

STIGMA ASSESSMENT: A MULTI-CRITERIA DECISION-MAKING APPROACH

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ABSTRACT

Stigma of contaminated land is caused by risk perception and has an uncertain nature. 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 this 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 the impact on value arising from the increased risk associated with a contaminated property and the effects of this on marketability and financeability (Chalmers & Roehr, 1993). Mundy (1992a) considers stigma as “results from perceptions of uncertainty and risk”. Since it is risk-perception driven, stigma does not exist in every case. Its existence depends on the market. 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 six causes of stigma:

- Fear of hidden clean-up costs: fear of insufficient clean-up today and that future clean-up may be required.
- 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.
- 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.

- Lack of mortgageability: inability to get financing for sale or future development of the property.
- Property type: market reaction to contamination differs according to whether the property is residential or commercial.
- How clean is clean: the remediation standard required and achieved in the clean-up may differ from what is publicly perceived as acceptable and “clean”.

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

- Disruption: whether the day-to-day business on the contaminated premises is affected.
- Concealability: can the pollution be seen, smelt or felt?
- Aesthetic effect: does the contamination visually alter the environment?
- Responsibility: who is the polluter?
- Prognosis: the severity and persistence of the contamination.
- Degree of peril: impact on the entire environment and human health.
- Level of fear: the degree of people’s fearful feelings 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 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, loss 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 unique (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. 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).

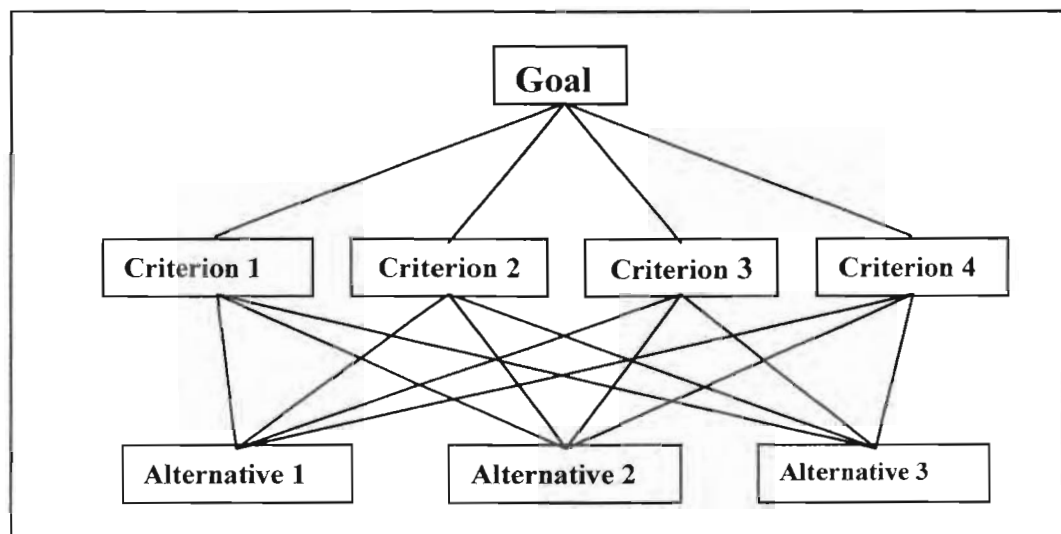
The data for constructing the model in this research was obtained from a survey of Australian valuers (Chan, 2000), with a case study used to demonstrate the application of this model.

SUGGESTED MODEL

The multi-criteria decision-making method used in this study is the 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 research studies. Ball and Srinivasan (1994) applied this method to house selection, Pan (1996) used this method to select real estate projects, while Bender et al. (1997, 1999) apply this method to analyse perceptions concerning the environmental quality of housing and to assess environmental quality perceptions of urban commercial property. Ho (1999) applied this method to determine preferences on office quality attributes.

AHP was introduced by Saaty (1980) and is based on the principle of breaking down the problem into its component parts (i.e. goal, criteria and alternatives) and arranging them into a hierarchical structure. A typical hierarchical decision-making structure is shown in Figure 1. 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.

Figure 1: Typical AHP hierarchical structure



Source: Based on ISNAR (1998)

In an AHP analysis, the priorities of the elements of the hierarchy are to be made by pairwise comparisons, comparing the elements in pairs against a particular criterion.

The mathematics of the AHP method is complex. For users of the AHP method, there are computer software products, such as 'Decision Science Plus', 'Ergo', 'DecideRight', 'Expert Choice' and 'Criterium DecisionPlus'.

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' perceptions 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, 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) and their views are a realistic representation of their clients.

Given this assumption, it is necessary to find out valuers' perceptions 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 a mail survey and personal interviews with valuers in 1998 (Chan, 2000).

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 2002) is reasonably comprehensive and that valuers should be familiar with it, the whole list was used in the survey. As the survey results are the collective view of more than 30 respondents, they are assumed to be statistically representative, and may be used as a benchmark to check the reasonableness of the probable stigma adjustment factors suggested by the test 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 previously. The resulting figure is then compared with the figure in the original valuation.

CRITERIA CONSIDERED BY AUSTRALIAN VALUERS

Patchin (1991) and Mundy (1992a) have identified thirteen criteria for stigma assessment. Patchin's trouble factor has common ground with Mundy's disruption factor; hence the two criteria may be deemed as one. 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:

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

- Community feeling / perceived risks
- Mortgageability
- Purpose of valuation.

Table 1 below summarises and contrasts the criteria from this survey and those identified by Patchin (1991) and Mundy (1992a). It can be seen that the Australian criteria include all 12 criteria identified by Patchin and Mundy. The four extra criteria (market condition, government regulation, listing on contaminated land register and valuation purpose) are normal valuation considerations. The sixteen criteria are considered reasonable and they are all incorporated to subsequently 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 regarded 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 2002 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.

**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
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

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 intervals. 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 view 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.

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 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.

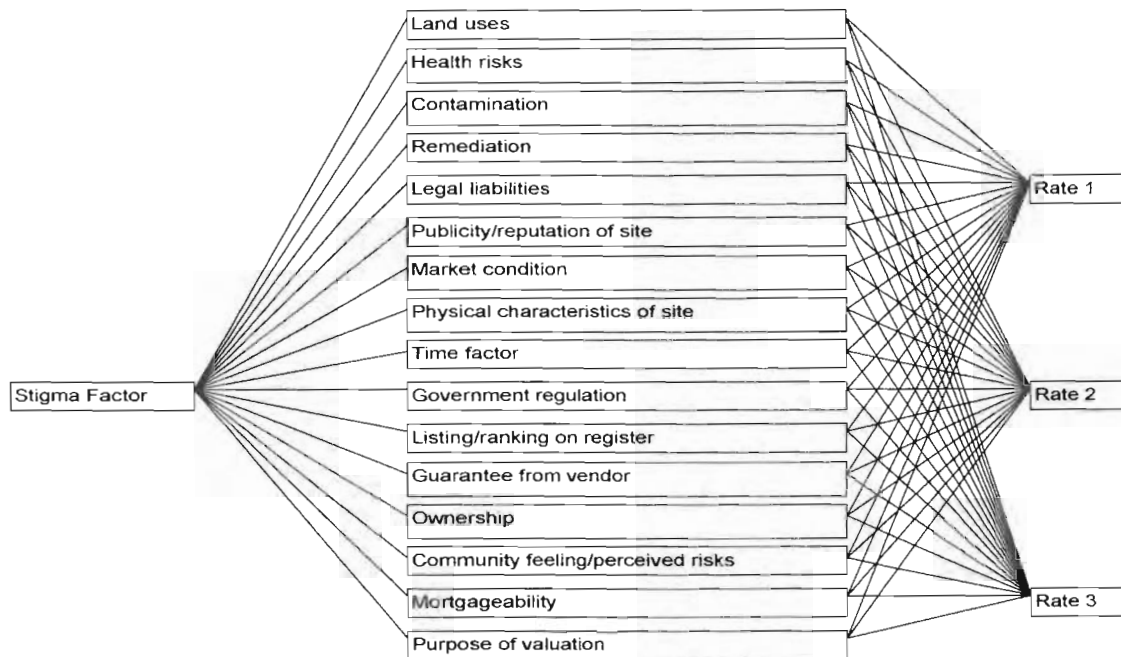
It is interesting to note that none of the figures in Table 2 is near the 69% reported by Patchin (1994). One reason may be that contaminated land in Australia is not as notorious as that in the US. It may also be due to Australian investors and developers perceiving the potential risks differently and are not as suspicious as their American counterparts, because land contamination laws in Australia are not as stringent as those in the US. For example, the Comprehensive Environmental Response, Compensation, And Liability Act 1980 in the US creates a “strict joint and several” liability scheme for the remediation of contaminated property such that even lenders, whether or not they caused the contamination, may be liable for remediation costs (Chan, Jefferies & Simons, 1998). There is no such “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’. Using the sixteen criteria identified above, the suggested AHP hierarchy model is constructed, as shown in Figure 2. This AHP model is used to find the relevant stigma impact expressed as a percentage of the unimpaired value of the property.

The model consists of 3 columns. Column 1 contains the goal; it is the target stigma adjustment factor that this model will return at the end of the process. Column 2 contains all criteria identified earlier. Column 3 contains the probable stigma adjustment factors. They are a range of probable stigma adjustment percentages that the valuer has estimated for the model using market evidence. For demonstration purposes, the model only uses three probable stigma adjustment factors, Rate 1, Rate 2 and Rate 3, selected from the range of probable stigma adjustment factors using the best/worst case approach.

Figure 2: AHP Hierarchy Model for Selection of 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, in respect of each of the alternatives (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.

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 alternatives and layer of criteria in the model are not fixed. In this research, only three alternatives 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'.

CASE STUDY

Testing of the model is demonstrated by the following case study, involving a motor service station in Wyong, NSW.

The subject property is a service station/car repair workshop. The land and building areas are about 1,400m² and 250m² 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, a valuer cannot disclose information of the subject property to a third party without the consent of the client. For example, Schedule 1, Rules Of Rules Of Conduct, of the Valuers Registration Regulation 1993 under the Valuers Registration Act 1975 (NSW) provides that “[t]he valuer must not disclose a valuation to another person unless authorised by the client or required by law to do so”. There is also similar provision in the Rules of Conduct of the Australian Property Institute. 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 sixteen criteria accordingly.

Using the same valuer to test run the model has a problem that the result may be affected by anchoring effects. In order to keep the impact of possible anchoring effects 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. 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 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 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.

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

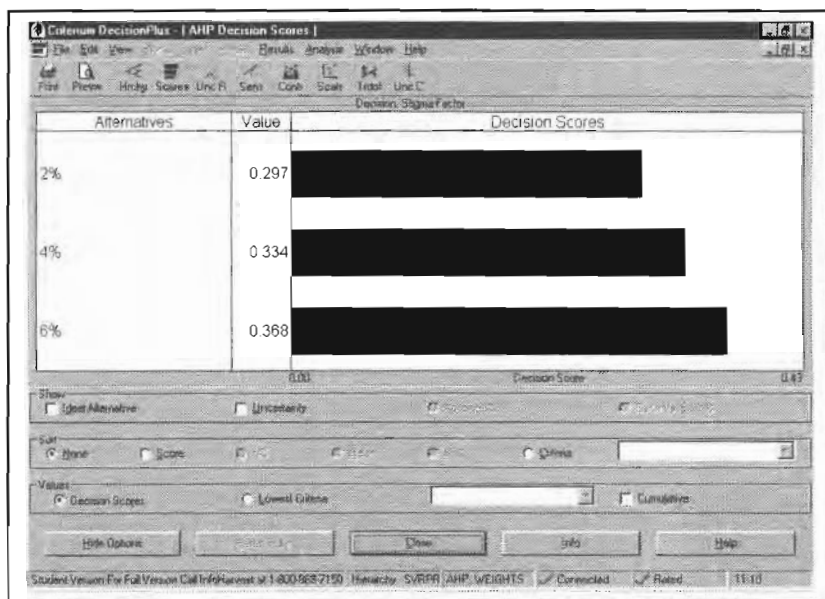
Table 3: Criteria and Alternatives Weighting of Case Study

Goal Level	Weights	Rating Set	(Rating scale 0 - 10)			
			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 weights in Column 2 are the relative importance of the criteria to the goal. 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. The weights in last three columns represent the relative importance of the criteria to each of the alternatives (probable stigma adjustment factors) based on a scale of 0 - 10. A score of '0' means no importance, while a score of '10' means extremely important.

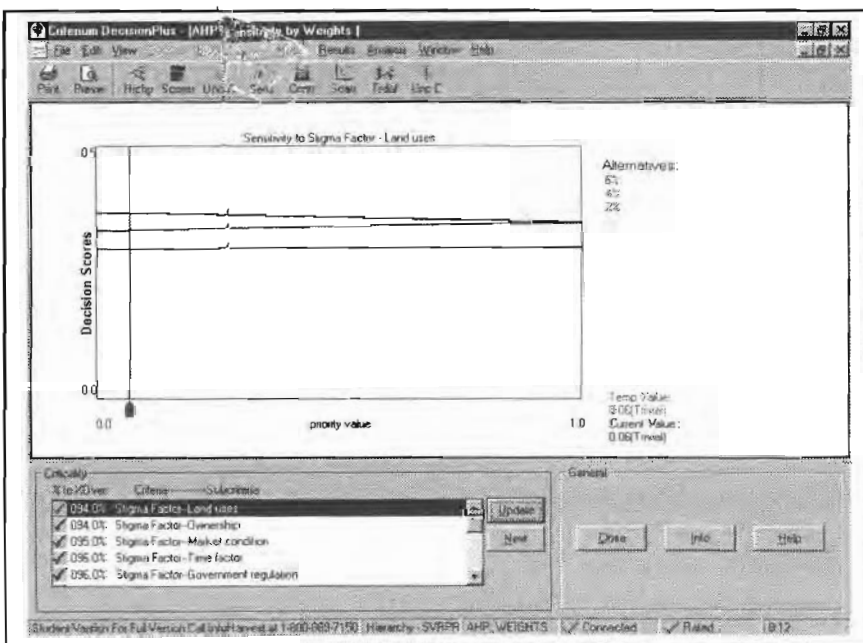
Based on all ratings, the AHP model returns the most likely stigma adjustment factor of 6% as shown in Figure 3.

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.

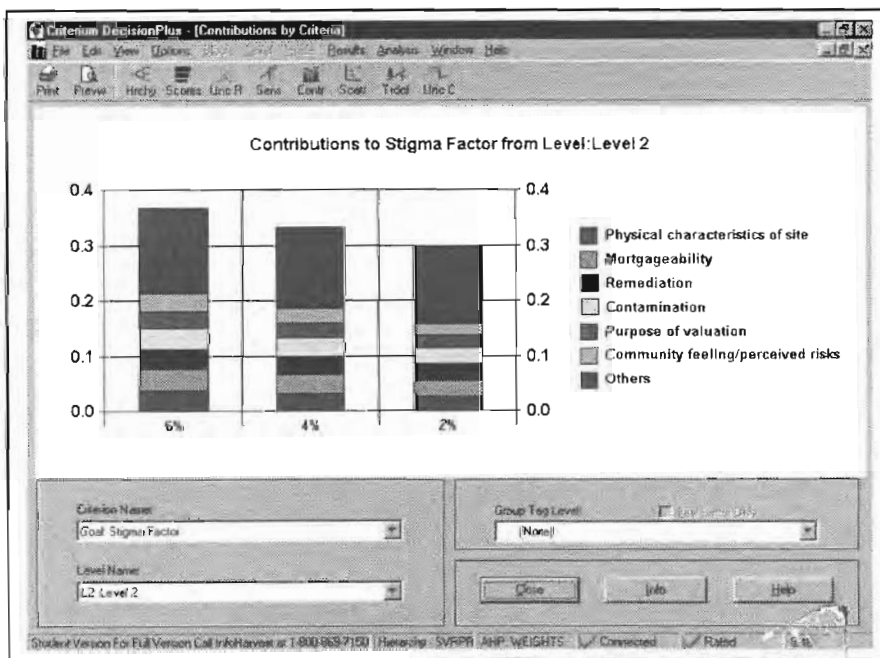
Figure 4: Sensitivity by Weights Analysis of Case Study



In a sensitivity analysis, if a change of 5% or less to a particular criterion 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 much higher 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), 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:

$$\begin{aligned}
 \text{Impaired value} &= \text{Unimpaired value} - \text{financial losses due to contamination} \\
 &\quad - \text{remediation costs} - \text{stigma adjustment} \\
 &= \$290,000 - \$20,000 - \$40,000 - (\$290,000 \times 6\%) \\
 &= \$212,600.
 \end{aligned}$$

This figure is around 6% below the original valuation of \$225,000. This difference is within the acceptable range ($\pm 10\%$) 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; mirroring Land Use No. 56 in Table 2. 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 MCDM model outlined above takes all stigma criteria into account and provides a logical and structured framework for valuers to assess stigma impacts. The model does not turn an inexperienced valuer to an experienced valuer in contaminated land valuation. The valuer still needs to be able to estimate a range of probable stigma adjustment factors (alternatives) using market evidence. The model only replaces what was guesswork by explicit rating of each criterion and processing the data with the AHP method.

The model has a built-in mechanism to check for sensitivity and robustness. It does not require valuers to carry out a survey of any individuals for each valuation. Nevertheless a valuer still needs to analyse market evidence. The survey in Table 2 is required to provide a benchmark mechanism for this research only. A valuer can use the model without a benchmark 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 it is used. Any change of environmental risk perception due to change of circumstances over time is directly reflected in the necessary ratings to the relevant criteria. Valuers need not have special knowledge to carry out the valuation, and 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 uncharted waters; his/her action tends to be cautious and conservative. Accordingly, the test valuer might have been cautious and supplied some conservative data. Thirdly, there are only three 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.

Although the result is encouraging, the model suggested is not meant to be definitive. It has the problem that the case study used only the original valuer to test run the model. More rigorous tests of the model with more case studies by independent valuers are required. Nevertheless, it is hoped that this paper serves to stimulate 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.

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