VARIATION IN HOUSING DESIGN: IDENTIFYING CUSTOMER PREFERENCES

E. Hofman, J.I.M. Halman
Faculty of Engineering Technology, Department of Construction Management & Engineering,
University of Twente, Enschede, 7500 AE
E-mail: e.hofman@utwente.nl

Abstract: Housing suppliers in different countries are exploring ways to deliver high levels of customization in housing design. To produce this variety economically, it is important to know how customers prioritise the different parts of a house design. For parts with a great variety need several alternative solutions could be created in advance while parts with a low variety need can be produced as standard solutions for all homes, hereby taking advantage of economies of scale. This article presents the findings of a survey about the variation needs among potential buyers of new houses in The Netherlands. A priority listing of housing attributes in terms of variation need could be derived. This listing is of paramount importance for building developers who consider offering customised housing. Also the trade off relationship between customer value of variety and maximum price that can be asked for a customised housing proposition is examined. This article concludes with suggesting some future directions of research.

Keywords: customer preferences, house building industry, mass customisation.

1. INTRODUCTION

Companies are being forced nowadays to react to the growing individualization of demand. Previous studies have suggested that if companies want to meet these customers' needs overtime better than competition, they should offer a large variety of products (Dertouzos, 1989; Kahn, 1998; Mac Duffie et al, 1996; Stalk and Hout, 1990; Halman et al, 2003). More variety will make it more likely that customers find exactly the options they prefer. In considering the implementation of product variety, companies are also challenged to create this variety economically. Thus, making enterprises more customer centric efficiently has become a top management priority in most industries (Tseng and Piller, 2003).

Also in the housing industry one might notice an increasing demand for variety. Recent research about construction firms in countries such as Japan (Gann, 1996; Barlow et al, 2003, Noguchi, 2003), USA (Kendall, 1999), Great Britain (Ball, 1999; Ozaki, 2003;) and The Netherlands (Van den Thillart, 2004) shows that several firms are exploring ways to deliver high levels of customisation in housing design. This without increasing the price too much and losing the advantages of serial, project-wise, production (Wolters, 2001). To produce this required variety economically, it is important to know how customers prioritise the different parts and elements (such as bathroom, kitchen, roof type etc.) of a house design. For parts with a great variety need several alternative solutions could be created in advance. Potential buyers will successively select the one that best fits their own requirements. Parts with a low variety need however, can still be produced as standard solutions for all homes, hereby taking advantage of economies of scale.

Notwithstanding its importance, there is still a lack of knowledge when it comes to product choices that customers make in a mass customisation configuration (Dellaert and Stremersch, 2005). More specific, while interest in mass customised housing solutions becomes more widespread (e.g. Barlow, 1999; Barlow et al, 2003; Noguchi, 2003) still the prioritisation of housing attributes in house design customisation is unknown. This study therefore focuses on investigating how potential new home buyers in The Netherlands

prioritise the different parts and elements in a house design from the perspective of getting a variety of alternative solutions to select from.

The structure of the rest of this article is as follows. In the research methodology section we explain the successive steps that have been followed in conducting a vignette based survey among potential new home buyers in The Netherlands. This section is followed by an analysis of the vignettes using Saaty's clustering method (Saaty, 1982). In addition to the vignettes, respondents also had to prioritise 35 housing attributes on the level of importance to get customised solutions. In the data analysis section the housing attributes are presented and sorted according to the relative importance of expressed customisation needs. In this section we will also present the relationship that has been found between the price offered for specific housing propositions and their appreciation effect on potential buyers of new houses. The housing attributes are further explored with factor analysis in order to verify the levels of housing decomposition found in literature. Finally in the last section, we will elaborate on the contributions and limitations of this research and suggest future directions of research.

2. RESEARCH METHODOLOGY

This study is based on empirical evidence drawn from a mail survey conducted in The Netherlands. A preliminary phase was spent defining our research objectives, conducting literature review as well as interviewing experts in the field of mass customised house building. After analysing current developments in the field of mass customisation in house building, the current research focused on exploring customers' priorities on variety needs in housing design. Based on the preliminary literature review and expert interviews, five levels of housing decomposition were identified. These levels are: Technical systems; Interior finish; Floor plan; House volume & exterior and; Environment; and they were used for structuring the first draft of our questionnaire.

2.1 Questionnaire design

Sometimes it is straightforward to measure priority judgements about a product or service. One can just ask the interviewee to select between two quality criteria. However, in complex decision making situations in which multiple options should be evaluated by customers, a vignette based questionnaire is preferred (Rossi, 1982; Govers, 1993; Wason et al, 2002). On a vignette, a personal or social situation is represented by some short descriptions. The descriptions comprehend the most important factors in the priority decision-making process and each description contains a well-defined stimulus component. Vignette-based studies are superior to direct-question-based studies because vignettes better approximate real-life decision making situations (Wason et al 2002). In our questionnaire design process, we followed the steps as suggested by Govers (1993): identification of relevant characteristics, creation of vignettes and collection and analysis of data. In our case the relevant characteristics consist of the five levels of housing decomposition as pointed out before. Choice alternatives at each of these levels increase customer value to some extent. The purpose of this study has been to elicit the relative weights of these choice alternatives. In this study vignettes are used to describe hypothetical housing propositions. These propositions are represented by the five levels of housing decomposition. Potential buyers of new houses had to score several vignettes with respect to the level they preferred this proposition. Table 1 outlines the levels of housing decomposition and the values linked with these levels (stimuli).

Table 1. Description of vignette characteristics

Level of housing decomposition	Value
A Technical systems	1 Choice
	2 No choice
B Interior finish	1 Choice
	2 No choice
C Floor plan	1 Choice
	2 No choice
D House volume & exterior	1 Choice
	2 No choice
E Environment	1 Choice
	2 No choice

The respondents also had to score each hypothetical situation under different price conditions. This ensures that the price constraint is built into the choice experiment. A six-point semi-labelled rating scale was used for scoring the criteria (see "Appendix 1); this is a so-called forced-choice response scale. Such a scale forces the respondents to decide whether they lean more towards the "very good" or "very poor" end of the scale for each vignette. Figure 1 presents an example of a first-order vignette.

Vignette no. 1: Imagine the following housing proposition:

Participation in designing your future home demands a lot of time, money and effort from the customer as well as from the professionals such as the housing developer, architect and the construction company. Therefore: the more variation is demanded, the higher the costs in general will become. A standard home is a home that's offered without any variation.

+ You will have **a say** about **technical systems (**such as the type of heating (wall or floor) and the number and location of the sockets, switches and water taps).
- You will have **no say** about the **interior finish** (such as the type of kitchen, washbasins and toilet, the floor - and wall finish and the door hardware (locks and latches).
- You will have **no say** about the **floor plan** (such as position and size of the living-, bed- and toilet rooms, kitchen and doorways).
- You will have **no say** about the **volume of the home and the exterior finish** (such as the size of the home, the type of roofing and the façade design).
- You will have **no say** about the **environment** (such as plot layout, parking lots and pavement of the neighbourhood).

1 = I evaluate this housing proposition as very good,
6 = I evaluate this housing proposition as very poor

Fig. 1. Example of a first-order vignette

A first order vignette defines one negative statement and four positive statements. A second-order vignette defines two negative statements and three positive statements, and so on. Maximizing the number of vignettes to be judged weighted against the respondents' time and

concentration. Therefore it was decided to present to each respondent ad random sets of ten vignettes. Respondents evaluated a total number of 15 vignettes. In addition to the vignettes we included 35 attributes in the questionnaire. These attributes are related to the five housing decomposition levels. For each attribute respondents were asked to score the relative importance to be involved in the housing design process.

2.2 Data collection

After constructing the questionnaire it was pilot tested within a group of four experts and ten non-experts. The group evaluated each question for clarity, specificity and representativeness. After small improvements the first draft was made ready to be sent out. The sampling frame consisted of 304 potential buyers of new houses. Their addresses where obtained with the help of a large Dutch real estate office. First we sent a letter to all 304 potential customers. In this letter we explained the meaning of the research, and we notified the respondent about a confirmation call a week later, to ask whether or not the respondent was willing to participate. Second, phone calls were made to each potential respondent. About 110 customers were reached to whom the meaning of the research was clarified. We also informed them that the survey would be anonymous; 86 persons agreed to participate while 24 refused. The sampling frame consisted of 304 potential buyers of new houses minus the 24 persons who refused to participate. This resulted in 82 respondents, giving a return rate of 27 percent, which is about average for a postal survey. The sample population represents the group of potential buyers of new single-family homes in the province of Utrecht in The Netherlands. Buyers of other homes such as apartments were not included within our sample population. To test our research for non-response bias, 20 non-respondents were shortly interviewed. The test did not show significant consequences of non-response for our survey estimates. The confidence interval of the survey results is 0.1 and the confidence level is 0.95. This means that the survey results approximate the true populations' mean with a confidence level of 0.95 and a confidence interval of 0.1.

2.3 Data Analysis and Results

After data collection we performed three types of data analysis. First we determined for the five levels of housing decomposition how customers prioritise these levels in terms of having a say in the design decision making process. The relative weights were calculated by using Saaty's clustering method (Saaty, 1982) for the respective vignettes. In a next step we determined the relative importance of expressed customisation needs for the 35 housing attributes that were included in this study. Finally we performed a regression analysis to determine the trade off between the potential price that can be asked for specific customised housing propositions and their effect on the way how potential buyers (re)evaluate such propositions.

Allocation of weights

To calculate the relative weights assigned by customers to the five levels of housing decomposition, we applied as explained before, Saaty's clustering method (Saaty, 1982). Clustering is a way to improve the consistency of estimations, in case respondents have to evaluate many or complex options. Besides this, clustering can dramatically decrease the number of estimations needed. The next procedure was followed (see also table 2):

- i = a, b…e, this is the first-order vignette with a variance of attribute i;
- ij = (a..e)(a..e) this is the second-order vignette with a variance of attributes i and j;
- In
- *Table 2* the varied attributes are indicated by a + sign.

Table 2. Weighting method for calculating priorities

	Attribute (i)					**Vignet (ij)**	**Mean score**	**Normalized mean score**	**Weights**				
	a	b	c	d	e		**step 0**	**step 1**	a	b	c	d	e
1st order vignettes	+					a	0,88	0,03	0,03				
		+				b	1,94	0,08		0,08			
			+			c	1,7	0,07			0,07		
				+		d	2	0,08				0,08	
					+	e	0,91	0,04					0,04
							Average weight 1st order vignettes		**12%**	**26%**	**23%**	**27%**	**12%**
2nd order vignettes	+	+				ab	2,35	0,09	0,003	0,007			
	+		+			ac	2,15	0,08	0,003		0,006		
	+			+		ad	1,72	0,07	0,002			0,005	
	+				+	ae	1,15	0,05	0,002				0,002
		+	+			bc	2,27	0,09		0,007	0,006		
		+		+		bd	2,28	0,09		0,007		0,007	
		+			+	be	1,62	0,06		0,005			0,002
			+	+		cd	1,7	0,07			0,004	0,005	
			+		+	ce	1,33	0,05			0,004		0,002
				+	+	de	1,35	0,05				0,004	0,002
						Total	25,35	1 **step 3 (w_i)**	0,010	0,026	0,020	0,022	0,008
							Average weight 2nd order vignettes (w)		**12%**	**30%**	**23%**	**26%**	**9%**

Attribute (i)		
a	technical systems	+ customer has voice in specific attribute (i)
b	interior finish	
c	floor plan	
d	house volume & exterior	
e	environment	

Step 0: The mean score of the first order vignettes S_i and second order vignettes S_{ij} are derived from the individual customer scores.

Step 1: The normalized mean score S_i and S_{ij} is calculated by $S_i / (\sum S_i + \sum S_{ij})$ and $S_{ij} / (\sum S_i + \sum S_{ij})$. The normalised scores are denoted by respectively $\hat{S}_i$ and $\hat{S}_{ij}$.

Step 2: The normalised attribute-scores $\hat{S}_i$ are multiplied by the matching normalised attribute-scores $\hat{S}_{ij}$ for the scores with corresponding $i = a, b, .., e$.

Step 3: The weights w_i are calculated by $w_i = \sum_{j=a}^{e} \hat{S}_i \hat{S}_{ij} / n$ for $i = a, b, .., e$. The final priority vector w is calculated by normalisation of w_i : $w = w_i / \sum_{i=1}^{n} w_i$

The customers' weights from table 2 are illustrated in figure 2. As can be concluded from this figure, customers evaluate the interior finish as the most important level of housing decomposition; it has a weight of 30%. Floor plan and the volume and exterior of the home have a weight of respectively 23% and 26%. The environment and technical systems are the least important levels with a weight of respectively 9% and 12%. The homogeneity of the participation levels has been measured by Cronbach's alpha (0.7933). This Cronbach's alpha is sufficient to confirm the five levels of housing decomposition as a subscale.

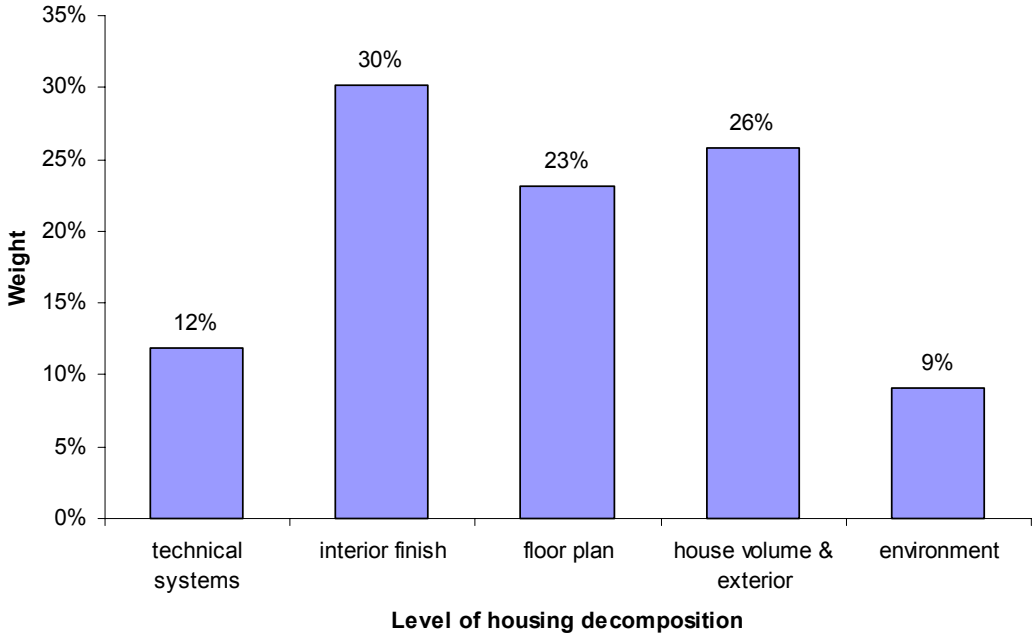

Fig. 2. Customer priorities in levels of housing decomposition

Relative importance of housing attributes

A characteristic of a hierarchy is that it consists of levels. The five levels of housing decomposition together form the highest hierarchy in this study. These levels were further decomposed into 35 housing attributes. Besides evaluating the proposed vignettes, respondents were also asked to score the relative importance of each housing attribute on their value of offering a customised solution. Figure 3 shows the 35 attributes sorted according to the relative importance for potential buyers of new homes of getting customised solutions.

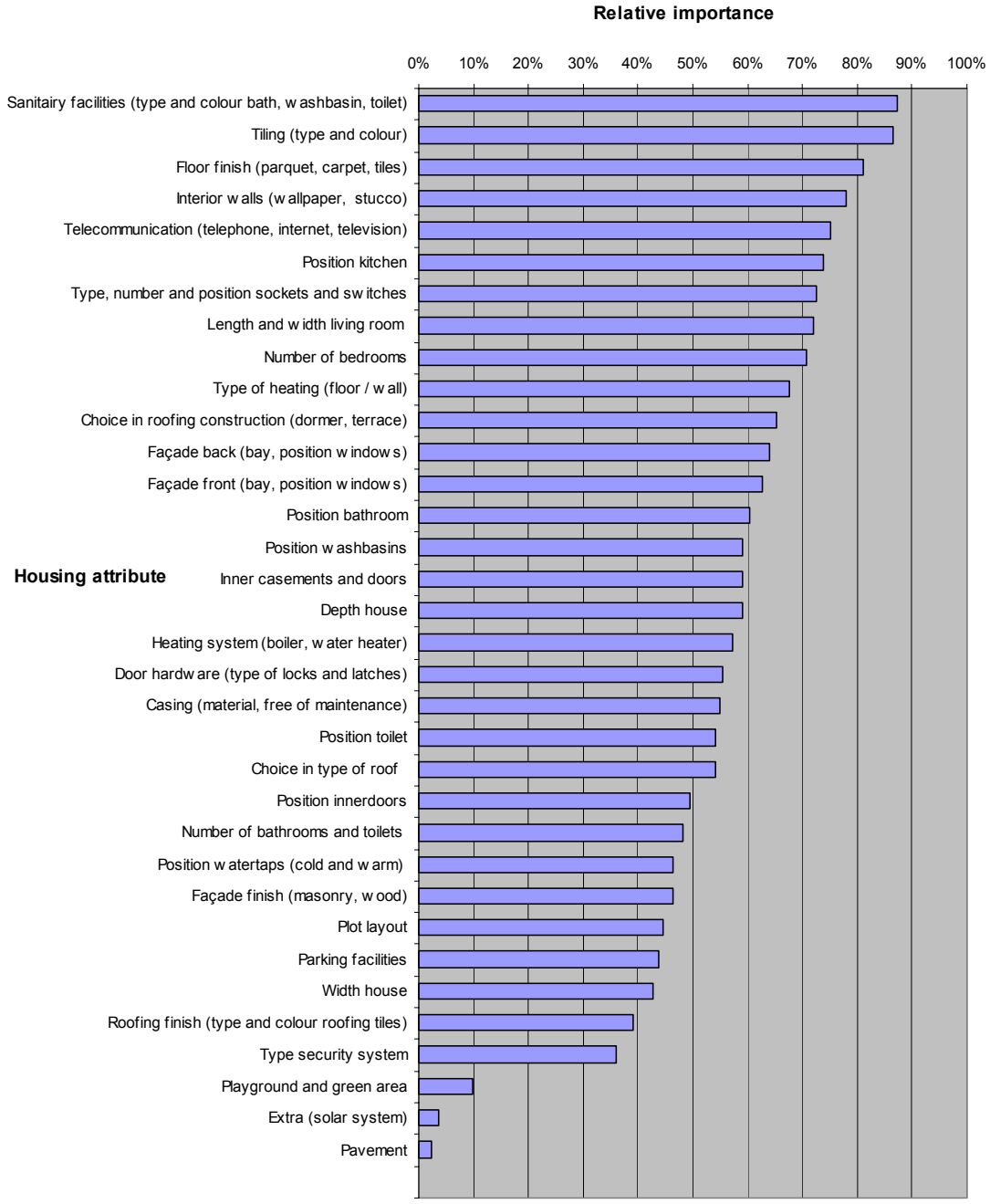

Fig. 3. Housing attributes: Relative importance for potential buyers

The attributes with the highest relative importance appear to be part of the level of housing decomposition "Interior finish" while the five least important attributes, except for the attribute roof finish, belong to the level "Environment".

Trade off between price and added value of customised solution

Respondents also had to rank each housing proposition under different price conditions. This allowed us to estimate the trade off between the price asked for a housing proposition and the added value from the perspective of the potential buyer. Figure 4 illustrates this price-value elasticity for the five distinguished levels of housing decomposition. The curves in figure 4

were determined by interpolation of our data. Using the regression analysis method we noticed that our data show an exponential fit; where the intercept was fixed at 0. Since the respective equations (see table 3) all show great resemblance, we assume the trade-off between price and customer-value to be similar for all five levels of housing decomposition.

Table 3. Regression model of Price - Customer Value trade off

Level of housing decomposition	Equation trend lines	R-squared
House volume and exterior	y = 4,3281e-4E-05x	R2 = 0,9966
Interior finish	y = 4,2881e-4E-05x	R2 = 0,9929
Floor plan	y = 4,0094e-4E-05x	R2 = 0,9998
Environment	y = 2,8164e-5E-05x	R2 = 0,9833
Technical systems	y = 3,3019e-6E-05x	R2 = 0,9626

In our questionnaire we further asked for the maximum amount of money a customer was willing to pay for the housing proposition that would best fit his or her needs. The results show that averagely a customer is willing to pay € 23.333 extra for the perfect housing proposition compared to a house in which no variation is offered. This amount is represented by the vertical axis in figure 4.

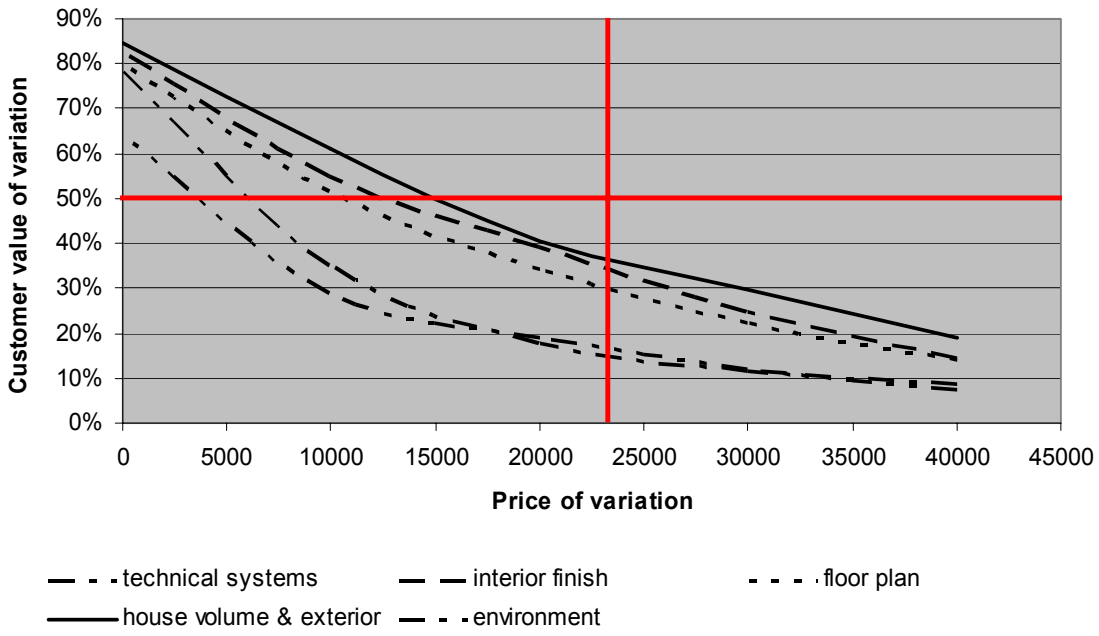

Figure 4. A Price-Value trade off in customised housing propositions

From the Price - Customer Value trade off relationship one might deduce that the minimum value to satisfy a customer is 50%. This limit is shown in figure 4 by the horizontal axis. The points of intersection between the price-value curves of the respective housing propositions and the lower limit indicate the maximum price for which each proposition remains acceptable. The difference between this price and the maximum sum a customer is willing to pay for his "perfect package" forms the opportunity-sales for the supplier. The supplier can add options to the package up to the maximum amount of money the customer is willing to pay.

2.4 Explorative factor analysis

To verify whether the hypothesized five levels of housing decomposition could empirically be confirmed we conducted a factor analysis. To determine the appropriateness of a factor analysis an overall test for significance of the correlation matrix is performed. This measure of sampling adequacy (MSA) falls with a value of 0.689 in the acceptable range (>0.50). The basic idea behind the factor analysis, in our case a principle component analysis (PCA), is that it may be possible to describe a large set of input attributes in terms of a smaller number of underlying components. These unobserved components capture most of the information or variation contained in the larger set of observed attributes. To interpret the PCA solution we tried to find labels expressing the contents of the factors. As the factors are unknown a priori, we labeled the factors indirectly by means of the attributes' factor loadings (r). After labelling, it is possible to verify whether these factors correspond to our initial hypothetical levels of housing decomposition.

In literature (Habraken, 1998; Kendall et al, 2000) it is claimed that five to six levels of housing decomposition exist, see table 4.

Table 4: factors found in literature

Habraken	**Van Randen**	**Kendall**
Major arteries	City structure	Urban structure
Roads	Tissue level	Urban fabric
Building elements	Support level	Base building
Partitioning	House allocation	Fit-out
Furniture	Infill level	Furniture and Equipment
Body and utensils		

Therefore we set the number of factors to extract to five. To make the PCA output more clearly to facilitate the interpretation of factors, we performed a Varimax Rotation. Varimax rotation performs an orthogonal rotation in which factors are forced to be uncorrelated (Conway & Huffcutt, 2003). However, if the factors correlate, this method is likely to produce distorted results. The alternative, oblique rotation, does allow for factor correlations. We performed both a Varimax as well as a Promax rotation. The results show highly similar pattern and factor structures, indicating that the assumption of uncorrelated factors matches the data. A cut-off score of r = 0,5 was considered reasonable for inclusion of a variable in interpretation of a factor. A first PCA with Varimax rotation yielded five factors with an Eigenvalue above 1,5 and which explained 65 percent of the variance of all 35 attributes. There was a clear dip between the eigenvalue for the first (8.6) and second factors (3.1). We repeated this PCA procedure two times with exclusion of those attributes with r smaller than 0,5. In total seven attributes where eliminated because of a poor association with the other attributes within the specific constructs. Retained in the final factor structures were five factors and 28 attributes with factor loadings of greater than 0.5.

Table 5: rotated component matrix after Varimax rotation

Rotated Component Matrix(a) after deleting 7 variables with r < 0,5

	Component				
	1	2	3	4	5
Position bathroom	**0,801**				
Position kitchen	**0,779**				
Length and width living room	**0,777**				
Position toilet	**0,752**				
Number of bedrooms	**0,730**				
Number of bathrooms and toilets	**0,666**				
Choice in roofing construction (e.g. dormer window)	**0,563**				
Position washbasins	**0,556**				
Door hardware (type of locks and latches)	**0,555**				
Façade back (bay, glass, position windows)	***0,520***		***0,514***		
Sanitairy facilities (type and colour bath, washbasin, toilet)		**0,855**			
Tiling (type and colour)		**0,841**			
Interior walls (wallpaper, stuc)		**0,776**			
Floor finish (parquet, carpet, tiles)		**0,745**			
Type of kitchen		**0,730**			
Façade finish (masonry, wood, other)			**0,862**		
Façade front (bay, glass, position windows)			**0,631**		
Pavement			**0,586**		
Width dwelling			**0,569**		
Casements (material)			**0,524**		
Type, number and position sockets and switches				**0,866**	
Water (combi of los)				**0,745**	
Type of heating (floor / wall)				**0,704**	
Telecommunication (telephone, internet, television)				**0,623**	
Type of alarmsystem				**0,515**	
Inner casements and doors					**0,660**
Position innerdoors					**0,611**
Choice in type of roof					***0,508***
Alpha	**0,90**	**0,87**	**0,80**	**0,78**	**0,54**
Alpha after deletion of italic loading	**0,87**		**0,76**		**0,59**

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 20 iterations.

The five factors accounted for 65% percent of the total variance of these 28 attributes. An overview of these factors and corresponding factor attributes and loadings is given in table 4. Factor I: "floor plan" consists of nine attributes that reflect floor plan issues, the respective factor loadings range from r = 0.52 to r = 0.80. This factor comprehends the issues such as: position of the kitchen, bathroom and toilets; the length and width of the living room, the number of bedrooms; and more notably also the design of the back façade loads heavily on this factor, so we might argue that customers think of the back façade as a floor plan issue, rather than of an exterior finish issue. Factor II: "interior finish" consists of five attributes that reflect interior finish issues, with variable loadings from r = 0.73 to r = 0.86. This factor refers to the issues: type of tiling, sanitary facilities, wall and floor finish and type of kitchen. Factor III: "exterior finish" consists of exterior finish issues with factor loadings ranging from r = 0.52 to r = 0.86. Attributes such as façade, width dwelling, and casements form part of this factor. Also the attribute pavement loads high on this factor. Factor IV reflects issues concerning "technical systems"; it has five loadings ranging from r = 0.51 to r = 0.87 on type, number and position of sockets and switches, water system, type of heating, telecommunication and type of alarm system. Factor V: "inner doorways" is a new factor and reflects issues about casements and inner doors. Also the variable door hardware has a relative high loading on this factor. Curiously enough also choice in type of roof loads high on this factor.

From this factor analyses it follows that in the mindset of the customer five factors concerning variation in housing design exist. One of the factors derived from theory "environment" could not be confirmed with this analysis; another factor however, "inner doorways" was added as a factor.

After labelling, an estimate of internal consistency for the factors, the scale reliability coefficient Cronbach's alpha, was computed. These estimates are shown in table 4. The

alpha's of the factors were larger than 0.78, except for the new factor labelled as "inner doorways". This level concerns positions of inner doors and type of doors & casements. Cronbach's alpha of this construct appeared to be 0.59 (after deletion of attribute choice type of roof), after adding the item door hardware this alpha increased to 0.73; therefore this attribute can be included in this factor as well. Because attribute "façade back" loads both on the first and third factor, we recalculated alpha for the first and third factor, after dropping this attribute, the alpha's slightly decreased in value but still remain acceptable. The results show that choice in back façade loads on the factor interior finish, the front façade has comparable loadings on both the level of interior finish as on the level of exterior finish. So, customers think different of the back façade then of the in front façade, this has consequences for the way variation in these attributes is offered.

3. CONTRIBUTIONS, LIMITATIONS AND FUTURE RESEARCH

The objective of this study has been to explore how potential new home buyers prioritise the different parts and elements in a house design from the perspective of getting a customised versus a standard solution offered. Based upon the findings of this study we will discuss the contributions and limitations of this study and suggest some directions for future research.

A main outcome of this study is the priority listing of housing attributes as presented in figure 3. This priority listing is of paramount importance for all building companies who offer or consider offering customised housing. Building developers may conclude from this listing what potential buyers regard as being the most important housing attributes of getting customised solutions. This priority listing will help building developers in decision making about the right balance between the level of variety (such as different types of bathrooms, kitchens, roof types etc.) to be offered versus the need to standardise and produce economically.

Although people in general prefer to have the opportunity to select from options, they will however be less inclined if this option also means an increase in price. A second principal contribution of this study has been the development of a model to deduce the trade off between customer value and price of housing proposition. The difference between customer value and price can be used to measure the incentive for the customer to buy. To outperform competitors, it is suggested that housing suppliers could follow a strategy of increasing this difference.

Based on an explorative factor analysis, we conclude that customers have five levels of housing decomposition in mind when they think of variation in housing design. These are the levels: floor plan, interior finish, exterior finish, technical systems and inner doorways. The environmental level is no longer part of this decomposition because there was no factor that could be labelled this way. Further analysis, specifically confirmative factor analysis (Netemeyer et al, 2003) must be conducted to strengthen these conclusions.

The moderate sample size could potentially limit the power of the statistical techniques used. A rule of thumb in factor analysis is a ratio of respondents to variables of at least 4:1. Nevertheless, if communalities are high, recovery of population factors in sample data is normally very good, almost regardless of sample size (MacCallum et al, 2001). In our case, average communality is 0.672. This is rather high and therefore we do not worry about the moderate sample size of 82. In addition, some opportunities for further research can be derived from certain limitations of our research. First, this study has been conducted in The Netherlands. One might question to what extent the results will also be fully applicable in other countries. Repeating this research also outside The Netherlands will reveal to what extent potential buyers of new houses in other countries differ in prioritizing attributes in

house design. Another limitation concerns the method used. Major advantage of the vignette method is that it has characteristics similar of an experiment and that it therefore approximates real-life decision-making situations. A weakness of the method however, is that the number of vignettes grows exponentially with the number of attributes and corresponding levels. Therefore only a limited amount of attributes can be investigated at a reasonable amount of costs (Gibson, 2001). Furthermore in our research we excluded house renters from our sample. We wonder to what extent our results can also be generalized for the house rental sector. This knowledge is of importance for housing corporations who are increasingly adopting more customer centric rental policies. They differ from private housing suppliers in a sense that they explicitly also have to take into account future rentability of their houses. Finally it must be noted that a limitation in our research concerns a lack of insight in the customer value of packages of options under different price conditions. In practice a housing supplier offers packages of variation at the different levels of housing decomposition at the same time. Such a strategy maximizes customer value and minimizes the matching price. In order to offer the right package, we need to enlarge insights in the way customers value possible packages of variation as a function of the matching package-prices. These packages are similar like multi attribute product alternatives and can therefore be analysed using techniques such as conjoint analysis.

An important consequence of the need to offer a variety of modules and components is that building companies will have to become capable in modularising their product portfolio. However, although methodologies have been developed recently for evaluating the applicability of modules and product platforms in different industries (e.g. Martin and Ishii, 2002), so far no systemic methodologies have been applied and tested in the specific setting of the house building industry. It is suggested therefore to initiate research that could provide insight about successful methods to define and implement modularisation concepts in the building industry and investigate also its implications for the building supply chain.

Filling the aforementioned gaps in literature would be an important contribution, both from an academic as well as from a managerial point of view. We are positive that our research has started on answering these pending issues by narrowing the focus for further research but also by suggesting expanding the investigation to other countries. This will broaden our state-of-the art knowledge about how to build customised houses economically.

4. REFERENCES

Ball, M. (1999) Chasing a snail: innovation and house building firms' strategies, *Housing Studies* 14 (1) pp. 9–22.

Barlow, J. (1999) From Craft Production to Mass Customisation, Innovation Requirements for the UK House building Industry, *Housing Studies* 14 (1) pp. 23-42.

Barlow, J., Childerhouse, P., Gann, D., Hong-Minh, S., Naim, M. & Ozaki, R. (2003) Choice and delivery in housebuilidng, lessons from Japan for UK house builders, *Building Research and information*, 31 (2), pp. 134-145.

Bartlett, K. Potter, M., Meikle, J., Ozaki, R., Hakes, J., Young, R.K., Duffy, F. & Hooper, A. (2000), *Consumer choice in housing: The beginnings of a house buyer revolt* (York, York Publishing Services).

Conway, J.M. and Huffcutt, A. I. (2003). A Review and Evaluation of Exploratory Factor Analysis Practices in Organizational Research, *Organizational Research Methods*, 6 (2), 147-168.

Dellaert, B.G.C. & Stremersch, S. (2005) Marketing Mass-Customised Products: Striking a Balance between Utility and Complexity, *Journal of Marketing Research* 42 (2) pp. 219-227.

Dertouzos, M.L. (1989) *Made in America: Regaining the Productive Edge* (Cambridge, MA, IT Press).

Gann, D.M. (1996) Construction as a manufacturing process? Similarities and differences between industrialized housing and car production in Japan, *Construction Management and Economics* 14 (5) pp. 437–50.

Gibson, L.D. (2001) What's wrong with conjoint analysis? *Market Research* 13 (4) pp. 16-19.

Govers, C.P.M. (1993), Quality of services "applicable to production?", *International Journal of Production Economics*, 30-31, pp. 385-397

Groves, Robert M, Dillman, Don A, Eltinge John L & Little, Roderick J. A. (2001), *Survey Nonresponse* (John Wiley & Sons).

Habraken, N.J. (1998), *The Structure of the Ordinary, Form and Control of the Built Environment*, The MIT Press, Cambridge, Massachusetss, London, England, ISBN: 0-262-08260-8

Halman, J.I.M., Hofer, A.P. & Van Vuuren, W. (2003), Platform-Driven Development of Product Families: Linking Theory with Practice, *Journal of Product Innovation Management*, 20 (2) pp. 149-162.

Kahn, B.E. (1998) Dynamic relationships with customers: high-variety strategies, *Journal of the Academy of Marketing Science* 26 (1) pp. 45-53.

Kendall, S. en Teicher, J. (2000), Residential Open Building, International Council for Building Research Studies and Documentation, E&FN Spon, London and New York. ISBN: 0-419-23830-1

MacCallum, R.C., Widaman, K.F., Preacher, K.J., Hong, S. (2001), Sample Size in Factor Analysis: The Role of Model Error, *Multivariate Behavioral Research,* 36(4), pp. 611-637.

MacDuffie, J.P., Sethuraman, K. & Fisher, M.L. (1996) Product variety and manufacturing performance: evidence from the international automotive assembly plant study, *Management Science* 42 (3) pp. 350-369.

Martin M.V. & Ishii, K. (2002) Design for variety: developing standardized and modularized product platform architectures, *Research in Engineering Design* 13 (4): pp. 213-235.

Netemeyer, R.G., Bearden, W.O. and Sharma, S. (2003). *Scaling procedures: Issues and Applications*. Thousand Oaks: Sage Publications.

Ozaki, R. (2003) Customer-focused approaches to innovation in house building, *Construction Management & Economics* 21 (9) pp. 557-564.

Noguchi, M. (2003) The effect of the quality-oriented production approach on the delivery of prefabricated homes in Japan, *Journal of Housing and the Built Environment* 18 (4) pp. 353-364.

Rossi, P. H. & Anderson, A. B. (1982) The Factorial Survey Approach: An Introduction, in: P.H. Rossi & S.L. Nock (Eds.), *Measuring Social Judgments: The Factorial Survey Approach* (Beverly Hills, CA: Sage Publications).

Saaty, T.L & Vargas, L.G. (1982) *The Logic of Priorities: Applications in Business, Energy, Health and Transportation*, (Den Haag, Kluwer Nijhoff)

Stalk Jr., G. & Hout, T. (1990) *Competing against Time* (New York, Free Press)

Tseng, M.M. & Piller, F.T. (2003) *The customer centric enterprise: advances in mass customisation and personalization* (Berlin, Springer).

Van den Thillart, C.C.A.M. (2004), *Customised Industrialisation in the Residential Sector, Mass Customisation modelling as a tool for benchmarking, variation and selection* (Amsterdam, SUN Publishers)

Wason, K.D., Polonsky, M.J. & Hyman, M.R., (2002), Designing Vignette Studies in Marketing, *Australasian Marketing Journal* 10 (3) pp 41-58.
Wolters, M.J.J. (2001) *The business of modularity and the modularity of business,* PhD Thesis *(*Rotterdam, Erasmus University Press).

Appendix 1: Questionnaire Customised Housing

Customer oriented house building is nothing more than building what the customer asks for. The customer may participate in for instance the design of:

- Environment; examples are paving, parking lots and playing fields;
- Skeleton and exterior finish; examples are the volume of the dwelling and choice of type of masonry;
- Floor plan; examples are position of bedrooms and the number of bedrooms;
- Interior finish and materialisation; examples are tiling and the finish of interior partitions;
- Technical systems; examples are electro technical systems and type of heating system.

Housing developers and construction companies want to effectively act upon customers' needs. We would be glad to here your opinion about variation in design.

We thank you for your cooperation!

General questions

If you would buy a <u>new</u> house, which <u>price category</u> would the house be part of? (amount of money in €)

Up to 100 000	100 000 – 200 000	200 000 – 300 000	300 000 – 400 000	400 000 or more
[ ]	[ ]	[ ]	[ ]	[ ]

Have you ever bought a newly built house before?

Yes	No
[ ]	[ ]

What house would like to buy?

Detached	Semi-detached	Corner house	Row house
[ ]	[ ]	[ ]	[ ]

What is your age category?

0-25 years	25-35 years	35-45 years	45-55 years	55-65 years	65 +
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

What is your family type?

Single family	Pair without children	Pair with children	Single-parent family
[ ]	[ ]	[ ]	[ ]

What is your income category?

Up to 10 000 Euro	10 to 20 thousand Euro	20 to 30 thousand Euro	More than 30 000 Euro
[ ]	[ ]	[ ]	[ ]

Example of vignette related questions

For each proposition please indicate how you judge these fictive situations:
1 = I mark this situation as very good**,** **6** = I mark this situation as very poor**.**

Sums of money are in €.
Participation in designing your future home demands a lot of time, money and effort from the customer as well as from the professionals such as the housing developer, architect and the construction company. Therefore: the more variation is demanded, the higher the costs in general will become. A standard home is a home that's offered without any variation.

Vignette no. 2: Imagine the following housing proposition:

Participation in designing your future home demands a lot of time, money and effort from the customer as well as from the professionals such as the housing developer, architect and the construction company. Therefore: the more variation is demanded, the higher the costs in general will become. A standard home is a home that's offered without any variation.

- You will have **a say** about **technical systems (**such as the type of heating (wall or floor) and the number and location of the sockets, switches and water taps).
+ You will have **no say** about the **interior finish** (such as the type of kitchen, washbasins and toilet, the floor - and wall finish and the door hardware (locks and latches).
- You will have **no say** about the **floor plan** (such as position and size of the living-, bed- and toilet rooms, kitchen and doorways).
- You will have **no say** about the **volume of the home and the exterior finish** (such as the size of the home, the type of roofing and the façade design).
- You will have **no say** about the **environment** (such as plot layout, parking lots and pavement of the neighbourhood).

1 = I evaluate this housing proposition as very good, 6 = I evaluate this housing proposition as very poor

How do you evaluate this housing proposition with respect to the offered participation, if you pay:	**1 = very good, [1]**	**[2]**	**[3]**	**[4]**	**[5]**	**6 = very poor [6]**
40 000 more than for a standard home?	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
30 000 more than for a standard home?	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
20 000 more than for a standard home?	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
10 000 more than for a standard home?	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
5 000 more than for a standard home?	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
0 more than for a standard home?	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

In total respondents were presented fifteen vignettes consisting of five first-order vignettes and ten second-order vignettes.

Additional questions
Please read following list and indicate how important variation in the different attributes is for you. Score each attribute and mark it with a cross.

Explanation score, pay attention!
1 = I think participation in this option is very important;
3 = I think participation in this option has a neutral importance;
5 = I think participation in this option is absolutely not important.

		How important is participation to you? 1 = very important, 5 = not important				
Code	**Name**	**1**	**2**	**3**	**4**	**5**
A.	**Environment**					
a.1	Plot layout	[ ]	[ ]	[ ]	[ ]	[ ]
a.2	Parking facilities	[ ]	[ ]	[ ]	[ ]	[ ]
a.3	Pavement	[ ]	[ ]	[ ]	[ ]	[ ]
a.4	Playground	[ ]	[ ]	[ ]	[ ]	[ ]
B.	**Volume and exterior finish**	**1**	**2**	**3**	**4**	**5**
b.1	Width dwelling	[ ]	[ ]	[ ]	[ ]	[ ]
b.2	Depth dwelling	[ ]	[ ]	[ ]	[ ]	[ ]
b.3	Choice in type of roof	[ ]	[ ]	[ ]	[ ]	[ ]
b.4	Choice in roofing construction (e.g. dormer window)	[ ]	[ ]	[ ]	[ ]	[ ]
b.5	Façade front (bay, glass, position windows)	[ ]	[ ]	[ ]	[ ]	[ ]
b.6	Façade back (bay, glass, position windows)	[ ]	[ ]	[ ]	[ ]	[ ]
b.7	Façade finish (masonry, wood, other)	[ ]	[ ]	[ ]	[ ]	[ ]
b.8	Casements (material)	[ ]	[ ]	[ ]	[ ]	[ ]
b.9	Roofing finish (type and colour roofing tiles)	[ ]	[ ]	[ ]	[ ]	[ ]
C.	**Layout house**	**1**	**2**	**3**	**4**	**5**
c.1	Length and width living room	[ ]	[ ]	[ ]	[ ]	[ ]
c.2	Position kitchen	[ ]	[ ]	[ ]	[ ]	[ ]
c.3	Position bathroom	[ ]	[ ]	[ ]	[ ]	[ ]
c.4	Position toilet	[ ]	[ ]	[ ]	[ ]	[ ]
c.5	Position inner doors	[ ]	[ ]	[ ]	[ ]	[ ]
c.6	Number of bedrooms	[ ]	[ ]	[ ]	[ ]	[ ]
c.7	Number of bathrooms and toilets	[ ]	[ ]	[ ]	[ ]	[ ]
		How important is participation to you? 1 = very important, 5 = not important				
D.	**Interior**	**1**	**2**	**3**	**4**	**5**
d.1	Interior walls (wallpaper, stucco)	[ ]	[ ]	[ ]	[ ]	[ ]
d.2	Tiling (type and colour)	[ ]	[ ]	[ ]	[ ]	[ ]

d.3	Sanitary facilities (type and colour bath, washbasin, toilet)	[ ]	[ ]	[ ]	[ ]	[ ]
d.4	Inner casements and doors	[ ]	[ ]	[ ]	[ ]	[ ]
d.5	Floor finish (parquet, carpet, tiles)	[ ]	[ ]	[ ]	[ ]	[ ]
d.6	Door hardware (type of locks and latches)	[ ]	[ ]	[ ]	[ ]	[ ]
d.7	Type of kitchen	[ ]	[ ]	[ ]	[ ]	[ ]
d.8	Position washbasins	[ ]	[ ]	[ ]	[ ]	[ ]
E.	**Equipment**	**1**	**2**	**3**	**4**	**5**
e.1	Type, number and position sockets and switches	[ ]	[ ]	[ ]	[ ]	[ ]
e.2	Telecommunication (telephone, internet, television)	[ ]	[ ]	[ ]	[ ]	[ ]
e.3	Type of alarm system	[ ]	[ ]	[ ]	[ ]	[ ]
	Type of heating (floor / wall)					
e.4	Water (combined or separate)	[ ]	[ ]	[ ]	[ ]	[ ]
e.5	Extra (solar system)	[ ]	[ ]	[ ]	[ ]	[ ]
e.6	Position water taps (cold and warm)	[ ]	[ ]	[ ]	[ ]	[ ]