THE USE OF CONJOINT ANALYSIS TO ASSESS THE IMPACT OF ENVIRONMENTAL STIGMA

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ABSTRACT

The identification of the correct approaches to use in the valuation of property affected by land contamination is of great interest, not only to the valuation profession, but also to the stake-holders (the developers, owners and lenders) of contaminated land. These parties wish to know the magnitude and duration of the impact of contamination on property values, both before and after remediation. However, uncertainty exists as to how to measure the impact, and the appropriate way to account for it. This paper demonstrates how the use of conjoint analysis, a survey-based approach, can aid the impact assessment of contamination stigma on residential property values.

Keywords: Site contamination, remediation, stigma, property values, public opinion surveys, conjoint analysis

INTRODUCTION

Stigma, in relation to remediated contaminated land, is the price (value) reduction required to compensate investors for perceived financial risks and uncertainties associated with remediated contaminated property. Uncertainties relate to negative intangible factors, such as the inability to effect a total "cure", the possibility of failure of the remediation method, the possibility of changes in legislation or remediation standards, difficulty in obtaining financing, or simply a fear of the unknown (Patchin, 1991; Syms, 1996; Reichert, 1997; Kennedy, 1997).

In order to value contaminated property and make an allowance for stigma (if it exists), it is important to determine just how the market participants behave toward property contamination. Their attitudes will be reflected in the prices they pay for affected property, and these prices form the main evidence used by valuers to value property. However, these prices alone do not provide any detailed information about the many components that make up price. It is the valuer's job to assess the important value-determining factors and the weights prescribed to each when analysing these prices to estimate value. As there are no formal techniques typically used to achieve this, the valuer uses his/her personal judgement to determine the relative weights.

For this reason, a study of buyer behaviour, in addition to sales price analysis, is warranted. This approach is supported by Mäler and Wyzga (1976) who observed that because the existing methods of analysis are often relatively crude, there can be the need to compare the results of more than one method. Researchers including Abelson (1979), Chalmers and Roehr (1993) and Kinnard et al. (1994) recommend the use of market sales analysis in tandem with opinion survey studies. Similarly, The Task

Group on Statistical and Market Survey Techniques (Appraisal Institute, 2000) recommend the use of more than one approach for validating the analysis and the conclusions reached.

As sales price analysis, in the form of an econometric treatment of risk perception and stigma, is covered adequately by other authors (see for example Dixon et al., 1988; Zeiss & Atwater, 1989, 1990; Priestley & Evans, 1990; Levesque, 1994; Dotzour, 1997; Simons, Bowen, & Sementelli, 1997; McCluskey & Rausser, 2000), this paper focuses on the use of a survey-based approach, conjoint analysis, to determine the importance of land contamination stigma and other important attributes in purchasing behaviour. By knowing how each attribute contributes to price, valuers are better informed to be able to compare the subject property with similar properties that have sold recently and adjust sale prices for differences between these to arrive at a final value estimate. This provides a more rigorous approach to sale price adjustment than simply basing these adjustments on what the valuer intuitively believes to be the most important.

Conjoint analysis is commonly used in the marketing field to predict consumer preferences for products or services. It is based on the premise that consumers evaluate the value or utility of a product or service by combining the separate amounts of utility provided by each attribute (Hair et al, 1995). Very few property valuation applications of conjoint analysis are reported in the literature. An exception is the paper by McLean and Mundy (1998). In introducing the conjoint analysis method, McLean and Mundy refer to the description provided by the NOAA Final Rule (Federal Register, January 5, 1996), as follows:

Conjoint analysis is a survey procedure that is used to derive the values of particular attributes of goods or services. Information is collected about individuals' choices between different goods that vary in terms of their attributes or service levels. With this information, it is possible to derive values for each particular attribute or service. If price is included as an attribute in the choice scenarios, values can be derived in terms of dollars, which can be used with the valuation approach.

This description gives support for use of the approach in tandem with the valuation approach. The approach helps to determine a consumer's preference structure. The preference structure explains not only how important each attribute is in the overall decision about a product, but also how the differing levels within an attribute influence the formation of an overall preference.

Other property-related applications of conjoint analysis that appear in the literature are reported in the marketing journals where new product design applications predominate. Examples of these include studies of consumers' preferences for housing alternatives, focusing on asking price, number of bathrooms and bedrooms, etc. (Louviere, 1979), travellers' hotel preferences focusing on seven hotel attributes to help in the design of a new hotel chain for Marriott (Wind, Green, Shifflet, & Scarborough, 1989), industrialists' location/relocation preferences in terms of cost, location, and premises to help property professionals provide more competitive market solutions (Levy, 1995), and business traveller's service preferences (physical environment and personal service) of luxury hotels in Singapore to inform management decisions (Mattila, 1999).

METHODOLOGY

Conjoint analysis assumes that consumers evaluate the value or utility of a product (real or hypothetical) by combining the separate amounts of utility provided by each attribute and that the trade-off decisions made are revealed through their product choices. An experimental design is used to analyse this behaviour. The procedure involves asking respondents to provide their overall evaluations of a set of hypothetical products that combine the possible attributes of that product at various levels. Simply by knowing a respondent's overall preference for a hypothetical product and what its attributes are, conjoint analysis can then decompose the preference to determine how much is due to each attribute it possesses and each possible value of that attribute. The technique involves a type of analysis of variance in which the respondents' overall preferences serve as a dependent variable, and the dependent variable and predictor variables are represented by the various attribute levels making up each alternative (Green & Tull, 1973).

Information integration theory is the main theory underlying conjoint analysis as developed by Anderson (1970). This theory, as described by Louviere (1988), is about the behaviour of numerical data in response to multiple pieces of information. The numerical data of interest consist of individual rating (or ranking) responses to combinations of different attributes of a product or brand. Information integration theory can therefore be used to study information processing revealed by consumers' responses to multi-attribute options.

The basic assumptions of the theory as outlined in Louviere (1988) include:

1. The unknown and unobservable overall utility that a consumer has in mind regarding the j-th brand is linearly related to a consumer's response on a category-rating scale. That is,

$$U_j = a + bR_j + e_j$$

where U_j is the overall utility to measure of the j-th brand, R_j is the observed response on a category-rating scale and e_j is a normally distributed error term that satisfies the assumptions of analysis of variance.

2. The category-ranking scale used by a consumer under appropriate experimental instructions and task conditions approximates an interval scale measurement level.

3. A consumer's response strategy reveals their decision strategy. The response strategy can be approximated by algebraic conjoint models amendable to experimental investigation and statistical parameterisation.

Of particular interest to this research was the property contamination attribute and its impact on value. Contaminated land, even if remediated, is often perceived negatively. People are concerned about the risks associated with such land when contemplating investment in it. However, valuers are often unclear of the magnitude of these negative perceptions and how important they are in purchasing decisions.

The levels of the contamination attribute tested in this research include:

- a clean site, but next to a currently contaminated site;
- a remediated site; and
- a clean site with no history of contamination.

Conjoint Analysis Procedure

Evidence shows that people tend to simplify choices among complex options so as to reduce the cognitive strain and information overload. They do this by focusing on a few attributes in their decision (Bruner et al., 1957). Thus, as a first step in the conjoint analysis, it is necessary to determine which attributes to study.

Several alternative methods exist for identifying the attributes relevant to consumers in forming their preferences. This research used both resident interviews and an initial postal survey of residents to identify the determinant property attributes in the targeted segment of the vacant residential land market. A case study area was selected for this purpose and residents living in the case study area were surveyed.

The case study area comprised some 8 hectares of prime riverfront land located on the northern border of North Fremantle, near Perth in Western Australia. In 1990–92, the former State Engineering Works site was redeveloped as a high-class, single-family residential suburb containing approximately 110 fully serviced sites ranging in size from 249 to 880 m^2. The subdivision also includes areas of public open space, in addition to a 9m wide strip of general open space comprised of a cycle path and walkway between the site and the top of the cliff adjacent to the Swan River. Located above the Swan River, the area obtains views over the river to East Fremantle in the south.

Prior to redevelopment, groundwater test results of the site indicated excessive levels of nitrate and salinity. Additionally, arsenic and cyanide were at the upper limits of safe standards for domestic supply. Results from tests indicated that the site's waste materials (including foundry clinker, coal residues and bulky by-product pyrites cinders from the adjoining site) had heavy metal values many times greater than established recommended concentrations in soils set by Australian authorities for various land uses. These wastes were found to be leaching into the sands beneath and resulted in the elevated levels of selected heavy metals found in the ground waters.

Site clean-up commenced in 1989. This involved relocating 47,500m^3 of visually contaminated materials (pyrites-clinkers, building rubble) off-site to a landfill in Henderson. The additional 15,000m^3 of contaminated sands beneath these wastes were relocated on-site, but well away from the river and covered with 5m of clean sand. The entire site was then covered with clean sand to a minimum depth of 1.5m. Environmental clearance was obtained from the Environmental Protection Authority (EPA) in April 1991 permitting the site to be redeveloped for residential purposes. Subsequently, the majority of the redeveloped residential lots sold during 1992–1995.

The residents' interview and survey results indicate that river access, proximity to Fremantle, price, land area, and river view are the most important attributes in resident's purchasing behaviour. A site's contamination history is an attribute significant to this research, so it was also included in the analysis. The more attributes and levels there are in the conjoint study, the greater the number of parameters to be estimated. This requires either a larger number of profiles or a reduction in the reliability of parameters. As such, the number of attributes was kept to a minimum that adequately described the product (vacant residential land) in a realistic way.

Once the list of attributes was obtained, a conjoint experiment was designed to understand how the target individuals integrate the attributes. The process involved forming all possible combinations of the attributes, and the associated levels of each and asking respondents to rank them. The attribute levels were selected to conform to actual levels encountered in a case study area (obtained from sales data and site information) to make the conjoint experiment as realistic as possible. From this, it was possible to measure the relative values of the attributes considered jointly by considering the trade-offs made between attributes.

Property Attributes Studied

There were six attributes identified, and between two and three levels of each were selected. These are shown in Table 1 below:

Table 1: Attributes and levels

Attribute	Level One	Level Two	Level Three
River Access	Within 200 m	200 – 1000 m	Over 2000 m
Proximity to Fremantle	Within 5 km	5 – 10 km	Over 10 km
Price	$250,000	$375,000	$500,000
Land Area	375 m^2	500 m^2	650 m^2
Contamination	Remediated site	Next to contam. site	Clean site
River View	River view	No river view	

As the attributes are required to be numeric, they have to be coded accordingly. Values were assigned as shown in the following table:

Table 2: Attribute values

Factor	Level One	Level Two	Level Three
River Access	200	1000	2000
Proximity to Fremantle	5	7	10
Price	250	375	500
Land Area	375	500	650
Contamination	1	2	3
River View	1	2	

For the current study, an additive main-effects model was used. This model uses the assumption that respondents, given a choice of property investments, will select that option which produces the highest utility. This follows the tradition of Lancaster's (1966) theory of consumer behaviour that assumes that an individual derives utility from the characteristics of a good and not from the good itself.

The additive composition rule was adopted as it enabled the use of a fractional factorial design. The advantage of using the fractional factorial is that it avoids the need to evaluate all 486 possible combinations (2 x 3 x 3 x 3 x 3 x 3) of the six attributes by selecting a smaller number of these alternatives. Using a fraction of all the possible combinations of the attributes helps to keep the research costs down and avoids respondent confusion and fatigue. However, when the additive compositional rule is adopted, only the main effects for each factor are estimated. Another advantage of using the fractional factor design is that the stimuli are created so that the factors are orthogonal; a requirement to ensure the correct estimation of the main effects.

A model was specified for each attribute to indicate how each attribute's levels are expected to relate to the ranks. Models are selected that most accurately represent how consumers actually form overall preference (as suggested by theoretical or empirical evidence). Conjoint analysis gives the analyst three options to choose from, ranging from the most restrictive (a linear relationship) to the least restrictive (separate part worths—the discrete model), with the quadratic model falling within this range. "More" and "less" commands for the discrete and linear models are used to show the direction of the expected relationship. For example, it is expected that river access is linearly related "less" to rankings, so that lower levels of the attribute (shorter distance to the river) will receive lower (more-preferred) rankings.

The choice of relationship does not affect how the stimuli are created, but it does impact on how and what types of part—worths are estimated by conjoint analysis. The "more" and "less" commands do not affect the estimates of the utilities, but are used simply to identify subjects whose estimates do not match the expected outcome. Each attribute had an expected outcome for respondent-preference (with the expected most preferred options shown in brackets) as follows:

River Access:	a shorter distance to the river (200 m)
Proximity to Fremantle:	a shorter distance to Fremantle (5 km)
Price:	a lower price ($250,000)
Land Area:	a larger site size (650 m^2)
Contamination:	a clean site (coded as "3")
River View:	a river view (coded as "1").

Data Collection

A full-profile method that shows all of the attributes was adopted for presentation of the stimuli, as this was considered to be a more realistic and more explicit portrayal of the trade-offs among attributes than the alternative trade-off method that shows only two attributes at a time. Further, the approach elicits fewer judgements; however, each judgement is more complex.

The Orthoplan (stimulus design) procedure generated a set of 18 full-profile descriptions for use in the experiment allowing for the estimation of the orthogonal main effects of each factor. An instruction sheet was provided to respondents, together with a sheet showing the set of 18 profiles. Respondents were asked to rank each profile (stimuli) in order of preference from high to low according to their perception of how likely a resident would be to purchase the land described by each profile. This involved the respondent making a trade-off between the various attributes presented. They were requested to enter the number 1 in a column on the sheet next to the profile they consider they would most likely purchase, and a ranking of 18 next to the least likely option to be purchased, and then to rank the remaining profiles accordingly.

Sample Selection

Ideally, a survey of the residents of affected property was preferable, but due to the small number of respondents in the initial residents' survey indicating a willingness to participate in the conjoint study, an alternative respondent group was sought. As the main aim of the research was to demonstrate the use of conjoint analysis, a convenience sample was employed. Property valuers who were attending a CPD seminar of the WA Australian Property Institute (API) on the valuation of contaminated land were selected for the survey. A total of 57 valuers were surveyed. The respondents covered the full range of API membership classifications and age-categories; however the majority were male (96.3%).

Analysis of the Data

Once the survey was run, the ranks (preferences for each full-concept) were collected and entered into a spreadsheet. The ranks become a dependent variable in a general linear model. Binary variables, set equal to 1 if the attribute level was present on the profile and set equal to 0 otherwise, were entered for n-1 levels of each attribute. These binary coded variables served as the independent variable set. The coefficients of the independent variables are the estimated part-worth utility scores of each attribute for each respondent and for the group. These scores are chosen by the conjoint estimation program so that when added together, the total utility of each alternative product (profile) will correspond to the original ranks as much as possible.

RESULTS AND DISCUSSION

While utilities were estimated for each individual respondent and for the group of all respondents, only the group results are presented.

Group Results

The results indicate that each attribute had an expected outcome for respondent-preference, outlined previously. If different levels of an attribute produce widely different utilities, the person is sensitive to the level (i.e., the attribute is important to them). Table 3 summarises the results. Both the utilities and averaged importance figures are shown. The attributes are listed in decreasing order of importance.

As proximity to the river and Fremantle are measured as distance from these amenities (rather than closeness to), the utilities for the River Access and Proximity to Fremantle attributes are reported as negative numbers. Similarly, for River View, the associated utility for "no river view" is reported as a negative number, while the expected preference for "river view" has an associated positive utility. The negative utilities for Price indicate that none of the prices listed are preferred, but respondents are less averse to some levels of price than others.

Table 3: Responses

Attribute	Average Importance	Utility Range
Contamination	34.74	1.49 to 7.27
River View	24.51	-2.37 to 2.37
River Access	11.89	-2.31 to -.23
Price	11.57	-3.98 to -1.99
Land Area	8.75	0.09 to 0.16
Proximity to Fremantle	8.56	-1.14 to -0.71

Estimated Utilities and Attribute Importance

The attribute with the broadest utility range indicates the attribute that a respondent group is most sensitive to. For example, the widest utility range is for the contamination attribute (1.49 to 7.27), indicating that the respondents were more sensitive to the level of the contamination attribute compared to the levels of the other attributes. The overall rankings of the property attributes in decreasing order of importance was Contamination, River View, River Access, Price, Land Area and Proximity to Fremantle. The averaged importance weight indicates the relative range of utilities for an attribute and provides a quicker visual tool for determining the most important attribute than the utility figures do.

Level Preferences for Each Attribute

The estimated utilities indicate that valuers prefer a clean site to either a clean site adjoining a contaminated site or a remediated contaminated site; the latter being least preferred of the three options. A river view is preferred to no river view, and being located within 200 metres of the river is preferred to being further away from the river, with preference decreasing with increasing distance from the river. A similar result was recorded for the proximity to Fremantle attribute, with preference decreasing with increasing distance to Fremantle. The $250,000 price tag is preferred to the more expensive alternatives, with preference decreasing as price increases. The 650 square metre land area is preferred to smaller sites, with preference decreasing as size decreases. These preferences followed the expected choice of preferences for each attribute as indicated by the expected outcomes shown above.

Valuation Implications

As an additive model was used, the average importance weights equate to a percentage and can be shown in a valuation model as follows:

$$V_i = f\,(X_{1,i},\, X_{2,i} \ldots\ldots\ldots\ldots\ldots X_{n,i})$$

where:
V_i = property value at the i th location

$X_{1,i}$ - $X_{n,i}$ = individual attributes of each property (e.g., land area, view, river access, land contamination, etc.)

The linear form could be shown in the following equation:

$$V_i = b_0 + b_1X_{1i} + b_2X_{2i} + b_3X_{3i} \ldots\ldots\ldots + b_nX_{ni} + a_oD_o + \ldots\ldots + a_mD_{rn} + e$$

In the above model, the dependent variable V_i being the value, and b_1 to b_n, and a_o *to* a_m are the average importance weights, i.e., the relative importance weightings in the property attributes (X_1 to X_n —the continuous characteristics such as site size, and D_o to D_m —the categorical (dummy) variables, such as river views).

The above model is very similar to a regression model and, as such, direct comparison should be possible. One method to compare the results from the different methods of conjoint analysis and regression analysis would be by comparing the relative contribution of each variable to the model result. A regression analysis was run in a parallel study (Bond, 2001), the results of which are shown below for purposes of demonstration.

Adopting one of the land sales in the case study area, the contribution toward price of each variable can be determined as follows:

Example: Lot 68 Foundry Court, 556 m^2 with river views sold in 1994 for $490,000

Rocky Bay Estate Regression Model:

Price = 100,669 – 90 (Land Area) + 202, 830 (View) + 189,378 (Sale Date).

The contribution to price of Land Area is 9.2%, View 37.36% and Sale Date, 34.89%.

To determine the impact of contamination, sales data from the case study area were pooled with sales of other similar properties and a regression model developed. The model adopted in the final analysis was a semi-log model as follows:

Pooled Regression Model:

Log of Price = 7.291+ 0.684 (log of 556 m^2) – 0.346 (Contamination) + 0.563 (Amenities) + 0.463 (View) + 0.657 (SD1) = 12.9514

The contribution to price of Land Area is a 10% increase in price, resulting in a 6.84% increase in price, Contamination being as 29% increase, and View being a 58.8% increase.

From the responses to the conjoint study, it can be seen that Land Area has an average importance weight of 8.75, which is only slightly below the contribution of Land Area to price in the models above. The average importance weight for View is 24.51 and for Contamination, this is -34.74. These figures are in line with the price contributions of the associated variables in the above regression analyses.

Another method of comparison is possible by applying dollar amounts to each attribute and comparing the results with those obtained from the regression analysis. First, the price per utility was calculated and this was then applied to the single utility equivalents of each attribute, as follows:

Price:	$166,667
Size:	$180/$m^2$
Proximity to Fremantle:	$47,892/km
River Access:	$612.75/m

View Vs No View:	$30,773
Contamination, Clean Vs Remediated:	-$120,317

Adopting the same land sale example used above, to calculate the predicted price from the semi-log model, the dollar effects can be estimated as follows:

Price:	$421,429
Contamination:	-$122,214
View:	$247,800
Land Area:	$291/m^2

For the variable of greatest interest, Contamination, the consistency between the models is surprisingly high. Further, the respondents ranked Contamination and River View as most important variables and this matched the significance of the coefficients of these variables in the regression models. The discrepancy in results between the models for the other variables is likely due to the differences in type and quantity of variables within each model, as noted above.

Using both approaches in tandem helps to check not only how well opinions are reflected in price, but also to check the probity and credibility of the results. Further, this information can be employed in the sales comparison approach to valuation. The utilities provide a guide on the adjustments to make for differences in the comparable and subject properties. However, the utilities are only relevant to the market segment studied. A set of respondents from a different market segment may consider other attributes to be more important in their purchasing decisions.

CONCLUSION

The conjoint analysis results provided support for the use of conjoint analysis in the field of property valuation by demonstrating that conjoint analysis can be used to validly determine the property attributes considered most important to purchasers. Further, the results were able to indicate the most preferred levels of each attribute included in the analysis. These were a clean site, a shorter distance to the river, a shorter distance to Fremantle, a lower price, a larger size section, and a river view.

The attribute importance and price information is particularly useful to valuers when valuing property affected by land contamination issues, including stigma. Knowledge of how each attribute contributes to price will assist with the comparison of the subject property to similar properties that have sold recently and more precise estimates of adjustments to be made for differences that exist between them. Adjusting sale prices in this manner provides a more reasoned and technically sound approach to the analysis than the simplistic approaches currently employed. Further, by calculating the dollar worth of each attribute and using this information in combination with the hedonic prices of each attribute calculated from a regression analysis, can result in a more informed value estimate.

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