to Smith,[(30)] one may argue that only those who have experienced the problem being studied should be assessed. In this study, the majority of the selected samples consist of people living next to or close to the railway. Since these respondents experience the exposure to hazmat today, there is a reasonable possibility that their preferences are relatively well founded.

The major result of the study is that the CE method seems applicable even in this kind of setting with numerous difficulties. Furthermore, the analysis reveals that the CE approach may provide a rich description of people's preferences and the determinants of their preferences. In the future, results of this and similar studies may provide guidance on different transport configurations (e.g., with hazmat), especially since policymakers may influence the attributes presented here. However, the feasibility of the CE method when studying people's preferences toward transport of hazmat cannot be established until future research is conducted. It is important to test the external validity by incorporating real payments and by making consistency and validity tests with larger samples. Furthermore, in this study, exposure is used as a proxy for risk as an attempt to incorporate risk attributes into CEs in a meaningful way. Future research is required to analyze whether this is practical. It is also plausible that the estimates presented here represent an upper bound due to a number of biases and more research is required to address these biases.

[14] In the Lund subsample, 23% of the respondents not owning their residences state that they spend their day at the same distance or closer to the railway compared to their nighttime place. This figure is 57% in the Borlänge subsample. For respondents not owning their residences, the figure is 59% in both subsamples.

APPENDIX A: CROSS-PLOTS

Fig. A1. Cross-plots of number of wagons/day, classification of hazardousness, and time of transport versus altered housing cost/month used in the choice sets.

APPENDIX B: INFORMATION

The following information section is given in questionnaires providing substantial information for the Lund subsample. Passages in italic indicate the information given in questionnaires providing limited information. For the Borlänge subsample, necessary adjustments are made in the text.

What is meant by hazardous materials?

About 3% of the goods that are transported by rail today are classified as hazardous. Hazardous materials are substances that can injure people and damage the environment and property.

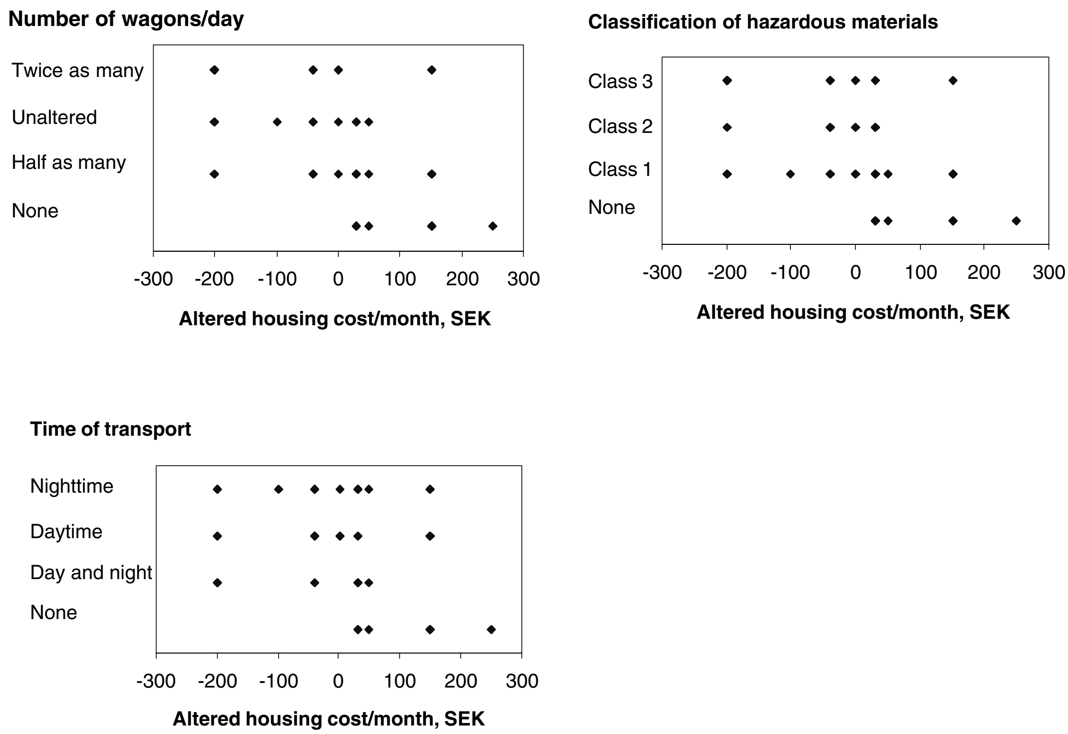

Fig. A1.

How often does an accident with hazardous materials occur in or near Lund?

At present about 70 goods trains, using Södra Stambanan, go through the center of Lund everyday. The probability of a goods train being derailed on the Eslöv-Malmö stretch is estimated to be 3–4 derailments over a period of 10 years, i.e., somewhat less than one every other year.

Goods trains transporting hazardous materials are rarely involved in accidents. Since the standards required of wagons that are used to transport the goods are rather demanding, spillage of hazardous substances is equally rare in the unlikely event of an accident. For instance, the probability of such an accident taking place on the Eslöv-Malmö stretch, and as a result of which gas leaks out, has been calculated to be one in 2,000 years.

What can happen if a hazardous material leaks out?

If a hazardous material leaks out, injury to people and damage to property and the environment may be the results, as well as inconvenience for the people living close by, who may have to be evacuated during clearance work. Even if there is no spillage of hazardous materials, people living in the area may have to be evacuated as a safety measure. In some cases, residents may have to leave their homes for up to a week.

Just how serious the consequences of an accident are depends mainly on what the spilled substance is, and the amount and speed of the leakage. Conditions in the immediate surroundings, such as the weather and distance to built-up areas, may also affect the consequences.

Should a hazardous material be spilled as a result of an accident, it is most likely that the outcome will be such that no people are injured and no property is damaged. Out of 10 accidents, 5 or more have no consequences at all, other than a decontamination of the scene of the accident.

What can happen in the worst-case scenario?

Worst-case accidents could mean dire consequences for people, property, and the environment. For example, if a large leakage of ammonia occurs, a toxic gas cloud could build up, leading to fatalities in the immediate vicinity and injuries to people within a radius of several kilometers from the accident site.

A large leakage of inflammable gas, when ignited, can lead to an explosion that may be directly fatal for people in the area. This type of accident also causes great damage to buildings and property.

However, the probability of the occurrence of an accident of the "worst type" is extremely small and may be expressed as: Assume that 10,000 accidents take place in which some hazardous substance leaks out (which very rarely happens). In only one of these cases will the accident be followed by very serious consequences.

No one has died in an accident involving hazardous materials in Sweden in the last 50 years. The probability that someone will die in an accident involving hazardous materials along the Eslöv-Malmö stretch is estimated to be one in 5,000 years.

Rail transport of hazardous materials through Lund

The last page of the questionnaire contains a map of the two railway lines that pass through Lund, Södra Stambanan, and Västkustbanan. About 70 wagons with hazardous materials pass through Lund on Södra Stambanan both day and night. No goods trains run on Västkustbanan.

APPENDIX C: INTRODUCTION TO THE CHOICE EXPERIMENT

The following introduction to the choice experiment is given in all questionnaires for the Lund subsample. For the Borlänge subsample, necessary adjustments are made in the text.

What is your standpoint regarding changes in the transport of hazardous materials?

This study assumes that the transport configuration of hazardous materials goods through Lund can be influenced. In turn, the transport configuration is assumed to influence the value of the properties in the area close to the railway line. The change in property value then gives rise to changes in the ratable value and real estate tax, expressed as an increased or decreased housing cost per month. These changes are assumed to affect the occupants of all types of housing, i.e., detached/semi-detached houses, collective ownership, and tenancies.

A further assumption is that the transported amount of hazardous materials can be classified according to its degree of hazardousness. The combinations of substances that constitute today's transports are assumed to have a degree of hazardousness of 2 on a scale from 1 (less hazardous) to 3 (very hazardous).

We now ask you to choose from different choice sets of configurations of transports of hazardous materials along Södra Stambanan through Lund. Each choice set contains:

- The number of wagons with hazardous materials that use the line daily.
- When the goods trains carrying hazardous materials use the line. Daytime is between 06 and 22 and nighttime is between 23 and 05.
- The classification of hazardousness of the transported material.
- The altered housing cost for your household compared to today.

Everything else is unchanged compared to the way you live today. The frequency of trains is assumed to be unaltered and thereby the level of noise that the railway causes.

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