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Stigma Assessment – A Multi-criteria Decision-making Approach

Abstract:

Stigma of contaminated land is caused by risk perception and has an uncertain nature. Researchers have found that there are many factors affecting stigma impacts. Given its risk perception nature, it is difficult to quantify stigma impacts. In this paper, it is proposed to assess stigma impacts using a multi-criteria decision making (MCDM) approach. In this regard, a model is constructed using the Analytical Hierarchy Process (AHP) technique. The case study shows that the MCDM approach has provided a logical and structured framework to process relevant criteria and it is feasible to apply the method to assess the required stigma adjustment factor.

Keywords

Contaminated land, stigma, multi-criteria decision-making, analytic hierarchy process, risk perception, margin of error

Introduction

Stigma is caused by risk perception and has an uncertain nature. Since it is risk perception driven, stigma may not exist if there is no market evidence for the existence of risk perception about a contaminated property. Accordingly it is incorrect to assume that all contaminated land has stigma. Where there is evidence that stigma exists, valuers need to consider the relevant factors/criteria in detail. Patchin (1991) has identified the following 6 causes of stigma:

1. Fear of hidden clean up costs – fear of insufficient clean up today that future clean up may be required.
2. The trouble factor – even when the cost of clean up has been allowed for, buyers still feel it is necessary to be compensated for the trouble of making the necessary improvement to the property and incurring the associated costs.
3. Fear of public liability – there may be future legal liability even though the property has been cleaned up to the current standards. The clean up standards may be raised in the future making the landowners liable again.
4. Lack of mortgageability – inability to get financing for sale or future development of the property.
5. Property type – different market reaction according to if the property is residential or commercial.
6. How clean is clean – the remediation standard required and achieved in the clean up may differ from what is publicly perceived as acceptable as “clean”.

The causes are also the factors/criteria that valuers need to consider when assessing stigma impact. Further to Patchin’s work, Mundy (1992a) puts forward the following 7 criteria for stigma assessment:

1. Disruption – whether the day-to-day business on the contaminated premises is affected.

2. Concealability – can the pollution be seen, smelled or felt?
3. Aesthetic effect – does the contamination visually alter the environment?
4. Responsibility – who is the polluter?
5. Prognosis – the severity and persistence of the contamination.
6. Degree of peril – impact on the entire environment and human health.
7. Level of fear – the degree of people's fearful feeling towards the contamination.

Various stigma assessment methods have been introduced by researchers such as Mundy (1992b), Chalmers & Roehr (1993), Patchin (1994), Syms (1997), and Bond (2001). However, these methods do not specifically take all stigma criteria into account. Some take these criteria into account, not specifically, but globally, as a whole. For example, Mundy (1992b) only uses the loss of marketability to demonstrate how contamination influences property value. Chalmers & Roehr (1993) only include net operation income, lost of income resulting from contamination, remediation costs, indemnification costs resulting from contamination, market discount rate of uncontaminated property, and risk-adjusted discount rate appropriate to a contaminated property in their stigma assessment model.

In contrast, Roddewig's (2000) stigma/risk score sheet method incorporates more stigma criteria than others, a total of 11 criteria are included. This method requires reference to evidence from comparable properties and is applicable where market evidence exists. Unfortunately market evidence in many cases is limited. In addition, given that contaminated properties are as unique as "fingerprint" (Wilson 1992), true comparables are difficult to find and it limits the application of this method.

In this paper, it is proposed to assess stigma with a model developed on the principle of multi-criteria decision-making (MCDM). MCDM is a generic term. It has a number of alternative names such as Multi-criteria Decision Analysis, Multi-attribute Utility Theory, Multiple Attribute Decision Making, and Multi-objective Decision Making, etc. A MCDM method, apart from the consideration of a number of criteria, has to consider the decision-maker's preferences implicitly and the alternatives explicitly. The decision-maker looks at a value function and uses it to select the "best" alternative (Henig & Buchanan 1996).

The data for constructing the model was obtained from a survey of Australian valuers. A case study is used to demonstrate the application of this model. The result shows that the model is worthwhile to be considered by practitioners in Australia and other countries.

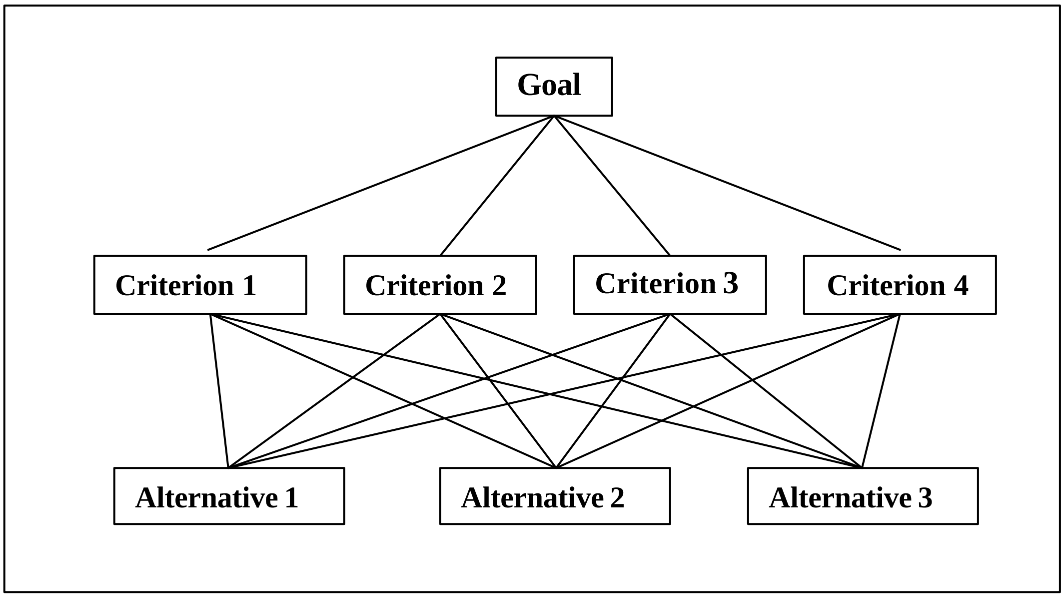
The suggested model

The multi-criteria decision-making method used is known as Analytic Hierarchy Process (AHP) technique. This method is chosen because of "its ability to rank both qualitative and quantitative parameters at the same time."(Bender et al. 1997) The method has been successfully applied to a number of property researchers. For example, Ball and Srinivasan (1994) apply this method to house selection in Boston, Pan (1996) uses this method to select real estate projects, Bender et al. apply this method to analyse perceptions concerning the environmental quality of housing (1997) and assess environmental quality perceptions of urban commercial property (1999) in Geneva, Ho (1999) applies this method to determine preferences on office quality attributes in Sydney.

AHP was introduced by Saaty (1980) and is based on the principle of breaking down the problem into its component parts (i.e. the goal, criteria and alternatives) and arranging them into a hierarchical structure. A typical hierarchical decision making structure is shown in Figure 1. The figure shows a simple AHP decision-making model that has one layer of criteria (determinant factors). For example, the goal may be to buy a car. The criteria may be style, body colour, speed, engine capacity, etc. The alternatives may be brand names such as Ford, Toyota, Honda, etc. It should be noted that there may be more than one layer of criteria. For more detailed analysis, each criterion in the first layer may give rise to several sub-criteria such that it is possible to have two, three or more layers in the model.

In an AHP analysis, the priorities of the elements of the hierarchy are to be made by pairwise comparisons, i.e. to compare the elements in pairs against a particular criterion. Saaty (1995) suggests that a matrix is the preferred form for pairwise comparisons because this approach reflects the dual aspects of priorities: dominating and dominated.

Figure 1 A typical AHP hierarchical structure



Source: Based on ISNAR 1998 p.1

The mathematics of the AHP method is rather involved. "Mathematically, the objective is to determine the non negative weights w_i of criterion c_i for $i = 1$ to n, where n is the number of criteria. If the weights $w = (w_1, \ldots, w_n)$ were known, then the relative importance of the criterion c_i compared to c_j would be the ratio of w_i/w_j The basic idea of AHP is to proceed from a pairwise comparison of the criteria and to evaluate the weights through a special procedure [for instance, using the eigen-vector method]" (Bender et al 1999). Details about the mathematics of AHP can be found in Saaty's "The Analytical Hierarchy Process Series".[1] Although the mathematics may be too difficult for users of the AHP method, fortunately there

[1] See references at the end of the article

are computer software products, such as ‘Decision Science Plus’, ‘Ergo’, ‘DecideRight’, ‘Expert Choice’ and ‘Criterium DecisionPlus’ that can help users get around the hurdles.

Methodology

The following process was adopted to develop the target method:

1. Finding out the criteria considered by valuers in stigma impact assessment.

   This is an essential step, as the proposed MCDM method will be built on the criteria. The necessary information for this model was obtained from a mail survey and personal interviews of Australian valuers in 1998 (Chan 2000).

2. Finding out valuers’ perception of environmental risks.

   The market value of a contaminated property is also determined by the deal between a willing seller and a willing buyer. Given the nature of contaminated land that it is more difficult to sell than clean properties, the buyers generally have more bargaining power. Their perception of the environmental risk will determine the market value. However, it is difficult to know who will be a willing buyer of contaminated land. Since buyers generally rely on the recommendations from valuers, valuers are assumed to be a good proxy for their clients (owners, purchasers, occupiers, developers, financiers and insurers, etc.) and their views are a realistic representation of their clients.

   Given the assumption, it is thus necessary to find out valuers’ perception of environmental risks of different land uses and industries and hence the associated stigma adjustment factor of the relevant land uses and industries. The necessary information was obtained from the same mail survey and personal interviews with valuers in 1998.

   There are many land uses and industries that are likely to cause land contamination. As the list of land uses and industries contained in Appendix II of the Contaminated Land Valuation Practice Standard 1994 published by the Australian Institute of Valuers and

Land Economists (AIVLE) (now replaced by Appendix II of Guidance Note 15 of the Australian Property Institute's (API) Professional Practice 2000) is reasonably comprehensive and that valuers should be familiar with it, the whole list was used in the survey. As the survey results are a collective view of over 100 respondents, they are assumed to be representative, and may be used as a benchmark to check the reasonableness of the probable stigma adjustment factors suggested by the valuers.

3. Test run the model.

   After the model has been constructed, valuers are invited to supply data for the test from a stigma affected contaminated property that they valued before. The resulting figure is then compared with the figure in the original valuation.

Criteria considered by Australian valuers

As mentioned previously, Patchin and Mundy have identified 13 criteria for stigma assessment. Patchin's trouble factor has common ground with Mundy's disruption factor, the two criteria may be deemed as one. For conciseness, it is assumed in this paper that they together have effectively identified 12 criteria. Although these 12 criteria have already been identified, it is unwise simply to incorporate them into the proposed model because of the difference in market conditions between the United States and Australia, and also different opinions between valuers in the two countries.

In order to find out what criteria are considered by Australian valuers when assessing stigma impact, both a mail survey of 500 valuers and a follow-up interviews of 40 valuers in New South Wales, Victoria and Queensland were conducted in 1998 (Chan 2000). The survey results show that Australian valuers generally look at the 16 criteria indicated below when estimating the stigma impact. No preference or priority for criteria was given by respondents because they were instructed simply to list the criteria considered relevant to stigma assessment. The purpose of this instruction was to uncover all possible criteria. Following is a list of criteria (with definitions) identified from the survey responses. In other words the list contains the criteria and the definition of them as given by and presumably adopted by the respondents.

1. Land uses – previous uses, current use and proposed use (highest and best use)
2. Health risks – continuous problems, known problems, potential problems
3. Contamination – type, degree, toxicity, ground water affected, residual contaminants
4. Remediation – costs, quality, cleaned up by whom, any sign-off environmental audit report
5. Legal liabilities – under sale/lease contract, any previous claim, potential claim
6. Publicity/reputation of site – media exposure, odour, visibility of contamination
7. Market conditions – supply, demand, property value, economic factors, demography
8. Physical features of site – location, dimensions, contour, facilities, proximity of adjoining properties
9. Time factor – time lapse since cessation of contaminated uses, time required (inherent difficulties) for clean up, length of previous contaminated uses
10. Government regulation – council restrictions and attitudes
11. Listing/ranking on a contaminated land register
12. Guarantee from vendor
13. Ownership – who was the previous and current owners
14. Community feeling / perceived risks
15. Mortgageability
16. Purpose of valuation

Table 1 below summarises and contrasts the criteria from this survey and those identified by Patchin and Mundy. It can be seen that the Australian criteria include all 12 criteria identified by Patchin and Mundy. The 4 extra criteria (Market condition, government regulation, listing on contaminated land register, and valuation purpose) are normal valuation considerations.

The 16 criteria are therefore considered reasonable and they are all taken to build the proposed model.

Table 1 Comparison of stigma criteria

Australian valuers	**Patchin (1991)**	**Mundy (1992a)**
Land uses	Property type	
Health risks		Prognosis
Contamination	How clean?	Degree of peril
Remediation	Hidden clean up cost	
Legal liabilities	Public liability	
Publicity / reputation of site		Concealability
Market conditions		
Physical characteristics of site		Aesthetic effect
Time factor	Trouble factor	Disruption
Government regulation		
Listing/ranking on register		
Guarantee from vendor		Responsibility
Ownership		Responsibility
Community feeling / perceived risk		Level of fear
Mortgageability	Mortgageability	
Purpose of valuation		

Environmental Risks perceived by Valuers

Stigma impacts have been allowed for as a percentage of the unimpaired value by researchers such as Patchin (1994) and Sanders (1996) and some respondents to the 1998 survey by Chan (2000). In addition, the API's Professional Practice 2000 points out that stigma "… represents a discount, beyond the direct and indirect costs likely to be incurred, required to compensate for the risks associated with contaminated or previously contaminated property…" Accordingly the same treatment of stigma impacts (i.e. as a percentage of unimpaired value) is adopted in this paper. Regarding the perceived risks, the respondents were requested to express their perceived risks in terms of a percentage of the unimpaired value of different land uses and industries. The survey result is summarised in Table 2 in Annex 1.

The figures are the perceived stigma adjustment factors for alternative land uses (residential, commercial and industrial) on contaminated sites. The analysis is carried out statistically with

95% confidence interval.[2] The first column of the table shows the previous/existing land uses or industries as listed in Appendix II of the AIVLE's Contaminated Land Valuation Practice Standard 1994. For the purpose of this survey, there is no difference between a former and current contaminated industries/land uses. The other columns show the perceived stigma adjustment factor (value reduction as a percentage of unimpaired value) if the land is alternatively used for residential, commercial or industrial purposes.

It can be seen that the figures match the common sense that the higher the perceived environmental risks associated with the previous/existing land uses or industries, the higher will be the stigma value reduction percentage. Since the figures represent a collective view of the respondents' risk perception of contaminated land, they are assumed to be the market's view and are used as a benchmark to check the reasonableness of probable stigma adjustment factors supplied by valuers for testing the validity of the proposed model.

As can be seen from the table, the respondents perceived that land use No. 51 (i.e. radioactive materials, use or disposal) has the highest environmental health risks. They believe that even after clean up, the average value reduction due to stigma can be as high as 43% for residential, 26% for commercial and 22% for industrial uses. It is interesting to note that even though more information is known about the danger of asbestos today and the general public's concern is easing, the respondents still regard asbestos (i.e. land use No. 6) as very dangerous and give it the second highest scores – 35% for residential, 21% for commercial and 18% for industrial uses.

Those land uses considered to have the lowest stigma impact are land uses No. 34 (marinas) and No. 45 (plant nurseries). The scores for marinas are 8% for residential, 3% for

[2] A zone of values within which one is confident that the true population mean lies. Increasing the confidence interval to 99% will increase the assurance that the zone contains the population mean, but it makes the estimate less precise (Lucey 1988).

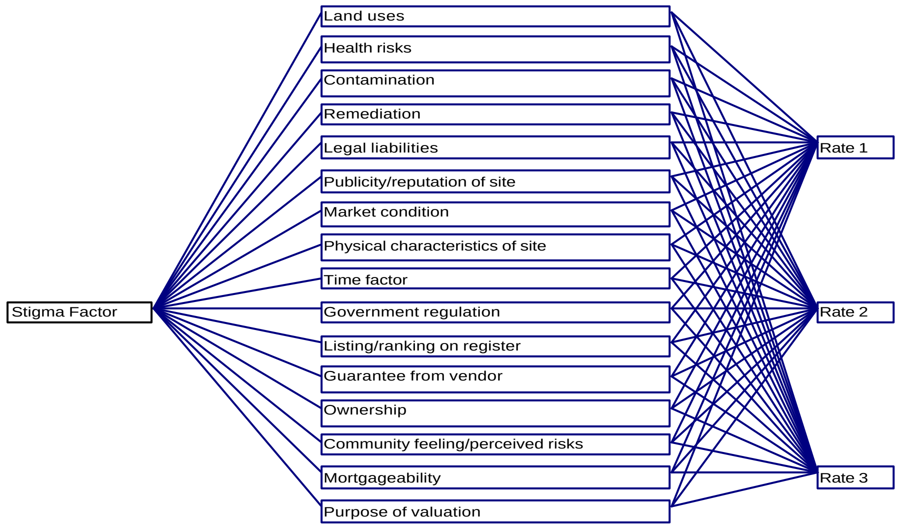
commercial, 2% for industrial uses whereas the scores for plant nurseries are 8% for residential, 4% for commercial and 3% for industrial uses. It shows that the respondents considered the risks involved are relatively minor such that the impact on the impaired value of the property is small.

It is interesting to note that none of the figures in Table 2 is near 69% reported by Patchin (1994). One reason may be that contaminated land in Australia is not as notorious as that in the US. It may also be due to Australian investors and developers perceiving the potential risks differently and are not as suspicious as their American counterparts because land contamination laws in Australia are not as stringent as those in the US. In particular, there is no joint and several liability in Australia.

The Proposed Model

In this study, the relevant AHP analysis is carried out with the software package 'Criterium DecisionPlus 3.0 Student Version' (a free evaluation copy can be down loaded from http://www.infoharvest.com). Using the 16 criteria identified above, the suggested AHP hierarchy model is constructed as shown in Figure 2.

Figure 2 AHP Hierarchy Model for Selection of Stigma Adjustment Factor



The AHP model is used to find the relevant stigma impact expressed as a percentage of the unimpaired value of the property. The stigma adjustment percentage is hereafter referred to as the stigma adjustment factor.

When applying the AHP model, the goal is to find the target stigma adjustment factor. The valuer needs firstly to rate the relative importance of the criteria with respect to the goal. The sum of the individual weights should add up to 100. Next the valuer needs to estimate using the best/worst case approach three probable stigma adjustment factors Rate 1, Rate 2 and Rate 3 for the subject property having regard to the evidence before him/her. These three rates are the alternatives of the AHP model. In respect of each of the probable stigma adjustment factors, the criteria are considered again and are rated according to their relative importance under a '0 – 10' scale. A zero rating means the criterion has no relevance. A rating of '10' means the criterion has extreme importance. For example, the valuer may have assigned 3 alternatives, say 5%, 6% and 7%, to the model. When rating the criterion 'land Use' for one of the alternatives, say 5%, the valuer may consider that this criterion is worth 7 out of 10. Accordingly a value of 7 is entered into the cell corresponding to Rate 1 and criterion 'land use'.

In rating the criteria, the valuer needs to exercise considerable judgement based on personal experience and the available evidence. After all necessary ratings have been carried out; the reasonable (target) stigma adjustment factor is obtained by processing the relevant weighted criteria and alternatives with the software package. It should be noted that the number of probable stigma adjustment factors (alternatives) and layer of criteria in the model are not fixed. In this research, only three probable stigma adjustment factors and one criteria layer are used for simplicity and demonstration purposes. In practice, the number can be changed as the participant (valuer) thinks fit. Likewise, the criteria may be subdivided into sub-criteria. For example, the criterion 'land use' may be subdivided into 'previous use', 'current use', and 'highest and best use'.

Testing the proposed model

Test of the model is demonstrated by the following case study:

Case Study

A Motor Service Station in Wyong, NSW

Service Station in Wyong
Courtesy of Mr. Michael McClifty, LandMark White

The subject property is a service station/car repair workshop. The land and building areas are about 1,400m^2 and 250m^2 respectively. The town planning zoning permits the property to be used for commercial use. The surrounding properties are commercial and residential. The highest and best use of the property is a service station plus ancillary commercial use. Given the previous and current service station use, the property is contaminated with petrol and oil. A valuation of the property was conducted in February 2000. The unimpaired value was assessed to be $290,000. There was a financial operation loss of $20,000 due to the land contamination. The estimated remediation cost was $40,000. The valuer adopted a stigma adjustment factor of about 3% and the impaired value was assessed to be $225,000.

In order to avoid bias in testing the model, it would be ideal to have an independent valuer using the model to value the contaminated land again. However, it is difficult to get the relevant information for this purpose. By law, the original valuer cannot disclose information of the subject property to a third party without the consent of the client. Since land contamination is a sensitive issue that may affect the business of the client, it is unlikely that the client will give the necessary consent. Accordingly the original valuer was requested to test the model.

The valuer was requested to supply the information required for the suggested AHP model assuming the underlying conditions of the original valuation remain unchanged. He had to estimate three probable stigma adjustment factors using the best/worst case approach and rate the 16 criteria accordingly.

In order to keep the impact of possible "anchoring effect"[3] to a minimum, the valuer was not told which computer software would be used for the analysis and hence he should have no access to the relevant software. Processing of the data using the said computer software was carried out by the author only. Since the mathematics behind the model is quite complex and the result is not known until all ratings are completed and calculations by the software are finished, it is not possible for the valuer to manipulate the ratings in the middle of the process to accommodate a pre-selected stigma adjustment factor figure. Hence the ratings given could be regarded as the valuer's best judgment.

The stigma adjustment factor obtained from the model was then compared with the one the valuer used in the original valuation. A revaluation of the property was subsequently prepared using the stigma adjustment factor from the AHP model. The new result was then compared with the original valuation. The figures in Table 2 in Annex 1 were used to check if the probable stigma adjustment factors supplied are reasonable. In order to make sure the figures supplied by the valuer were his genuine estimates, he had no access to Table 2 so that he did not copy figures from it.

For the purpose of this research, the valuer suggested three stigma adjustment factors, 2%, 4% and 6% for the AHP model. He also provided weighting for the criteria and alternatives as shown in Table 3.

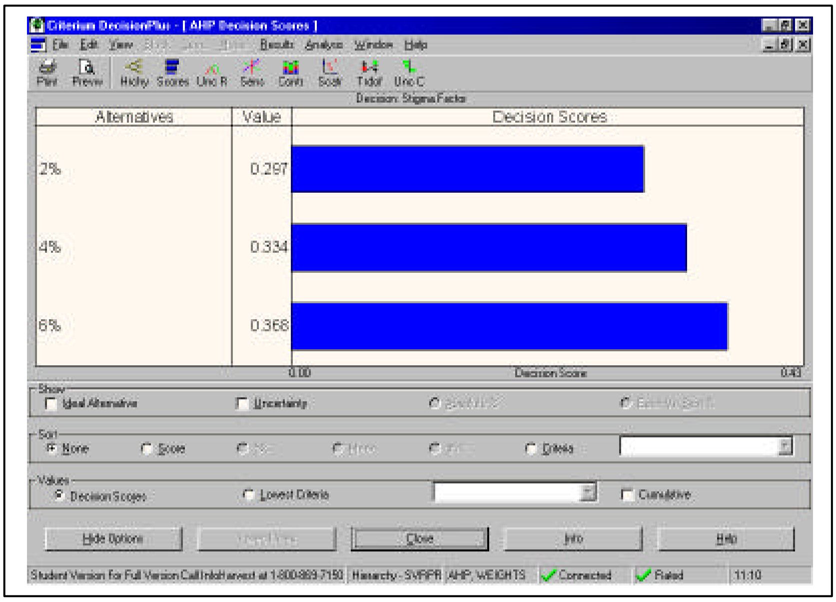
[3] The impact of possible bias due to the previous experience of the valuers (Diaz 1997, Gallimore & Wolverton 1998)

Table 3 Criteria and Alternatives Weighting of Case Study

						(Rating scale 0 - 10)
Goal Level	***Weights***	***Rating Set***	***Lowest Criteria***	***2%***	***4%***	***6%***
Stigma Factor	6	Land uses	Land uses	6	7	7
	7	Health risks	Health risks	7	8	9
	10	Contamination	Contamination	7	8	9
	10	Remediation	Remediation	7	8	9
	3	Legal liabilities	Legal liabilities	4	4	4
	3	Publicity/reputation of site	Publicity/reputation of site	6	7	8
	5	Market condition	Market condition	5	5	5
	10	Physical characteristics of site	Physical characteristics of site	5	6	7
	4	Time factor	Time factor	3	3	3
	4	Government regulation	Government regulation	5	5	5
	4	Listing/ranking on register	Listing/ranking on register	4	5	6
	2	Guarantee from vendor	Guarantee from vendor	2	2	2
	6	Ownership	Ownership	5	5	5
	8	Community feeling/perceived risks	Community feeling/perceived risks	5	6	7
	10	Mortgageability	Mortgageability	7	8	9
	8	Purpose of valuation	Purpose of valuation	5	6	7
Total	100					

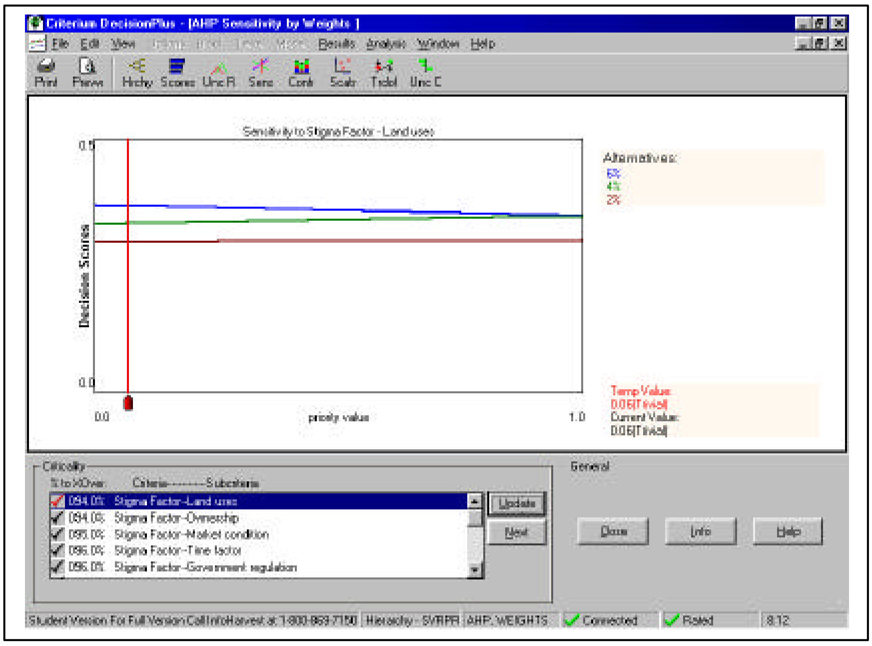
The valuer considered that all criteria were relevant for the subject property. His major concerns were the nature of contamination, the remediation required, the physical characteristics of the site and mortgageability. Based on these ratings, the AHP model returns the most likely stigma adjustment factor of 6% as shown in Figure 3.

Figure 3 Stigma Adjustment Factor Ranking of Case Study



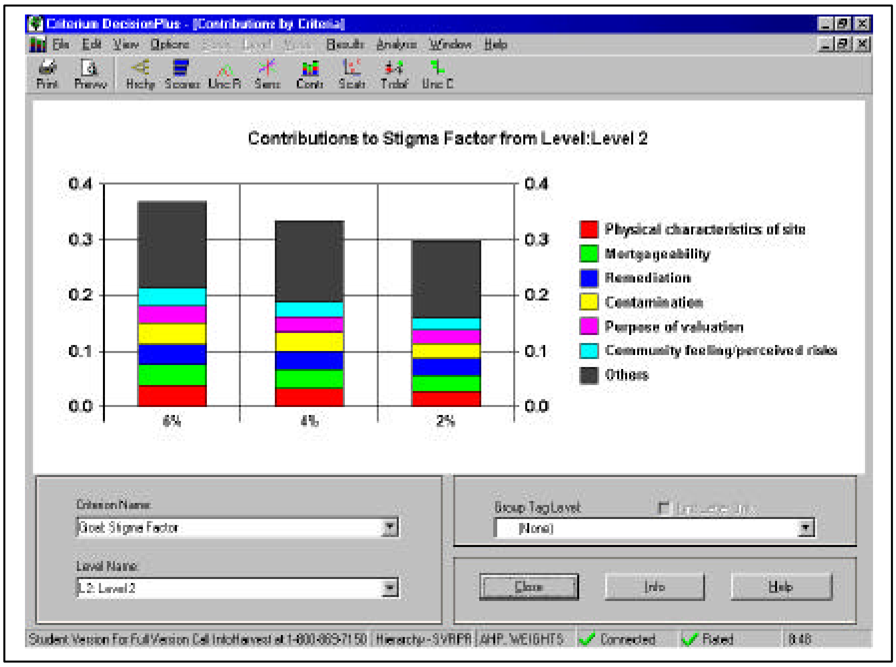
Before accepting 6% as the preferred alternative, sensitivity by weights and contribution by criteria analysis have been carried out to test the robustness and reasonableness of the model. Figure 4 below shows results of the sensitivity by weights analysis.

Figure 4 Sensitivity by Weights Analysis of Case Study



In a sensitivity analysis, if a change of 5% or less to a particular criteria weight causes the change of the preferred alternative, the model is sensitive and it is risky to rely on the current input (InfoHarvest 1996). Figure 4 shows that the three sloping lines are distinctively apart. The ‘criticality’ list box lists all criteria in the order of decreasing criticality of their priorities. In this case it shows that the score of ‘land uses’ is most critical. It has a crossover percentage of 94% and is very much high than the 5% critical value. As can be seen from the graph, the preferred alternative 6% is highly insensitive to changes in the value of the critical weight. Accordingly the model is not sensitive and is acceptable. The reasonableness of the model is verified by the contribution by criteria analysis as shown in Figure 5.

Figure 5 Contribution by Criteria Analysis of Case Study



The criteria which have the highest contribution to the decision score of the alternatives are displayed as coloured boxes on the right hand side. The stacked histogram on the left hand side shows the contribution of the criteria to the three probable stigma adjustment factors. The height of the stacked bars shows the respective decision score of the alternatives. In Figure 5, all key criteria are affecting the alternatives. In comparison, the criteria have more contribution to the ranking of the preferred alternative (6%) than to the other two alternatives. Having regard to the ratings given in Table 3 (Criteria and Alternatives Weighting of Case Study) on p. 15, the contribution of the criteria is reasonable and the model is an acceptable one. Using the preferred stigma adjustment factor of 6%, the impaired value of the property is assessed as follows:

Impaired value = Unimpaired value – financial losses due to contamination

– remediation costs – stigma adjustment

= \$290,000 – \$20,000 – \$40,000 – (\$290,000 x 6%)

= \$212,600

This figure is around 6% below the original valuation of $225,000. This difference is within the acceptable range (±10%) in a normal market as outlined below.

Reconciliation of the Test Result

In the case study, the property is a service station/car repair workshop; it mirrors Land Use No. 56 in Table 2 in Annex 1. The alternative use is commercial. The valuer adopted a probable stigma adjustment percentage range of 2 – 6%. Table 4 below shows that the range is not exactly the same as the benchmark figures.

Table 4 Comparison of preferred Stigma Adjustment Factors and Benchmark Figures

Source	**Stigma Adjustment %**
Case Study	2 - 6
Land Use No. 56 in Table 2	5 - 10

This finding is not a surprise because the benchmark figures are not site specific but only reflect the average estimation of valuers for that particular class of land uses and industries. In contrast, the valuer had to look at all relevant factors concerning the subject property in the case study. Accordingly, it is very rare that there is a perfect match with the benchmark figures. Having regard to these reasons and the fact that the valuer had no access to benchmark figures, the probable stigma adjustment figures supplied by the valuer are considered reasonable.

The revaluation with the preferred stigma adjustment factor returns a result that is around 6% below the original valuation of $225,000. In the English court case *Singer & Friedlander Ltd v John D Wood & Co [1977] 2 EGLR 84*, the concept of "margin of error" of valuation was considered. Watkins J said that "The permissible margin of error is … generally 10 per cent either side of a figure which can be said to be the right figure … In exceptional circumstances the permissible margin, …, could be extended to about 15 per cent, or a little more, either way." In a study by Crosby, Lavers and Murdoch (1998), they find that "there is no recorded instance of anyone [experts and judges] favouring a figure in excess of 20%. It appears therefore that, to date, 20% has been universally regarded as the absolute limit." Using the court ruling as a benchmark, the case study result is well within the legally recognised "margin of error" of valuation and is thus reasonable and acceptable.

Conclusion

Stigma impacts depend on a number of factors. It is thus reasonable to apply a multi-criteria decision-making approach to assess stigma impacts. The CADM model outlined above takes all stigma criteria into account and provides a logical and structured framework for valuers to assess stigma impacts. It has a built-in mechanism to check for sensitivity and robustness. It does not require valuers to carry out a survey for individual valuations. The survey in Table 2 in Annex 1 is required to provide a benchmark mechanism for this research only. A valuer can use the model without a survey as demonstrated by the above case study.

On the other hand, the model does not need the availability of a large amount of contaminated land sales data required for a multiple regression analysis. An important feature of the model is that it is time independent. There is no need to change the structure every time when it is used. Any change of environmental risk perception over time is directly reflected in the necessary ratings required by the model. Valuers need not have special knowledge to carry out the valuation. Despite the complicated AHP mathematics, a valuer can easily construct and apply the model with appropriate computing equipment and software. Once the model is constructed, the valuer can use it repeatedly.

The case study shows that the revaluation result is close to the original valuation. The margin of error of valuation is around 6% and is acceptable under the current court ruling. There are several reasons for a lower revaluation figure. Firstly, although the valuer was required to assume all conditions affecting the property remains unchanged; he was nevertheless affected by subsequent facts available after the original valuation. Secondly, the valuer was unfamiliar with the proposed stigma assessment model. This is similar to the situation when a person enters unchartered waters, he/she tends to be cautious and conservative to play safe.

Accordingly the valuer might have been cautious and supplied some conservative data. Thirdly, there are only 3 probable stigma adjustment percentages in the model. The model can only choose the preferred stigma adjustment factor from the supplied figures. In order to enhance the accuracy, the model can be expanded to have more sub-criteria layers and to include a range of probable figures that increase at narrower intervals. This may help the model return a more precise figure.

The model suggested here does not mean to be definitive. More rigorous tests of the model are required. Hopefully this paper will arouse interest for further research into the validity and applicability of the method for not only contaminated land valuation but also other real estate valuations as well.

Annex 1

Table 2 Stigma value reduction percentages perceived by Australian valuers (with 95% confidence)

Land uses / Industries	Residential (%)		Commercial (%)		Industrial (%)	
1. Abattoirs and Animal Processing Works	18	27	7	13	5	11
2. Acid/alkali plant and formulation	20	28	10	15	7	12
3. Agricultural Activities (Vineyards, Tobacco, Sheep Dips, Market Gardens)	10	20	4	8	2	6
4. Airports	8	18	3	7	1	6
5. Alumina Refinery Residue Disposal Areas	19	28	8	14	4	10
6. Asbestos production, and disposal	29	42	16	26	12	24
7. By-Product Animal Rendering	19	28	8	15	5	10
8. Bottling Works	7	13	2	7	1	7
9. Breweries	8	15	2	6	1	5
10. Brickworks	9	19	2	10	1	9
11. Car Wreckers	12	19	4	8	2	5
12. Cement Works	12	19	4	9	1	7
13. Cemeteries	15	27	5	13	3	7
14. Ceramic Works	9	17	2	6	1	4
15. Chemicals manufacture and formulation	22	34	10	15	6	13
16. Coal Mines and Preparation Plants	20	33	10	18	6	15
17. Defence Works	17	27	7	12	4	9
18. Docks	7	14	2	7	1	4
19. Drum Reconditioning Works	15	23	6	11	2	11
20. Dry Cleaning Establishments	11	19	4	9	2	6
21. Electricity Distribution	11	19	4	11	3	8
22. Electroplating and Heat Treatment Premises	16	25	7	12	3	11
23. Ethanol Production Plants	18	28	8	14	3	12
24. Engine works	10	18	4	8	1	8
25. Explosives industries	17	26	7	13	3	13
26. Fertiliser Manufacturing Plants	17	26	7	14	4	15
27. Gas works	18	31	7	14	4	12
28. Glass Manufacturing Works	11	20	5	9	2	7
29. Horticulture/Orchards	6	15	2	8	1	4
30. Industrial Tailings Ponds	22	33	11	18	7	16
31. Iron and Steel Works	17	27	7	18	4	11
32. Landfill Sites	21	32	11	23	9	19
33. Lime Works	17	26	9	15	6	14
34. Marinas and Associated Boat Yards	5	11	1	6	1	3
35. Metal treatment	14	24	7	13	2	11
36. Mineral Sand Dumps	15	24	7	13	4	9
37. Mining and Extractive Industries	18	27	8	14	5	11
38. Munitions Testing and Production Sites	21	31	10	17	6	16
39. Oil Production, Treatment and Storage	24	35	10	18	7	14
40. Paint Formulation and Manufacture	21	32	9	15	6	13
41. Pesticide Manufacture and Formulation	26	37	12	20	9	20
42. Pharmaceutical Manufacture and Formulation	15	25	7	16	4	12
43. Photographic Developers	13	21	5	10	3	7
44. Piggeries	13	21	5	10	2	10

Land uses / Industries	Residential (%)		Comme rcial (%)		Industrial (%)	
45. Plant Nurseries	6	11	2	5	0	7
46. Plastic or Fibreglass	11	18	4	8	1	9
47. Power Stations	15	24	6	13	3	10
48. Prescribed Waste Treatment and Storage Facilities	24	35	11	19	7	18
49. Printed Circuit Board Manufacturers	10	18	4	8	1	10
50. Properties Containing Underground Storage Tanks	16	25	6	15	4	13
51. Radioactive Materials, Use or Disposal	35	51	19	33	15	29
52. Railway Yards	12	21	4	13	2	11
53. Research Laboratories	9	18	3	13	1	10
54. Sawmills and Joinery Works	10	16	3	8	2	8
55. Scrap Yards	12	21	4	8	2	6
56. Service Stations	13	22	5	10	2	6
57. Sewerage Works	21	32	10	19	5	16
58. Smelting and Refining	19	30	8	16	5	15
59. Sugarmill or Refinery	11	20	5	10	1	9
60. Tanning and Associated Trades (eg Fellmongery)	18	28	9	15	4	13
61. Timber Treatment Works	18	28	8	15	5	14
62. Transport/Storage Depots	10	15	4	7	1	7
63. Tyre Manufacturing and Retreading Works	11	17	4	8	1	9
64. Waste Treatment Plants in which Solid, Liquid Chemical, Oil, Petroleum or Hospital Wastes are Incinerated, Crushed, Stored, Processed, Recovered or Disposed of	24	38	12	22	8	19
65. Wood Storage Treatment	13	21	5	10	2	10
66. Wood Treatment Facility	16	26	7	15	3	14
67. Wood Preservation	15	25	7	15	3	14

Source of industries and land uses list: AIVLE 1994 Appendix II

References:

Australian Institute of Valuers and Land Economists (AIVLE), 1994, Contaminated Land Practice Standard.

Australian Property Institute (API), 1999, *Guide Note 15*, Professional Practice 2000, pp.183 – 205.

Ball J. & Srinivasan V.C., 1994, Using the Analytic Hierarchy Process in House selection, *Journal of Real Estate Finance and Economics*, 9, pp. 69 – 85.

Bender A., Din A., Favarger P., Hoesli M. & Laakso J., 1997, An Analysis of Perceptions Concerning the Environmental Quality of Housing in Geneva, *Urban Studies*, 34(3), pp. 503 – 513.

Bender A., Din A., Hoesli M. & Laakso J., 1999, Environmental quality perceptions of urban commercial real estate, *Journal of Property Investment & Finance*, 17(3), pp. 280 – 296.

Bond S., 2001, The Use Of Conjoint Analysis To Asses The Impact Of Environmental Stigma, *Pacific Rim Property Research Journal*, 7(3), pp. 182 – 194.

Chalmers J.A. & Roehr S.A., 1993, Issues in the Valuation of Contaminated Property, *The Appraisal Journal*, LXI (1), pp. 28 – 41.

Chan N., 2000, How Australian Appraisers Assess Contaminated Land, *The Appraisal Journal*, LXVIII(4), pp. 432 – 440.

Crosby N., Lavers A. & Murdoch J., 1998, *Property Valuation Variation And The "Margin Of Error"*, Paper presented at the 4th Pacific Rim Real Estate Society Conference, Perth, 19 – 21 January.

Diaz J., 1997, An Investigation into the Impact of Previous Expert Value Estimates on Appraisal Judgment, *Journal of Real Estate Research*, 13(1), pp. 57 – 66.

Gallimore P. & Wolverton M. 1998, Price-knowledge-induced bias: a cross-cultural comparison, *Journal of Property Valuation And Investment*, 15(3), pp. 261 – 273.

Henig M. & Buchanan J., 1996, *Decision Making by Multiple Criteria: A Concept of Solution*, http://www.mngt.waikato.ac.nz/depts/mnss/john/procon.htm, 29 February 2000.

Ho D., 1999, Preferences on Office Quality Attributes: A Sydney CBD Study, *Australian Land Economics Review*, 5(2), pp. 36 – 42.

InfoHarvest Inc., 1996, *Criterium DecisionPlus Trialware User's Guide and Tutorial.*

Information and Discussion Forum on Priority Setting in Agricultural Research (ISNAR), 1998, *Measurement Methods - The Analytic Hierarchy Process*, http://www.cgiar.org/ ISNAR/Fora/Priority/MeAnalit.htm, 17 June 1998.

Lucey, T., 1988, *Quantitative Techniques – An Instructional Manual*, ELBS.

Mundy B., 1992a, Stigma and Value, *The Appraisal Journal*, LX (1), pp. 7 – 13.

Mundy B., 1992b, The Impact of Hazardous Materials on Property Value, *The Appraisal Journal*, LX (2), pp.155 – 162.

Pan S., 1996, *A Study of Multi-aim Decision Making for Real Estate Projects*, research paper presented at the 2nd Pacific Rim Real Estate Society Annual Conference, Sanctuary Cove, Gold Coast, Queensland, 21 – 24 January.

Patchin P.J., 1991, Contaminated Properties – Stigma Revisited, *The Appraisal Journal*, LIX (2), pp. 167 – 172.

Patchin P.J., 1994, Contaminated Properties and the Sales Comparison Approach, *The Appraisal Journal*, LXII (3), pp. 402 – 409.

Roddewig R., 2000, Adjusting Environmental Case Study Comparables by Using an Environmental Risk Scoring System, *The Appraisal Journal*, LXVIII(4), pp. 371 – 374.

Saaty T.L., 1980, *The Analytic Hierarchy Process*, New York: McGraw Hill.

Saaty T.L. & Forman E.H., 1992, *The Hierarchon A Dictionary of Hierarchies*, The Analytic Hierarchy Process Series, Vol. V, RWS Publications.

Saaty T.L., 1994, *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*, The Analytic Hierarchy Process Series, Vol. VI, RWS Publications.

Saaty T.L., 1995, *Decision Making for Leaders The Analytic Hierarchy Process for Decision in a complex world*, The Analytic Hierarchy Process Series, Vol. II, RWS Publications.

Saaty T.L., 1996, *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*, The Analytic Hierarchy Process Series, Vol. I, RWS Publications.

Saaty T.L. & Kearns K.P., 1985, *Analytic Planning The Organisation of System*, The Analytic Hierarchy Process Series, Vol. IV, RWS Publications.

Saaty T.L. & Vargas L.G., 1991*The Logic of Priorities Applications of The Analytic Hierarchy Process in Business, Energy, Health & Transportation*, The Analytic Hierarchy Process Series, Vol. III, RWS Publications.

Saaty T.L. & Vargas L.G., 1994, *Decision Making in Economic, Political, Social, and Technical Environments with the Analytic Hierarchy Process*, The Analytic Hierarchy Process Series, Vol. VII, RWS Publications.

Sanders M.V., 1996, Post-Repair Diminution in Value from Geotechnical Problems, *The Appraisal Journal*, LXIV (1), pp. 59 – 66.

Spencer J.A., 1993, Standard for Valuation of Contaminated Land in Australia, *The Valuer And Land Economist*, 32(8), pp. 585 – 587.

Syms P.M., 1997, *Contaminated Land*, Blackwell Science.

Wilson A.R., 1992, Environmentally Impaired Valuation: A Team Approach To a Balance Sheet Presentation, *Technical Report: Measuring the Effects of Hazardous Materials Contamination on Real Estate Values: Techniques and Applications*, Appraisal Institute, pp. 23 – 42.