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RISK SCORING FOR BROWNFIELDS DEVELOPMENT DECISION

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ABSTRACT

Land development demands strategic decisions to combine technology and effort to create valuable real estate 'capital'. Brownfield decisions involve an elaborate cost-benefit analysis with multiple perspectives. The analysis requires a multi-criteria and multi-actor interactive reasoning process to be applied to the subject property. A 'balanced approach' for brownfield development decisions expects that the assessment, judgement, and communication takes into account both the risk factors and the actors involved in the development process. This paper analyses the risk associated with brownfield development from the perspective of key stakeholders, using analytical hierarchical process (AHP) to identify relative importance, scale, and score of brownfield risk criteria. Using a set of comprehensive brownfield risk factors that we have developed earlier, a survey of experts to conduct risk comparison is carried out which allows for scoring and weighing (ranking) of these risks in a multi-factor decision process. Brownfield development as a context for risk evaluation permits stated preference based risk scoring for multi-actor groups involved in such developments but with diverse interests. The result indicates a general consistency of risk preferences in brownfield context of multiple actors. The paper presents a hierarchy of risk preferences, which may be used for explicit risk evaluation and communication in brownfield financial decision and value reporting.

Keywords: Brownfield; Analytic Hierarchy Process (AHP); Risk Communication; Valuation; Decision

INTRODUCTION

Land development involves strategic decisions to combine technology, capital and effort to create value for real estate. Brownfield land development decisions demand knowledge-based inputs to inform cost-benefit perception. These decisions demand a multi-criteria and multi-actor risk analysis process to be applied to the subject property. A 'balanced approach' expects the assessment, judgement, and communication to take into account both risk factors and actors involved in the development process.

The brownfield land market is typically illiquid and 'thin', featured by high transaction cost, low transparency, slow adjustment e.g. time delay, lack of open trade, and complex liability. All lead to asset uncertainty. The sector exhibits major information cost and risk aversion behaviour. Identify and reduce information risk help in raising the allocation efficiency of brownfield land. Due to fear (sensitivity) of value loss, privately held

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information on risk associated with brownfield assets is of high value. However, efficiency in communication of risk is low. Our finding of developer risk scoring supports this claim.

Estimated market price of property assets (i.e. valuation) allow for risk. However, given the implicit nature of brownfield cost, its valuation is subject to the following concerns:

- How effectively are the risks identified, captured/estimated, managed/reduced?
- How explicitly are risks reported for valuation and decision making?
- How to convey risk in an efficient way in a multi-dimension risk environment e.g. by likelihood, density, cost to mitigation/reduction/elimination?
- How do risks impact on market value of brownfields?
- When market failure is severe and alternative options are unavailable, does the demand for efficient risk communication (e.g. standardisation or externalisation) increase?

This paper aims to identify key elements of brownfield risk as perceived by key actors involved in brownfield land development process. Risk elements are then ranked in terms of their relative importance and weighted to facilitate explicit communication in the valuation and decision processes. This involves the design of a survey to capture risk analytic factors for an actor involved in the development process. The data is analysed using analytic hierarchical process to derive the relative rank (importance) and score (relative number) of brownfield risk criteria. It brings together risk criteria, decision process, and information (availability, quality, and effectiveness) in brownfield decision. This paper examines the effectiveness of communication of risk criteria in the brownfield context. From the perspective of an actor's perception or stated preference, this study explores the possibility of explicit risk communication for complex brownfield evaluation and decision making.

BROWNFIELD ANALYSIS AND DECISION

The brownfield literature is mainly concerned with the issues such as value, risk, and productivity. The estimation of risk in a brownfield land development project is essential for various stakeholders – developers, valuers, lenders and other built environment professionals.

There have been studies that have empirically investigated the relationship between environmental hazard, stigma (e.g. if the location is close to previously landfill site) and land prices using (1) a spatial and (2) a non-spatial modelling framework. The spatial modelling framework links with mainstream location (urban economic) theory, while the latter links more closely to information economics and behavioural ideas. A third stream of analysis related to brownfield projects concerns with the normative strategy and decisions such as location choice, social justice and compensation determination, data, methodology and cross-context applicability of results.

Due to the difficulties in assessing the societal perception based risk for brownfield lands, these are far more inefficiently allocated than other land markets. Government actions in the market context are sub-optimal as these are driven by a mixed, sometimes conflicting interests and motives. Despite suffers from inefficiency, government engagement in brownfield projects has been substantive.

In a typical development feasibility analysis, the risks associated with brownfield may not be explicitly expressed by risk premium. Hence it is important to understand what are brownfield land development risks and associated concerns? The term risk as is used in the market economy is all encompassing term for the probability of not achieving certain objectives. The research interest in understanding components of risks is increasing for brownfield asset classes (Glumac et al 2011; Rizzo et al 2015). There is a sizeable literature on risk and valuation of brownfields (e.g. hazardous land), focussing on the physical and psychological aspects of value. Syms (2004,1999, 1996), for example, examined the perception of risk and remediation processes in the valuation of contaminated land in the UK. In the US, contamination risk is captured by measure and analysis of environmental externality in valuation process (e.g. Wilson 1996, Case et al 2006, Simons et al 2008).

Risk in human decision-making is usually defined and measured probabilistically. But its evaluation also demands clear identification, classification and sorting elements suited for analytic decision-making. There are 2 rational ways to treat uncertainty (esp. the "cost" side of uncertainties, i.e., the risk). One is inductive, where facts are observed, measured, analysed, and 'extended' into risk perception. The pure form of risk-adjusted return based on empirically observed historical returns is of such nature. It effectively relies on the "continuity of a similar likelihood or pattern occurring into the future". The other is deductive, where one establishes a logical relationship (e.g. sequence) between quantified risk factors and an expected outcome in a "risk model". This study and analysis involve both inductive and deductive logics to relate actor subjective judgement (stated preference) and logical, consistent reasoning. The process helps identify and validate valuation related factors to ensure rigorous analysis to examine rational decision-making. It is useful to assume that investors learn by absorbing past information and continuously revising (updating) their knowledge to guide predictive decisions.

Brownfield decisions are typically associated with complex multi-actor environment (Glumac et al 2015; Lange et al 2014). Active market for risk trade is the precondition to derive discount rates or cost estimate for risk accounting. Unfortunately, actor perception, and socio-political risk of brownfields, are rarely market allocated. Environmental impact or negative externality from production and capital formation processes are costly to measure. Furthermore, the basic concept of risk itself is not fully settled (Carmichael 2016). This calls for a perception based analytic approach to identifying and explicitly evaluating brownfield risk factors and preferences that are associated with brownfield cost (e.g. information asymmetry) and value (e.g. intangible and not-for-trades) related decisions.

ANALYTIC HIERARCHY PROCESS (AHP) FRAMEWORK

This study uses a multi decision making technique called Analytical Hierarchy Process. Saaty (2008 pp.83) describes AHP as "a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales." It allows information from knowledgeable expert people to identify their stated preference of risk and value.

AHP focuses on individual decision making consistency, a defining feature of rational behaviour. The analysis demonstrates a process to identify 'consistent choice makers', who are rational and knowledgeable. Rational decision makers make reasonably consistent comparison towards decision making. In this paper risk preferences of specialists/experts in the brownfield development process, using relative scores of previously-developed risk criteria and structure have been analysed.

The extensive testing of the AHP theory in the built environments context is evident in recent years. For example, the methodology has been applied to residential property selection, forecasting, and demand analysis (Ball and Srinivasan 1994; Schniederjans et al 1995; Ong and Chew 1996; Kauko 2003), foreign direct investment into property (Bender et al 2000), stigma contaminated land valuation (Chan 2001, 2002), investment property risk scoring (Hutchison et al 2005), CBD building quality assessment (Ho et al 2005), hotel investment decision (Newell and Seabrook 2006), building accessibility for construction (Wu et al 2007), commercial property risk (Chen and Khumpaisal 2009), asset allocation (Chen et al 2011), construction technology innovation (Hardie and Newell 2011), work place wellbeing (Khamkanya et al 2012), facilities location selection (Opasanon and Lertsanti 2013), consumer location choice (Chadawada et al 2015), and emerging commercial property market investment risk (Gupta and Tiwari 2016).

AHP models stated preferences for risk in the brownfield context within a defined or perceived period and context. The results are based on opinion of experts, not historic experiences (decisions) and evidences (i.e. actual choice of exchange). In that sense, the outcome from AHP remains 'want-based' (implicit), which may show inconsistency from empirically based prediction and decision.

Recognising the limits to capacity of multiple criteria processing, comparison, judgement of the human mind (Saaty 1990 cited Miller 1956), AHP allows breaking down a complex decision problem into paired comparison of individual risk criteria, which is then logically combined to arrive the overall ranks. When simple individual choice units need to be combined for complex overall decision or strategy making, AHP is an effective method to derive relative weights of risk criteria. The model generates ratio scale and consistency index (CI), which are based on solving an eigenvalue problem. The ratio scales are derived from eigenvectors. CI is calculated from eigenvalue. To enable numerical assessment, the numerical scale is turned into a matrix system, with diagonal always valued at 1. Table 1. shows an effective AHP scale system.

Table 1. An effective scale used in AHP

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Comparison slightly favour one activity over the other
5	Strong importance	Comparison strongly favour one activity over the other
7	Very strong importance	An activity is favoured very strongly over the other and its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of highest possible order of affirmation
2,4,6,8	For comparison between the above values	Sometimes one needs to interpolate a compromise judgement numerically
Reciprocals of above	If activity *i* has one of the above nonzero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with the *i*	

Source: Saaty (1994)

Preference and relative importance/intensity that are derived by paired comparison of risk criteria then generate a n(n-1)/2 numerical matrix (A). Table 2 shows an example of the 6 principal criteria paired compassion matrix. It contains 15 comparison values of relative importance. Then the important step is evaluation of the consistency across the matrix as an indicator of rational reasoning and judgement. If perfectly consistent, the A matrix should be able to solve: Aw=nw.

Table 2. Results of pairwise comparison of risk criteria

	site specific	political & legal	socio-economic	planning	project	financial & market
site specific	1	1/3	3	1	1	1/3
political & legal	3	1	3	3	2	1/3
socio-economic	1/3	1/3	1	1/3	1	1/3
planning	1	1/3	3	1	3	1/3
project	1	1/2	1	1/3	1	1/3
financial & market	3	3	3	3	3	1
column Sum	9.33	5.5	14	8.67	11	2.67

Saaty (1994) suggests that an A matrix is consistent if and only if A_{max}=n. In practice, A_{max}≥n. Inconsistencies in elements in an A matrix means variation of A_{max} from n. Consistency index (CI), CI=(A_{max}-n)/(n-1), is used to represent this deviation. CI is then compared with a random index (RI), see Table 3. This helps determine a consistency ratio (CR), where CR=CI/RI. As a decision rule (Saaty 1994), the consistency ratio for a 5^2 matrix should not be much higher than 10%.

Table 3: Value of random index (RI)

N	1	2	3	4	5	6	7	8	9	10
Random Index (RI)	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

(Source: Saaty 1994)

Saaty (1994) shows main steps of the AHP methodology, which is clearly lay out in Gupta and Tiwari (2016 pp.163):

1. Define objective and state the problem;
2. Broaden objective and select elements of criteria, sub-criteria, alternatives;
3. Make pairwise comparison of the elements, calibrate them on a numeric scale of 1-9, and arrange them in an n^2 matrix. n is the total number of comparable elements;
4. Normalise the n^2 matrix, calculate to find priority vector/weighting, maximum eigenvector, CI and CR;

5. Check if maximum eigenvalue, CI and CR are reasonable, then decision will be taken as per the weighting obtained, or else the process is repeated till these values are satisfactory;
6. Evaluate alternatives according to weighting;
7. Provide rank to various alternatives.

Guided by the AHP theory, the hierarchical risk ranking is explored in a conceptual frame of sub-groups (e.g. owner, planning, developer, consultant, others) to rationalise the priority-based decision process of brownfield risk judgement, scoring, and ranking. It helps capture perceived risks.

BROWNFIELD RISK CRITERIA AND HIERARCHY

Literature and practice show that risk communication for brownfield asset valuation amongst key actors in the property industry is often implicit and inefficient. These actors do not necessarily share their respective risk assessment of brownfield assets. It is likely to experience the 'communication problem' at aggregate decision level i.e. all key decision makers, as well as at sub-group decision level i.e. industry or profession level decision makers, for brownfield valuation. Even if these actors communicate effectively (consistently), given their diverse preferences and priorities, there is a lack of quantitative measure to express their aggregate evaluation of risk in brownfield asset evaluation for decision making. Moreover, the risk assessment of different actor groups involved in brownfield projects has not been researched. One may 'naively' expect that the risk assessment of developers would differ from valuers or lenders or other actors in built environment but this needs proper investigation. The analysis helps in better understanding risks from rational collectively choice perspective for each actor and by each group of actors.

Brownfield value optimisation or risk (social and private) minimisation also demands user's (e.g. occupier and externality bear) perspective. Brownfield risk is organised into a structured hierarchical risk criteria system (Saaty 1994). Previous studies such as Syms (1996; 1997; 1999), Chan (2001, 2002), Glumac et al (2015) discuss brownfield risk criteria for valuation from development project delivery and process and psychological (e.g. stigma) perspectives. Evaluation of brownfield asset demand a broader risk set to reflect influence of a network of actors. AHP helps capture and describe perception and logical judgement of actors who are knowledgeable. This becomes the most probable types of decision maker, of preferred criteria for weighting (score) and ranking to aid brownfield decision. Timmermans et al. (1982), Page and Berger (2006) and Rizzo et al. (2015) show progressive insights of stakeholder concerns and methods to identify factors.

The hierarchical risk criteria capture the decision problem and context for this study. Based on an extensive literature analysis and exchange ideas with brownfield industry expert, risks relating to valuation (e.g. market), planning (e.g. social cost), project (e.g. technology), and investment (e.g. ownership) are organised and analysed in a multi-actor framework. Main actors include: developer, planning, lender/insurer, consultant, other social forces. This approach yields an initial risk set of 10 principal criteria and a total 64 sub-criteria. After taking into account industry experts' validation feedbacks, we revised and condensed the criteria system. The result is an operational risk criteria hierarchy of 6 principal criteria and 30 sub-criteria. Table 4 is the latest version used for the survey. Detail of the conceptual basis and process to derive the criteria is addressed in Wu et al. (2016).

Table 4. Principal risk and sub-criteria structure

Principal Risk Criteria	***Sub-Criteria***	
Site specific risk	1	Size and natural condition of the site
	2	Topography / relief
	3	High cost of social decontamination
	4	Associated environmental conditions
	5	Landscape and aesthetic effect
Political and legal risk	1	Location of the site within the settlement
	2	Image and homogeneity of the settlement
	3	Negative externality
	4	Regulatory processes and structure
	5	Fiscal risk (e.g. taxation, insurance, subsidy)
Socio-economic risk	1	Proximity of disposal and supply systems
	2	Accessibility to transportation systems
	3	Social amenities and quality
	4	Treatment facilities and services
	5	Crime and safety
Planning risk	1	Zoning law and regulations
	2	Long-term growth management policy
	3	Planning or other official approvals
	4	Heritage overlay and control
	5	Land development control processes
Project risk	1	Cost over-run
	2	Time delay for land remediation
	3	Technology selection to build and site treatment
	4	Disposal of project waste and contaminated soil
	5	Land development design and planning
Financial & market risk	1	Economic (e.g. access to labour, job, customer)
	2	Information (e.g. adverse publicity, stigma, uncertainty)
	3	Supply and demand for development sites
	4	Project and market finance uncertainty
	5	Market liquidity and transaction cost

(Source: Wu et al. 2016)

SURVEY DESIGN

One would expect that directly associated decision makers make rational and consistent choices regarding brownfield risk/criteria preference behaviour, while less directly related professional (still, relevant ones) make less consistent decision (i.e. more dispersed tastes), and show different priority regarding brownfield development. This study does not test consumer (user) preference. The study does not include opinion on risk of lenders and owners. This study assumes a mature market with established market-based institutional infrastructure.

The risk set is constructed at both principal and sub-criteria levels. Paired comparison of risk criteria (principal and sub-criteria) allows us to (i) form a system for comparison between options as per the AHP logic (comparability) and (ii) subjectively evaluate relative strength of preference between the compared options (intensity). We conducted the survey using a popular online survey tool (www.surveymonkey.com). It has a total of 9 questions. The 6 principal criteria and 30 sub-criteria expect a total of 75 paired comparisons plus their scoring (i.e. 1-5). Ethics approval was obtained prior to activation of the survey. Sampling targets experts who have experience of brownfield projects. No participant is identifiable in the data collection process. To encourage participants to complete the full survey of paired comparison, survey instruction suggests intuitive judgement approach to the survey fill out.

The survey was opened in July 2016. Approximately 50 expert practitioners were invited. A total of 27 industry practitioners participated, of which 15 completed the full survey. The rest (12) were partially completed, which also provide some valid data. Table 5 shows that 26% respondents are from land development industry, 37% from planning & government sector, 15% from valuation & consultancy sector, and 22% from such fields as commercial property, landscape architecture, quantity surveying, and built environment education.

Table 5. Survey response by question

Risk Criteria	Responded	Skipped	Respond Rate
principal risk criteria	22	5	81%
site specific sub criteria	19	8	70%
political/legal sub criteria	16	11	59%
socio-economic sub criteria	16	11	59%
planning sub criteria	16	11	59%
project sub criteria	15	12	56%
financial and market sub criteria	15	12	56%
ranking of principal risk criteria	23	4	85%

RISK CRITERIA RANKING RESULTS

This study distinguishes brownfield risk research from two perspectives, namely, the general public, who relies on intuitive judgement about brownfields, which involves moral value judgement (e.g. good, bad, emotional values), and the experienced professional expert, who typically concerns with rational reasoning regarding delivery, cost-benefit, and liability. This paper specifically deals with the professional context. Among the professionals, we are interested in understanding the expert risk preference in general (aggregate), as well as by professions (sub-groups).

We have associated professionals' perception of brownfield risk criteria with several clusters/groups, namely, (1) developer, who as risk taker and shorter-term strategist, is concerned about 'private cost', project success, and reputation, (2) planners who is concerned with longer-term public (social) good, and private interest, (3) owner (e.g. lender and insurer), who has long term interest of land productivity and liability, (4) consultant/surveyor (e.g. valuer), who intends to provide impartial and comprehensive consideration of market value, (5) other relevant actors, who are supporting the brownfield project but are less directly involved in brownfield decision making.

This study pays less analytic attention to users (end product consumer), as they typically approach brownfield risk by social norms (e.g. welfare and quality of life). The communication problem for brownfield valuation may reflect market return (private gain) from the developer perspective and regulation control (public good) from the government perspective. It may also be treated from an asymmetrical information perspective, given that the 'core profession' (i.e. main decision maker) may command more project knowledge whereas the 'marginal profession' (i.e. minor stakeholder) commands less direct project knowledge. This is a 'knowledge asymmetry' context of rationality, consistency, and 'rational' human choice.

Table 6 shows the analytic results for the 6 principal criteria. The result suggests financial & market risk (21.3%) and project risk (19.2%) are the most important elements. Planning risk (17.3%) and site specific risk (16.91%) are similarly ranked. Political & legal risk (13.2%) and socio-economic risk (11.21%) are less important. Table 6 also shows weighting and ranks of principal criteria for each professional group. There are variations between developer, planning, consultant, and others. Some show contrasting interest. Developer rates financial & market risk most highly (23.4%). Least of their concern is socio-economic risk (9.6%). Planner and consultant rate highly site specific and project risks. Interestingly, planner rate second planning risk (18.6%). Consultant has more balanced ranks, though they scored planning risk (14.2%) least important. Other relevant professionals are more site (26.4%) and project (22.2%) oriented. Similar to planning and consultant, they are not directly liable to market and project finance, but directly liable to project quality. In general, most elements of stated preferences are expected from observable industry norms.

Table 6. Principal criteria risk preference

principal criteria	normalized weighting					rank
	developer	planning	consultant	relevant	**overall**	
financial & market risk	23.39%	17.42%	14.84%	16.91%	21.32%	1
project risk	19.15%	17.57%	21.49%	22.23%	20.03%	2
planning risk	17.47%	18.31%	14.15%	16.13%	17.34%	3
site specific risk	17.67%	18.62%	19.25%	26.38%	16.91%	4
political & legal risk	12.73%	13.05%	15.92%	8.59%	13.18%	5
socio-economic risk	9.59%	15.02%	14.36%	9.75%	11.21%	6

Table 7 present detailed weighting for each principal and sub-criteria, as well as relative weighting of each sub-criterion in the decision process as defined by the brownfield risk-criteria hierarchy. Among all sub-criteria, associated environmental conditions (4.73%) is the most concerned risk criteria. It is followed by project and market finance uncertainty (4.69%). The least concerned risk criteria are image (homogeneity) of settlement (1.81%) and proximity of disposal and supply system (1.79%). It is then possible to consider least risky brownfield project by most influential risk sub-criteria or by top criterion under each principal criterion.

Table 7. Aggregate risk ranks for brownfield development

Main Risk Criteria	**Sub Risk Criteria**	**Weighting (%)**			**Rank**
		Main Criteria	Sub Criteria	Resultant	
Project Risk	Cost over-run	20.03%	22.40%	4.49%	3
	Time delay for land remediation	21.32%	18.23%	3.65%	11
	Technology selection to build site treatment	16.91%	18.06%	3.62%	12
	Disposal of project waste & contaminated soil	17.34%	20.15%	4.04%	10
	Land development design and planning	13.18%	21.16%	4.24%	7
Financial/Market Risk	Economic	21.32%	16.53%	3.52%	13
	Information	20.03%	20.58%	4.39%	5
	Supply and demand for development sites	21.32%	19.87%	4.24%	6
	Project and markets finance uncertainty	16.91%	22.00%	4.69%	2
	Market liquidity, transaction	17.34%	21.02%	4.48%	4
Site Specific Risk	Site/natural condition	16.91%	16.98%	2.87%	20
	Topography/relief	11.21%	15.03%	2.54%	25
	Cost of site decontamination	20.03%	24.04%	4.07%	9
	Associated Environmental conditions	21.32%	27.95%	4.73%	1
	Landscape and aesthetic aspects	16.91%	16.00%	2.71%	23
Planning Risk	Zoning law and regulation	17.34%	19.90%	3.45%	14
	Long term growth management strategy	13.18%	19.28%	3.34%	16
	Heritage overlay and control	11.21%	19.62%	3.40%	15
	Land development control process	20.03%	16.90%	2.93%	19
	Planning or other official approvals	21.32%	24.30%	4.21%	8
Political & Legal Risk	Site location within settlement	13.18%	17.01%	2.24%	27
	Image/homogeneity of settlement	17.34%	13.76%	1.81%	29
	Negative externality	13.18%	25.18%	3.32%	17
	Regulatory process and structures	11.21%	23.46%	3.09%	18
	Fiscal risk	20.03%	20.58%	2.71%	22
Socio-Economic Risk	Proximity of disposal and supply systems	11.21%	15.94%	1.79%	30
	Accessibility to transportation	16.91%	24.52%	2.75%	21
	Social amenities and quality	17.34%	20.27%	2.27%	26
	Treatment facilities and services	13.18%	16.35%	1.83%	28
	Crime and safety	11.21%	22.92%	2.57%	24

(Note: the normalisation is based on geometric means.)

Table 8 reports top 10 most concerned risk criteria. They made up 43.6% of the decision weight. Table 8 also shows the most concerned brownfield scenario that takes top sub-criterion into account. The group includes cost over-run, project and market finance uncertainty, associated environmental conditions, planning or other official approvals, negative externality, accessibility to transpiration. They made up 24.2% of the decision weight.

Table 8. Aggregate risk ranks and ranks by principal criteria

overall top ranks			
Risk Criteria	**Risk Sub Criteria**	**Weighting**	**Rank**
site specific risk	Associated Environmental conditions	4.73%	1
financial & market risk	Project and markets finance uncertainty	4.69%	2
project risk	Cost over-run	4.49%	3
financial & market risk	Market liquidity, transaction	4.48%	4
financial & market risk	Information	4.39%	5
financial & market risk	Supply and demand for development sites	4.24%	6
project risk	Land development design and planning	4.24%	7
planning risk	Planning or other official approvals	4.21%	8
site specific risk	Cost of site decontamination	4.07%	9
project risk	Disposal of project waste and contaminated soil	4.04%	10
		43.56%	
top rank in each principal criteria			
Risk Criteria	**Risk Sub Criteria**	**Weighting**	**Rank**
project risk	Cost over-run	4.49%	3
financial & market risk	Project and markets finance uncertainty	4.69%	2
site specific risk	Associated Environmental conditions	4.73%	1
planning risk	Planning or other official approvals	4.21%	8
political and legal risk	Negative externality	3.32%	17
socio-economic risk	Accessibility to transportation	2.75%	21
		24.19%	

Our analysis also considers the most concerned risk criteria in each of the sub-groups. Table 9 shows developer concerns financial risk (information 7.5%; project and markets finance uncertainty 5%). They highly value the importance of information. Site and project specific risks follow. Planner concerns highly site specific risk (associated environmental conditions 5.5%; site decontamination cost 5.2%). They seem to concern less planning risk e.g. the highest ranked being heritage overlay & control (4.4%). Brownfield consultants value site specific (associated environmental conditions and topography/relief) and project specific (land development design & planning; cost over-run) risks more highly. Other relevant professionals' concerns focus on project and site specific risks.

Table 9. Risk ranks by sub-groups

Risk Criteria	Risk Sub Criteria	Weighting	Overall rank	sub-group
financial & market risk	Information	7.47%	1	
site specific risk	Associated Environmental conditions	5.01%	2	
financial & market risk	Project & markets finance uncertainty	5.00%	3	**developer**
project risk	Cost over-run	4.98%	4	
site specific risk	Cost of site decontamination	4.70%	5	
site specific risk	Associated Environmental conditions	5.50%	1	
site specific risk	Cost of site decontamination	5.15%	2	
project risk	Cost over-run	5.05%	3	**planning**
socio-economic risk	Crime and safety	4.68%	4	
planning risk	Heritage overlay & control	4.42%	5	
site specific risk	Associated Environmental conditions	7.78%	1	
project risk	Land development design & planning	6.06%	2	
site specific risk	Topography/relief	5.77%	3	**consultant**
financial & market risk	Market liquidity, transaction	4.81%	4	
project risk	Cost over-run	4.75%	5	
project risk	Disposal of project waste & contaminated soil	5.23%	1	
site specific risk	Cost of site decontamination	5.02%	2	
project risk	Land development design & planning	4.87%	3	**relevant**
project risk	Technology selection to build site treatment	4.82%	4	
site specific risk	Site/natural condition	4.31%	5	

The final step to look at sub-group's risk preference is "top ranks by principal criteria". Table 10 gives a breakdown of each group's top sub-criterion that is under each of the principal criteria. Developer concerns a combination (27.5%) of information, environmental conditions, cost over-run, zoning law/regulation, regulatory process/structure, and crime & safety. Planner concerns a 'risk package' (27.6%) including environmental conditions, cost over-run, crime/safety, heritage overlay control, negative externality, supply and demand of development sites. Consultant (28.2%) concern project design and planning, market conditions, and environmental conditions most strongly. Relevant professional (25.3%) tend to emphasis disposal project waste & contaminated soil, cost of site decontamination, negative externality.

The results are interpreted in the context of brownfields in a mature market system. This helps describe market allocation efficiency of brownfield resources. As the criteria set is constructed from a comprehensive valuation decision making perspective, this study does not intend to single out the 'brownfield only' criteria from other important land development criteria relevant to brownfield decisions. As the aggregate ranks (table 8) show, brownfield decision-makers understand the environmental sensitivity brownfields may have, and associated financial viability. It may lead to substantial cost that is difficult to plan and control. They are also aware of the market liquidity problem, which is closely associated with market transparency and availability of valuable information. The brownfield sector is heavily regulated, subject to frequent direct government intervention. All may be translated into costly planning/design responses and longer expected development time and higher expected cost of project delivery. Specifically, the 'extra cost' to decontaminate (or mitigate) and the cost to dispose brownfield waste can be substantial. They may become a source of long-term liabilities. The insights that we received from AHP analysis may help us understand such policy decisions as provision of brownfield assistance programs and subsidies in related redevelopment and financing processes.

Table 10. Risk ranks by principal criteria and sub-groups

Risk Criteria	Risk Sub Criteria	Weighting	Overall rank	Sub-group
project risk	Cost over-run	4.98%	4	
financial & market risk	Information	7.47%	1	
site specific risk	Associated Environmental conditions	5.01%	2	developer
planning risk	Zoning law & regulation	4.21%	7	
political & legal risk	Regulatory process & structures	3.41%	13	
socio-economic risk	Crime & safety	2.37%	22	
	Sub-total	27.45%		
project risk	Cost over-run	5.05%	3	
financial & market risk	Supply & demand for development sites	3.89%	8	
site specific risk	Associated Environmental conditions	5.50%	1	planning
planning risk	Heritage overlay & control	4.42%	5	
political & legal risk	Negative externality	4.05%	7	
socio-economic risk	Crime & safety	4.68%	4	
	Sub-total	27.59%		
project risk	Land development design & planning	6.06%	2	
financial & market risk	Market liquidity, transaction	4.81%	4	
site specific risk	Associated Environmental conditions	7.78%	1	consultant
planning risk	Planning or other official approvals	4.15%	10	
political & legal risk	Fiscal risk	2.18%	21	
socio-economic risk	Accessibility to transportation	3.17%	15	
	Sub-total	28.16%		
project risk	Disposal of project waste & contaminated soil	5.23%	1	
financial & market risk	Economic	3.51%	12	
site specific risk	Cost of site decontamination	5.02%	2	relevant
planning risk	Long term growth management strategy	3.69%	9	
political & legal risk	Negative externality	4.01%	7	
socio-economic risk	Social amenities & quality	3.80%	8	
	Sub-total	25.26%		

RISK SCORE, CONSISTENCY AND STATED PREFERENCE

Choice consistency is an important element of AHP theory. This analysis requires the calculation of consistency ratio (CR) of each pairwise comparison process. Each survey involves 7 pairwise comparison matrixes, a total 75 comparisons (i.e. (6×5/2+5×4/2)). The average CR is 5.3 % for all comparisons, and 4.5% for all sub-criteria comparisons. The CR for principal criteria is 10.9%, slightly higher than the 10% mark. Given the one off and anonymous nature of the survey, the consistency level is satisfactory. It is likely that review and comments on survey design by industry experts had helped effective communication to ensure sound consistency from the responses.

The question of consistency in choice-making involves interactions of intuitive action and rational choice; the latter is described largely by consistency in choice making behaviour among alternatives. It is important to note that decision consistency may be affected by: (1) instruction and information, (2) rationality (mental), (3) knowledge and its distribution in market, organisation and society. It is unclear that what has contributed to inconsistency of preference – a central question of rationality difficult to directly validate by economic data.

In the past, attempt has been made to calculate weighted scores of alternatives e.g. sites, scenario, properties, options. Whipple (2006) demonstrates how to convert rank (weight) to adjusted price. The weights are applied to selected scenario or comparable sales (properties). But that is based on adjustment of historic transactions of comparable properties. It is a subjective rating to consider the relative importance of observed prices. The method is revealed preference-based. When trades are not market driven, actual prices can be biased. AHP is stated preference based. It treats explicit risk premium as a ‘hidden price’ for implicit markets like the brownfield sector. Based on experience, current knowledge, individual taste and belief, relative price and cost (risk) is approached via survey-based perception indication to unveil preference. It is then possible to examine the data by ranking and comparing observed actions and prices (i.e. revealed preference).

CONCLUSIONS

Brownfields are formal industrial sites that are commonly regarded as risky asset in post-industrial cities and nations due to existing or potential environmental cost. In this paper, we are interested to explore what brownfield risks experienced experts concern, prefer to reduce, or choose to avoid? More specifically, this paper explores individual decision maker's stated preference of brownfield risks, or more precisely, the 'aversion' of brownfield risk factors, which is measured by relative rank. It also examines communication effectiveness of brownfield risks among key stakeholders (i.e. sub-groups). Complex decision process such as brownfield is approached from the basic individual choice (judgement) perspective.

Using AHP theory as the underlying organising structure and analytic logic, this paper is able to analyse, score, weight and rank stated risk preferences using a comprehensive brownfield risk set. We explicitly derived stakeholder risk concerns and their relative importance. Given the illiquidity and low transparency of brownfield assets, this scoring and ranking process would help develop a process which could bring together dispersed stakeholder evaluations and their hidden preferences towards a "value consensus". However, its link to the actual price of risk (i.e. discount rate) remains unclear.

As Saaty (2008) argues, inconsistency in human judgement motivates learning and progress, which could be interpreted as a source of human rationality. As the AHP approach was also applied to the sub-group level of stakeholders, this study allows evaluating brownfield risk according to specific professional interest groups. It helps gain insights about group preference in a complex decision making process. What emerges is an evaluation framework for multi-criteria, multi-actor complex decision making and assessment. This tool is clearly needed for brownfield evaluation and decision making for complex problems.

This paper focuses on the choice sets that are high in internal consistency, which are the majority of the expert professionals. The result is a stable set of order and rank for the brownfield risk criteria, useful for effective communication. However, it may also be true that the less the structured knowledge that we have, the more random (or higher inconsistency) our response to a complex decision will be. Without possessing critical information, we will be incapable to organise consistent reasoning to generate so-called 'rational choice'. Inconsistency in decision making and judgement may relate to the degree of knowledge and experience, to gain better understanding of rationality and consistency in decision making.

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