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Modeling multi-stakeholder multi-objective decisions during public participation in major infrastructure and construction projects: a decision rule approach

ABSTRACT

Major infrastructure and construction (MIC) projects are those with significant traffic or environmental impact, of strategic and regional significance and high sensitivity. The decision making process of schemes of this type is becoming ever more complicated, especially with the increasing number of stakeholders involved and their growing tendency to defend their own varied interests. Failing to address and meet the concerns and expectations of stakeholders may result in project failures. To avoid this necessitates a systematic participatory approach to facilitate decision-making. Though numerous decision models have been established in previous studies (e.g. ELECTRE methods, the analytic hierarchy process and analytic network process) their applicability in the decision process during stakeholder participation in contemporary MIC projects is still uncertain. To resolve this, the decision rule approach is employed for modeling multi-stakeholder multi-objective project decisions. Through this, the result is obtained naturally according to the "*rules*" accepted by any stakeholder involved. In this sense, consensus is more likely to be achieved since the process is more convincing and the result is easier to be accepted by all concerned. Appropriate "*rules*", comprehensive enough to address multiple objectives while straightforward enough to be understood by multiple stakeholders, are set for resolving conflict and facilitating consensus during the project decision process. The West Kowloon Cultural District (WKCD) project is used as a demonstration case and a focus group meeting is conducted in order to confirm the validity of the model established. The results indicate that the model is objective,

reliable and practical enough to cope with real world problems. Finally, a suggested future research agenda is provided.

Keywords

Public participation; Multi-stakeholder multi-objective decision-making; Conflict analysis; Consensus building; Major infrastructure and construction projects.

INTRODUCTION

The decision making process of contemporary major infrastructure and construction (MIC) projects is becoming ever more complicated, especially with the increasing number of individuals/groups involved (Akter and Simonovic 2002) and their growing tendency to guard their own interests by influencing the implementation of projects (Olander and Landin 2008). Project managers, therefore, need to coordinate different stakeholder (or stakeholder group) relationships and it has been suggested that engaging them throughout the project lifecycle is an effective way of achieving this (Li *et al.* 2012a). Public participation enables a two-way communication between the decision-makers and other stakeholder groups in an open and transparent manner and therefore improves the accountability of the decision making process, the project's long-term viability and benefits to the community.

Despite the international trend towards increased implementation of participatory mechanisms for MIC schemes, numerous issues exist during the participatory process that can adversely affect the effectiveness and efficiency of public participation activities or even lead to project failures [International Association for Public Participation (IAPP) 2008]. In China, for example, the current participatory mechanism at the project level exists only as part of the environmental impact assessment (EIA) process and such rather limited public participation has resulted in many controversial MIC projects in the country, such as the Nu River Dam and the Yuanmingyuan Lake Drainage scheme (Moore and Warren 2006; Zhang and Jennings 2009). Through a series of interviews with a diverse group of experts, Li *et al.* (2012a) have identified more barriers to effective participation in the construction industry in China in terms of bureaucratic structure, public capacity, process management, legislation, personnel, etc.

An inherent disadvantage of public participation is that it cannot always guarantee a mutually acceptable solution and may instead lead to confrontation and disputes (Shan and Yai 2011). This is especially the case for MIC projects since stakeholder interests are rather diverse, as evidenced in Hong Kong's recent Guangzhou–Shenzhen–Hong Kong Express Rail Link project (Tan *et al.* 2009; Liang 2010). These interests can be either quantitative (e.g. a compensation plan for those who need to be relocated due to the development of a MIC project) or qualitative (e.g. maintaining local characteristics for the general public) and are often conflicting (e.g. the development of the whole community at the cost of the project-affected people in terms of their quality of life). Numerous project failures resulting from insufficiently addressing stakeholder concerns and meeting stakeholder expectations throughout the project lifecycle are detailed in the literature (e.g. Morris and Hough 1993). To avoid this necessitates the clear identification of any potential stakeholder conflict and a convincing approach for achieving a consensus.

To this end, a multi-stakeholder multi-objective decision making model is developed based on decision rule theory. The West Kowloon Cultural District (WKCD) project is used as a demonstration case and a focus group meeting is conducted in order to confirm the validity of the model used. Finally, a proposed future research agenda concludes the paper.

MULTI-STAKEHOLDER MULTI-OBJECTIVE DECISION-MAKING

Multi-criteria decision analysis (MCDA)

Decisions made in delivering a MIC project can affect various stakeholders (or stakeholder groups) with diversified objectives about the proposed project (Olander 2007). Accordingly, diverse measures are used by different stakeholders (or stakeholder groups) to evaluate the project's ability to meet their objectives. Identifying stakeholder objectives and analyzing stakeholder criteria therefore become indispensable tasks during the participatory process in order to increase the likelihood of project success (Atkin and Skitmore 2008). According to Belton and Stewart (2002:2), multi-criteria decision analysis (MCDA) is "*an umbrella term to describe a collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter*". Although there are many other ways to define MCDA, and many terms to describe them (e.g. Multiple Objective Decision-Support Systems, MODSS) (Harrison *et al.* 2008), the basic elements of MCDA are, however, very simple and include "*a finite or infinite set of alternatives, at least two criteria, and, obviously, at least one decision-maker*" (Figueira *et al.* 2005: xxii). Through MCDA, the decision maker(s) can be more confident when choosing the best alternative, assigning alternatives to pre-defined and preference-ordered classes, and rank alternatives from the best to the worst (Greco *et al.* 2005). To do this, Rogers *et al.* (2000) propose a five-step procedure of defining objectives, formulating criteria, generating alternatives, evaluating alternatives, and finally selecting a preferred alternative/group of alternatives.

In recognizing the importance of understanding multiple stakeholder objectives in project decision making, many government departments in different countries and researchers worldwide have identified 17 major stakeholder concerns in MIC projects (Li 2013). Some researchers (Li *et al.* 2012b) have adopted a questionnaire approach incorporating a 5-point Likert scale (1 = "least important" and 5 = "most important"), rating, ranking and prioritizing the identified major stakeholder concerns with regard to four different MIC project stakeholder groups (i.e. general public, government departments, pressure groups (Non-Governmental Organizations, NGOs) and other project affected groups). Supplemented by expert knowledge during the follow-up validation interviews, the extremely important concerns of MIC project stakeholders were determined (Table 1). The significant differences among the four stakeholder groups regarding their respective concerns in MIC schemes were also tested. The results indicate that conflict is inevitable as each stakeholder group has its own history, character, gender, culture, values, beliefs, and behaviors that influence its actions and motivation during participation (Li *et al.* 2012b). In view of this, more effort should be directed to establishing a convincing decision approach for balancing the interests of the various stakeholder groups involved as far as possible.

<Insert Table 1 here>

Multi-objective decision-making in a multi-stakeholder context

Difficulties arise in multiple-objective decision-making due to the increased number of individuals/groups involved (Akter and Simonovic 2002) and is also the case for most contemporary decision-making during the development of MIC projects. This is especially due to the increased desire and power of stakeholders (or stakeholder groups) to affect the project implementation according to their own concerns (Atkin and Skitmore 2008; Olander and Landin 2008). Winn and Keller (2001) therefore propose a modeling methodology for corporate decisions of this kind that links multi-attribute decision analysis (that focuses on multi-objective decisions) and the descriptive analysis in the stakeholder literature (that focuses on multi-stakeholder decisions). Three major types of decision-making models applied in the multi-stakeholder multi-objective context have been identified by Greco *et al.*

(2005), including outranking methods (e.g. ELECTRE) (Harrison *et al.* 2008), multi-attribute utility and value theories (e.g. the Analytic Hierarchy Process and Analytic Network Processes) (Lee and Chan 2008) and non-classical approaches (e.g. the Decision Rule Approach) (Pawlak 1998; 2005). Though a number of studies have compared these models according to different criteria (Tsamboulas and Yiotis 1999; De Montis *et al.* 2005), no consensus has yet been reached on a "one-size-fits-all" method and it is impossible to select the "best" applicable method without considering the specific characteristics of the decision problem involved (De Montis *et al.* 2005).

Lee and Chan (2008) adopt the analytic hierarchy process (AHP) to evaluate urban renewal proposals; the accountability of this method and its ability to treat uncertainty, however, are questionable (Tsamboulas and Yiotis 1999). Moreover, the pairwise comparisons involved in AHP require solely expert participation (Lee and Chan 2008) instead of all the interested parties (e.g. the general public, project-affected people and pressure groups) and this goes against the true spirit of public participation, which in emphasizes and respects the rights of all concerned. Time constraints, on the other hand, can be a major concern for the tedious comparing process involved, especially when a large number of criteria or alternatives are present (Lee and Chan 2008). As a non-compensatory aggregation method, ELECTRE II ensures that the poor performance of any one criterion is reflected in the overall performance of the option and has therefore been implemented by Harrison *et al.* (2008) in natural resource management. It is however, criticized as too complicated a method and not easily communicated or understood by non-specialists (Harrison *et al.* 2008). Its implementation in participatory decision-making for MIC projects is, therefore, disputable due to the diverse educational backgrounds and intelligence levels of the participants involved. The decision rule approach was defined by Greco *et al.* (2005) as a process during which the justification of any decision made is based on "*rules*" in the form of "*if [condition], then [decision]*" (e.g.

“if the quality of management is low, then the company has a loss”) (Pawlak 2005). Greco *et al.* (2005) further explain its theoretical background, concluding that both representation and recommendation tasks can be fulfilled by applying the decision rule approach.

It is applicable in the construction project decision-making increases since the result is obtained in a natural way according to the “*rules*” accepted by the decision maker. In ideal participatory activities, such a decision maker can be any stakeholder (or group of stakeholders) involved even with a diversified influence in making project decisions. In this sense, consensus is more likely to be achieved since the process is more convincing and the result is easier to be accepted by all concerned (Tam and Tong 2011). A core issue for effectively and efficiently implementing the decision rule theory is, however, to set the right “*rules*” – comprehensive enough to address multiple objectives while straightforward enough to be understood by multiple stakeholders. Such a dilemma has hindered the adoption of this technique in the construction industry to date. This paper, therefore, explores the potential of modeling multi-stakeholder multi-objective project decisions based on this decision rule approach. Thorough but concise, appropriate “*rules*”, are established for resolving conflict and facilitating consensus during the decision process.

RESEARCH METHODS AND PROCESS

While details of the specific design aspects of the research methods adopted for each stage are explained in later sections (so as to frame them in a more specific and relevant context), this section describes the whole research process and presents a brief overview of the research methodologies employed to achieve the envisaged research aim and objectives. The research study was carried out according to four steps, comprising: (i) model preparation; (ii) model construction; (iii) model demonstration; and (iv) model validation. Various research methods were used to collect and analyze information concerning participatory decision-making both locally and internationally, including a literature review, Delphi, modeling, a case study, a questionnaire survey and a focus group meeting.

Model preparation

An extensive literature review was first conducted on the theories of modeling multi-stakeholder multi-objective decisions during public participation in MIC projects. The Delphi technique was then adopted and a total of 23 experts invited to comment on the roles of the four different stakeholder groups in making project related decisions as detailed later. The Delphi technique allows researchers to maintain significant control over bias in a well-structured, academically-rigorous process using the judgment of qualified experts (Hallowell and Gambatese 2010). As a research method, Delphi is well-suited to handling the open-ended and creative aspects of complex problems by virtue of its multi-dimensional features and potential to capture a wide range of interrelated variables; and its ability to facilitate independent thought (by the experts) and the gradual formation of group solutions while avoiding the pitfalls of face-to-face interaction, such as group conflict and individual dominance (ANVUUR 2008). The Delphi technique has been increasingly applied in construction management research (Sourani and Sohail 2014) and in this study it is conducted to solve the problem of subjectivity in quantifying the influence of different stakeholder groups in MIC project decision making. Through this, a maximum amount of unbiased and objective information is expected to be obtained from the panel of experts.

Model construction

As an important construction management research method, modeling is recommended by Fellows and Liu (2002) to represent a designed or actual object, process or system, or representation of a reality. This is because a model usually shows the inter-relationships between different parameters or variables that are identified and quantified through data collection in surveys (Wong 2006). As a result, a multi-stakeholder multi-objective decision making model was developed based on the decision rule approach. Comprehensive but straightforward "*rules*" were set to quantify the stakeholder influence in project decision-making and prioritize conflicts/consensus between stakeholder group pairings. The steps of the modeling process with the accessible mathematical basis, as detailed later, are also "*rules*" established to cope with the stakeholder conflicts involved, and therefore facilitate the process of consensus building, during public participation in MIC projects.

Since few sophisticated mathematical calculations are required during modeling, Microsoft Excel is utilized instead of other programming platforms such as matrix laboratory (MATLAB). By adopting such plain programming language and an easy-to-use and intuitive programming platform, it is expected that the modeling procedures as well as the results can be more easily communicated or understood by non-specialists (Schumann *et al.* 2010). This is of particular importance for participatory modeling (as detailed in this research) since the educational backgrounds and intelligence levels of the participants involved can be rather diverse.

Model demonstration

The West Kowloon Cultural District (WKCD) project in Hong Kong was selected as an example to demonstrate the application of the developed model. A questionnaire survey was also conducted to investigate the views of the major stakeholder groups regarding three alternative conceptual plan options of WKCD. The survey (including the sampling approach, and respondent profiles) is discussed in detail in the Section ***A questionnaire approach.***

Model validation

Based on the findings of the literature review, a conclusion can be drawn that no similar decision process was designed to cope with multi-stakeholder multi-objective problems in construction management research. It is therefore impossible to validate the developed model using comparative cases employed in previous research. Instead, a focus group meeting was organized in order to confirm the validity of the multi-stakeholder multi-objective decision-making model established in the study (Table 10). A focus group exercise is a dynamic, in-depth and moderated discussion by a group of experts with some shared expertise in, social/cultural experiences of, or concern over an issue/phenomenon (ANVUUR 2008). Though lacking anonymity when compared to alternatives such as surveys, physical interaction involved in focus group exercises allow the moderator to probe issues in depth, address new issues as they arise, and to ask participants to elaborate on their responses. Moreover, interactions can generate more discussion and, therefore, more information. The choice of the focus group method over Delphi technique was based, primarily, on the constraints of time.

PRIORITIZING CONFLICTS/CONSENSUS BETWEEN STAKEHOLDER GROUPS

The influence of different stakeholder groups in making project decisions

In any participatory exercise, there must be a promise that the participants' contribution will affect the decision (IAPP 2007). However, for decisions relating to MIC projects, the degree of influence of different stakeholder groups can be rather diverse. To accurately define such diversified influence levels necessitates the incorporation of a *stakeholder influencing factor*, *SIF*. This comprises two different parts: the *stakeholder attribute value*, *A* (Olander 2007;

Phillips 2003; Post *et al.* 2002; Jawahar and McLaughlin 2001; Mitchell *et al.* 1997); and the *vested interest–impact index*, *ViII* (Olander 2007; Bourne and Walker 2005; Ward and Chapman 2003; Cleland 1999; Ward 1999). Stakeholder attributes include power, *P*, (the stakeholder's power to influence), legitimacy, *L*, (the legitimacy of stakeholder relationships) and urgency, *U*, (the urgency of the stakeholder's claim). The *A* value of a certain stakeholder group can then be assessed by first determining the weight of each attribute and summing the weights of attributes that the group possesses (Olander 2007). Though the influence of any stakeholder group can be assessed by the decision maker through the evaluation of its *A* value, it is also necessary to analyze the probability and level of stakeholder impact involved (Olander 2007). This is the role of the vested interest–impact index, *ViII*, which comprises two parameters: the vested interest level (probability of impact), *v*; and the influence impact level (level of impact), *i*, so that

$$ViII = \sqrt{\frac{v \times i}{25}} \tag{1}$$

both *v* and *i* being measured on a 5-point Likert scale (1 = 'very low' and 5 = 'very high') (Bourne and Walker 2005). The stakeholder influencing factor, *SIF*, is then given by (Olander 2007)

$$SIF = A \times ViII = A \times \sqrt{\frac{v \times i}{25}} \tag{2}$$

A four-round Delphi survey was conducted to investigate the roles of different stakeholder groups in MIC project decision making. By its inherent nature, the Delphi method serves as a self-validating mechanism (Yeung 2007) because individual experts are able to re-assess their scores with reference to the consolidated mean scores as assessed by other experts. As a result, assessors can have a greater flexibility to evaluate stakeholder influence in MIC project decision making without sacrificing its objectiveness and reliability. The success of the

Delphi technique primarily depends on the careful selection of panel members. In this study, 23 experts were purposively chosen based on their theoretical knowledge of, and practical experience in, project decision making related to public participation activities. The eligible participants were expected to have a minimum of three years of working or research experience in the construction and infrastructure-related industries or in relevant disciplines (e.g. decision making in infrastructure and construction projects or urban planning) or have previously been participants in the public participation activities of at least two projects. This helped to identify the views of four main stakeholder groups of: (1) the general public; (2) government departments; (3) pressure groups (NGOs); and (4) other project-affected groups. An agreement was reached among the majority of experts that the three elements (*P*, *L* and *U*) are of equal importance and the weight of each is therefore 1/3. The participants then evaluated (and reevaluated) the vested interest levels, *v*, and the influence impact levels, *i*, of the different stakeholder groups involved on a scale of 1 to 5, where 1 denotes "very low" and 5 denotes "very high". The reassessed mean values were finally calculated for each stakeholder group and the *SIF* obtained through Eq. 2. Table 2 summarizes the results.

<Insert Table 2 here>

Prioritizing conflicts/consensus between stakeholder group pairings

While it is impossible to handle all the conflicts that arise throughout the MIC project life cycle, policy and decision-makers should strive to resolve as many as possible to maximize the chance of project success. One approach to this, as suggested by most experts, is to index stakeholder group influences (conflict based and refer to $SI_{conflict}^{(x,y)}$) as a function of their *SIF* values. This can be done in a pair-wise manner, the index being

$$SI_{conflict}^{(x,y)} = SIF_x \times SIF_y \quad (3)$$

where x and y denote the two stakeholder groups involved.

The existence of a consensus between different pairs of stakeholder groups is quite common (Tam and Tong 2011) but their contribution in building a final consensus among the overall stakeholders can, however, be different since each paired stakeholder groups as a whole plays a different role. An index of paired stakeholder group influence (consensus based and refer to $SI_{consensus}^{(x,y)}$) is therefore also developed combining the stakeholder influencing factors (SIF) as

$$SI_{consensus}^{(x,y)} = SIF_x \times SIF_y \tag{4}$$

In this way, the conflict/consensus based influence of each pair of four stakeholder groups can be calculated and ranked, as shown in Table 3.

<Insert Table 3 here>

DEVELOPING A MULTI-STAKEHOLDER MULTI-OBJECTIVE DECISION MAKING MODEL

The purpose of the participatory decision making approach for both the government and the community is to build a consensus (Ng *et al.* 2012). However, it is impossible to derive a mutually agreed solution among the various stakeholder groups involved unless their conflicting interests are clearly identified and thoroughly analyzed. The model therefore comprises two major parts – conflict analysis and consensus building – resulting in a five-step modeling process. This involves (i) identifying the dominant opinions of different groups towards their major concerns; (ii) quantifying the degree of conflict/consensus between any two groups involved through a conflict function ($F_u^{conflict}(x,y)$) and consensus function ($F_u^{consensus}(x,y)$); (iii) quantifying the acceptance level of any paired groups ($SAI_u^{(x,y)}$) by combining the calculated functions of conflict and consensus; (iv) adjusting the acceptance index ($Adjusted\ SAI_u^{(x,y)}$) between any two groups by taking into account their influence in project decision making ($SI_{conflict}^{(x,y)}$ and $SI_{consensus}^{(x,y)}$); and (v) determining the overall acceptance level of the stakeholders ($SAI_u^{overall\ stakeholders}$) by summing the adjusted acceptance index for each paired stakeholder groups, as described in the next sections.

Conflict analysis

The part of the model that aims to identify conflicts (within a particular stakeholder group and among all the stakeholder groups) is based on Pawlak's (1998; 2005) decision rule approach for conflict analysis. A finite, non-empty set *U* (the *universe*) is first established, with each of its elements being referred to as an *agent* (Pawlak 2005). Three (and only three) standpoints (favorable, neutral and against) of each *agent* towards issue *v* are represented respectively by +1, 0 or –1 (or +, 0, –) through $v: U \rightarrow \{+1,\quad 0,\quad -1\}\ or\ \{+,\quad 0,\quad -\}$ (Pawlak 1998). An alliance relation between any *x* and *y* agents occurs only if they both hold the same opinion, view, voting result, etc., of issue *v* (i.e. $v(x) = v(y)$). Otherwise (i.e. $v(x) \neq v(y)$), the *x* and *y* pair of agents fall into a conflicting relation.

Following Pawlak (1998; 2007), three indices are introduced to explain the decision rules for analyzing conflicts. These comprise: a *strength index* (*STR*) (percentage of agents with the same viewpoint of a fact in one group to all the agents from different groups); a *certainty index* (*CER*) (percentage of agents with the same viewpoint of a fact within a group); and a *coverage index* (*COV*) (percentage of agents with the same viewpoint in one group of all those who have the same viewpoint). This is then expanded to take into account the three standpoints of agents (favorable, neutral and against) to produce nine factors that comprehensively reflect the conflict and/or consensus among agents in one single group and from different groups (Tam *et al.* 2009; Tam and Tong 2011).

Dominant certainty factor and dominant voice of a stakeholder group

When making a multi-stakeholder multi-objective decision, conflicts may exist not only among different stakeholder groups, but also within the same group of stakeholders. It is important to identify the dominant opinions (or beliefs, views, votes, etc.) of a stakeholder group and therefore facilitate the consequent consensus-building process among different stakeholder groups. To achieve this necessitates the use of the certainty index (*CER*) and the three certainty factors, to obtain the percentage of supporting, indifferent and opposing stakeholders of a fact within a group (Table 4). Any of the three kinds of certainty factors (favorability, neutrality and opposition) with a value of more than 0.50 is defined as the dominant certainty factor reflecting the most noticeable view of a stakeholder group towards the fact under consideration. Otherwise (i.e. if none of the three certainty factors has a value of more than 0.50), stakeholder opinions should be reallocated.

<*Insert Table 4 here*>

Conflict function

The conflict function ($F_u^{conflict}(x, y)$) describes the conflicting level between any x and y stakeholder groups towards all their concerns factors involved in a multi-stakeholder multi-objective decision u, as (Pawlak 1998):

$$F_u^{conflict}(x, y) = \frac{Q(x, y)}{N} \tag{5}$$

where $Q_{(x,y)}$ denotes the number of concern factors involved in the decision *u* towards which the stakeholder groups *x* and *y* are in conflict; and N is the total number of concern factors involved in the decision *u*.

This definition, however, ignores the dissimilarity between the two types of conflicts involved in the decision making process between paired stakeholder groups that are in conflict, i.e. (i) one of the two conflicting stakeholder groups holds a dominant view of favorability (or opposition) while the other is neutral; and (ii) the two stakeholder groups are supporters and opponents of the issue under discussion. The degrees of conflict in these two scenarios are different and should not be treated equally when calculating the conflict function. Instead, the degree of conflict involved in the latter case is higher than that in the former: according to Pawlak (1998), the number of concerns (or facts) involved in the decision *u* towards which the two stakeholder groups (x and y) are in conflict of the former kind should be adjusted by multiplying by 50% when calculating the conflict function – suggesting an adjusted conflict function in the form (Pawlak, 1998):

$$\begin{aligned} F_u^{conflict}(x,y) &= \frac{Q(x,y)}{N} \\ &= \frac{[Q_{(x,y)}^{(+,-)} + Q_{(x,y)}^{(-,+)}] + [Q_{(x,y)}^{(0,+)} \times 50\% + Q_{(x,y)}^{(0,-)} \times 50\% + Q_{(x,y)}^{(+,0)} \times 50\% + Q_{(x,y)}^{(-,0)} \times 50\%]}{N} \\ &= \frac{Q_{(x,y)}^{(+,-)} + Q_{(x,y)}^{(-,+)}}{N} + \frac{[Q_{(x,y)}^{(0,+)} \times 50\% + Q_{(x,y)}^{(0,-)} \times 50\% + Q_{(x,y)}^{(+,0)} \times 50\% + Q_{(x,y)}^{(-,0)} \times 50\%]}{N} \end{aligned} \quad (6)$$

where $Q_{(x,y)}^{(+,-)}$ and $Q_{(x,y)}^{(-,+)}$ denote the number of concern factors involved in decision *u* towards which the *x* and *y* stakeholder groups are supporters (or opponents) and opponents (or supporters); and $Q_{(x,y)}^{(0,+)}$, $Q_{(x,y)}^{(0,-)}$, $Q_{(x,y)}^{(+,0)}$ and $Q_{(x,y)}^{(-,0)}$ represent the number of concern factors involved in decision *u* towards which one of the *x* and *y* stakeholder groups holds a dominant view of favorability (or opposition) while the other is neutral.

$\frac{Q_{(x,y)}^{(+,-)}+Q_{(x,y)}^{(-,+)}}{N}$ can be therefore defined as the strong conflict function ($F_u^{strong\ conflict}(x,y)$) while $\frac{Q_{(x,y)}^{(0,+)}\times 50\%+Q_{(x,y)}^{(0,-)}\times 50\%+Q_{(x,y)}^{(+,0)}\times 50\%+Q_{(x,y)}^{(-,0)}\times 50\%}{N}$ is the weak conflict function ($F_u^{weak\ conflict}(x,y)$).

Consensus building

Project decisions cannot be based purely on the degree of stakeholder conflict involved since less conflict does not necessarily win more stakeholder support. Therefore, the allied relations among the stakeholder groups need to be identified, so that an optimal decision can be reached involving both minimum conflict and maximum positive consensus.

Consensus function

The stakeholder groups holding the same dominant view on an issue constitute a coalition concerning that issue. Three categories of coalition can be defined according to the three possible natures (favorable, neutral or against) of the stakeholders' dominant view, including the *supporting coalition* (coalition of the supporters whose consensus is considered by the decision-makers as positive), the *neutral coalition* (coalition of the neutrals whose consensus is considered by the decision-makers as neutral) and the *opposing coalition* (coalition of the opponents whose consensus is considered by the decision-makers as negative). To reveal the degree of consensus between each x and y pair of stakeholder groups towards all their concern factors involved in making a multi-stakeholder multi-objective decision (u), involves the consensus function

$$F_u^{consensus}(x,y)=\frac{P(x,y)}{N} \tag{7}$$

where $P(x,y)$ represents the number of concern factors involved in decision u towards which the stakeholder groups x and y constitute a coalition; and N is the total number of concern factors involved in decision u.

The consensus function can also be described by taking into account the three possible types of coalition that the x and y stakeholder groups may constitute (the supporting coalition, the neutral coalition and the opposing coalition), as

$$F_u^{consensus}(x,y)=\frac{P(x,y)}{N}=\frac{P_{(x,y)}^{+}+P_{(x,y)}^{0}+P_{(x,y)}^{-}}{N}=\frac{P_{(x,y)}^{+}}{N}+\frac{P_{(x,y)}^{0}}{N}+\frac{P_{(x,y)}^{-}}{N} \quad (8)$$

where $P_{(x,y)}^{+}$, $P_{(x,y)}^{0}$ and $P_{(x,y)}^{-}$ denote the number of concern factors involved in decision u towards which the x and y stakeholder groups constitute a supporting, neutral and opposing coalition respectively.

$\frac{P_{(x,y)}^{+}}{N}$, $\frac{P_{(x,y)}^{0}}{N}$ and $\frac{P_{(x,y)}^{-}}{N}$ can be therefore defined as the positive consensus function ($F_u^{positive\ consensus}(x,y)$), the neutral consensus function ($F_u^{neutral\ consensus}(x,y)$) and the negative consensus function ($F_u^{negative\ consensus}(x,y)$).

Index of stakeholder acceptance

Every "right" decision made in a multi-stakeholder multi-objective context should address the diverse needs of all the stakeholder groups as far as possible and be supported by the majority, even if not all, of them. Stakeholder acceptance is especially crucial to the success of MIC projects (Atkin and Skitmore, 2008) and its level can be evaluated by aggregating the degrees of consensus and conflict between each pair of stakeholder groups. An index ($SAI_u^{(x,y)}$) indicating the acceptance level of any x and y stakeholder groups towards all their concern factors in making a multi-stakeholder multi-objective decision u, is therefore established through a combination of their consensus function ($F_u^{consensus}(x,y)$) and conflict function ($F_u^{conflict}(x,y)$), as:

$$SAI_u^{(x,y)} = F_u^{positive\ consensus}(x,y) - F_u^{negative\ consensus}(x,y) - F_u^{conflict}(x,y) \tag{9}$$

where $F_u^{positive\ consensus}(x,y)$ and $F_u^{negative\ consensus}(x,y)$ are the positive and negative consensus functions respectively between the *x* and *y* groups towards decision *u* as defined in Eq. (8); and $F_u^{conflict}(x,y)$ donates the conflict function between the *x* and *y* groups towards decision *u* as defined in Eq. (6).

Any conflict in the attitudes of paired stakeholder groups towards their concern factors related to a project decision, regardless of its kind (strong or weak conflict as defined in Eq. (6)), plays a negative role in winning support from the two stakeholder groups. The existence of a consensus between two stakeholder groups, however, should be treated in different ways according to its nature (supporting, neutral or opposing) when evaluating its contribution in obtaining stakeholder acceptance. In fact, only the supporting coalition and their favorable consensus (if there is any) will add to the degree of support of the two stakeholder groups to the decision. Their neutral consensus (if there is one) contributes nothing while their opposing consensus (if there is one) can affect their acceptance level in a negative manner.

It is inappropriate to assess the overall acceptance level of the stakeholders of a project decision by simply summing up the acceptance index of each paired stakeholder groups since the influence of different stakeholder groups throughout the decision making process can be different (Table 2). Instead, the calculated acceptance index of any *x* and *y* stakeholder groups should be adjusted by taking into account the paired stakeholder group influence index (conflict based) ($SI_{conflict}^{(x,y)}$ as defined in Eq. (3)) and the paired stakeholder group influence index (consensus based) ($SI_{consensus}^{(x,y)}$ as defined in Eq. (4)), through

$$Adjusted\ SAI_u^{(x,y)} = F_u^{positive\ consensus}(x,y) \times SI_{consensus}^{(x,y)} - F_u^{negative\ consensus}(x,y) \times SI_{consensus}^{(x,y)} - F_u^{conflict}(x,y) \times SI_{conflict}^{(x,y)} \quad (10)$$

The overall acceptance level of the stakeholders towards all their concern factors involved in a multi-stakeholder multi-objective decision u can be therefore obtained by summing the adjusted stakeholder acceptance index of each pair of stakeholder groups. Given that the adjusted stakeholder acceptance index of the paired stakeholder groups (x, y) has the same meaning to that of the paired groups (y, x), they should be considered only once when calculating the acceptance level of the overall stakeholders, i.e.:

$$SAI_u^{overall\ stakeholders} = \frac{\sum_{x,y \in M\ and\ x \neq y} Adjusted\ SAI_u^{(x,y)}}{2} \quad (11)$$

where M donates the set of the overall stakeholder groups involved in the decision making process; and $Adjusted\ SAI_u^{(x,y)}$ is the adjusted acceptance index of the x and y stakeholder groups of decision u.

Accordingly, a decision u with a positive overall value of the acceptance index ($SAI_u^{overall\ stakeholders}$ >0) is determined as favorable, with larger values indicating a greater support of the stakeholders. Otherwise, the decision-makers may have to reconsider their decision in order to avoid the failure of the whole project due to insufficient stakeholder support.

A DEMONSTRATION CASE

The West Kowloon Cultural District (WKCD) project was selected as a demonstration case since it is one of the most ambitious projects in the history of Hong Kong, and has been a source of controversy from the first day it was proposed (An *et al.* 2011). In order to make Hong Kong a hub for art and culture in Asia, the Hong Kong Special Administrative Region (HKSAR) Government promulgated a development plan for WKCD in 1998 that included theaters, museums, public parks, shopping malls, and residences (Wu 2006). The project was suspended in 2006 due to strong criticisms from the public of its master plan, which included a costly and enormous "Canopy" design scheme (An *et al.* 2011; Wu 2006). The West Kowloon Cultural District Authority (WKCDA) was established the same year to take over responsibility for developing the project. A three-stage public engagement exercise was organized, through which design proposal A won the most public support and therefore determined the conceptual basis for the WKCD's master plan [An *et al.* 2011; West Kowloon Cultural District Authority (WKCDA) 2010]. However, serious doubts were raised over the credibility of the survey and the criteria for proposal selection (An *et al.* 2011). The established multi-stakeholder multi-objective decision making model was therefore applied to verify whether the design proposal A, of the three alternative conceptual plan options available, performed best in balancing the interests of the diverse stakeholder groups involved.

A questionnaire approach

A structured questionnaire was designed to elicit the views of the major stakeholder groups of the three alternative conceptual plan options of WKCD (i.e. the design proposals A, B and C). Three options ("+", "0" or "–") were available representing the respondents' attitudes (favorable, neutral or opposing) towards the performance of the WKCD conceptual plans on each major stakeholder concern factor (Table 1). The original version of the questionnaire was fine-tuned through a pilot test with seven potential respondents from four different stakeholder groups (i.e. general public, government departments, pressure groups and project affected groups), all purposively chosen according to their familiarity with the WKCD project. The major revision from this was the elimination of the five major stakeholder concern factors, which, according to the experts, were inapplicable to WKCD. These are: "F2:

Availability of local job opportunities", "F3: Economic benefits to government and local citizens" and "F5: Value-for-money of the proposed project(s)" (since the information related to the economic impact of the conceptual plan options of WKCD was not made publicly available), "F15: Conservation of local cultural and historical heritage" (since there are no cultural or historical heritage features within the WKCD site) and "F16: Compensation and relocation plan/strategy" (since no relocation is involved when developing the WKCD project).

To ensure the usefulness and reliability of the survey findings, different sampling approaches were adopted and most of the respondents from government departments, project-affected groups and pressure groups were selected for purposive sampling. With the exception of members of the general public, who were chosen randomly, the key criteria for selecting the respondents were their familiarity with WKCD or other similar infrastructure/city planning projects and their theoretical knowledge of, and practical experience in, the existing public participation process in Hong Kong or mainland China – potential respondents are expected have a minimum of two years of working or research experience in construction and infrastructure-related industries or in relevant disciplines or have previously been involved in the WKCD project or in the participatory exercises of other MIC projects. As a result, a total of 242 completed and valid responses were obtained by means of mail, email and fax or through street survey, of which 74 were from the general public, followed by 62 from project affected groups, 55 from government departments and 51 from pressure groups. They evaluated the extent to which the three conceptual plan options of WKCD address the various stakeholder concerns.

To better understand the voting distribution within a single stakeholder group and among different stakeholder groups necessitates the calculation of the nine factors identified by Tam *et al.* (2009), Tam and Tong (2011) and Pawlak (2005; 1998). More importantly, the three certainty factors (favorability, neutrality and opposition) help to reveal the dominant opinions of different stakeholder groups (Table 6), according to which the conflict function ($F_u^{conflict}(x, y)$) and the consensus function ($F_u^{consensus}(x, y)$) of each paired stakeholder group were identified for the three WKCD design alternatives through Eq. 6 and Eq. 8 respectively. Tables 5, 7 and 8 summarize the results for the design proposal A.

<Insert Tables 5, 6, 7 and 8 here>

The acceptance index ($SAI_u^{(x,y)}$) for each pair of stakeholder groups and its adjusted value ($Adjusted\ SAI_u^{(x,y)}$) were obtained by combining the calculated conflict and consensus functions and taking into account the paired stakeholder group influence index (conflict or consensus based) ($SI_{conflict}^{(x,y)}$ or $SI_{consensus}^{(x,y)}$) through Eq. (9) and Eq. (10). By summing the adjusted acceptance index of each paired stakeholder group, the acceptance level of the overall stakeholders towards all their concerns in each conceptual plan option of WKCD were finally determined, as shown in Table 9.

<Insert Table 9 here>

Result analysis

The three conceptual plan options for WKCD, i.e. the design proposals A, B and C, provided overall stakeholder acceptance indices of 0.446, -0.304 and -0.519 respectively, indicating that design proposal A performs much better than the two other alternatives in addressing stakeholder concerns and balancing stakeholder interests. For the proposal A, only the paired groups of general public and pressure groups had a negative adjusted stakeholder acceptance index (–0.006 as shown in Table 9), with conflicts existing in the concerns of i, iv, vi, vii and viii (Table 8). Facilitating the communication between these two groups towards their conflicting concern factors therefore becomes the major task for not only the decision makers but also the other stakeholder groups to ensure the project is delivered in a smooth and satisfactory way.

MODEL VALIDATION AND DISCUSSION

In order to confirm the validity of the multi-stakeholder multi-objective decision-making model developed in this study, a focus group exercise was convened with members from the government, general public, project affected groups, private sector, academia and NGOs respectively (Table 10). The panel of experts was selected based on two main criteria comprising: (i) the experts having a minimum of five years of working or research experience in the construction and infrastructure-related industries or in relevant disciplines or have previously been involved in the participatory exercise of at least two MIC projects; and (ii) the experts not having contributed to the development of the multi-stakeholder multi-objective decision-making model. The experts' diverse backgrounds and solid working/research experience contributed to enhancing the validity of the focus group meeting outputs. To facilitate and expedite the focus group process, each panel member was sent a package of information in advance that included an overview of the context and methodological design of the study, initial findings from the empirical research and how these feed into the model, as well as a description of the model. The session lasted two and a half hours and was well structured with a set of discussion guidelines. In the end, each expert was asked to assess the model against the four criteria of transparency, simplicity, robustness and accountability, according to a scoring scale of 1 to 5, where 1 denotes "poor" and 5 denotes "excellent". In fact, some researchers have compared multiple multi-stakeholder multi-objective models according to different aspects and the above criteria adopted in this study were selected based on the findings of De Montis *et al.* (2005) and Tsamboulas and

Yiotis (1999). The specific characteristics of the decision problem under discussion (e.g. the social-political context in Hong Kong and mainland China, traditional conservative Chinese, etc.) also determined the choice. All panel members also provided feedback on the reasons for their ratings and their comments, views and suggestions were recorded and transcribed for qualitative analysis.

<Insert Table 10 here>

The assessments of the panel members are presented in Table 11. All items were highly rated (above 3.5), confirming the transparency, simplicity, robustness and accountability of the model.

<Insert Table 11 here>

A recurring problem highlighted in the research was that of a significant divergence of views among the various stakeholder groups, even among the individuals from the same stakeholder group, towards their concerns over project decisions in the multi-stakeholder multi-objective context. This phenomenon, as noted by the government representatives, is common in a territory such as Hong Kong, which is prone to accumulate conflicts of all kinds due to limited/scarce land resources and the diverse/changing demands of its sophisticated community for both rapid economic growth and sustainable city development. It is, however, not solely a Chinese problem, since conflict grows out of the mismatch of the histories, characters, genders, cultures, values, beliefs, and behaviors of different stakeholder groups (Randeree and Faramawy 2011) rather than ideological clashes between East and West.

Members of the general public, project-affected groups and pressure groups (e.g. NGOs), on the other hand, criticized the decision maker(s) as sometimes simply ignoring the conflicting stakeholder interests or dealing with them in an autocratic manner. Although this may on the surface accelerate the project delivery process, it is inadvisable due to (1) the growing tendency of stakeholder groups to try to influence the implementation of MIC projects in accordance with their individual concerns and needs (Olander and Landin 2008) and (2) their increased power, which can halt a whole project (Atkin and Skitmore 2008). To avoid this necessitates the implementation of public engagement mechanisms through which other stakeholder groups (the general public/end-users; pressure groups such as the NGOs and mass media; and project affected groups) in addition to the government can positively contribute to project decisions. Meanwhile, the representatives of academia recommended that each stakeholder group needs to maintain an effective dialogue with their counterparts in a respectful and inclusive way during the decision process, as a consensus cannot be reached among diverse parties if their own interests are overemphasized.

The multi-stakeholder multi-objective decision-making model developed from the study allows such co-determination throughout the course of MIC projects. This, as observed by a government representative, copes better with real world situations and helps to relieve the tension between government and society by improving the openness, transparency and accountability of the decision-making process and therefore corresponds with the philosophy of the government to maintain a harmonious society. A policy advisor of a provincial bureau further pointed out that other than prioritizing different project proposals, the model has identified the major conflicts involved and therefore points to the direction of government's future work in realizing the optimal project concept. The general public and pressure groups (such as NGOs and mass media), on the other hand, are more willing to participate and accept the results since the decision-making process is concise, transparent and convincing. More importantly, the established model is well structured and easy to follow since it uses straightforward mathematical approximations to represent reality. The academia contingent highly valued the ability of the developed model to provide a well-defined methodological representation of complex real-world decision situations, e.g. its performance in treating a large number of projects/criteria as compared to the commonly used analytical hierarchy process (AHP), which in practice is very difficult for the decision maker to compare numerous pairwise criteria in a consistent way. In addition, the decision rule approach, when modeling multi-stakeholder multi-objective decisions, offers the closest to a human rational approach to decision analysis and therefore performs well in encouraging different interest groups with diverse educational backgrounds and intelligence levels to contribute to the decision process. This is clearly in line with the true spirit of public participation in emphasizing and respecting the rights of all concerned. In addition, all the academic representatives intimated that the overall modeling methodologies are suitable for international implementation when coping with multi-stakeholder multi-objective decision problems. An exception are some detailed issues that require attention when applied in different social-political-cultural contexts, i.e. the applicability of and the priority levels attached to various stakeholder concerns and the influence of different stakeholder groups in MIC project decision making. Members of pressure groups, on the other hand, worried that it is still a challenge to encourage the silent majority (i.e. the general public) to take part in any participatory decision activities in Eastern societies such as Hong Kong and mainland China, where a traditional culture of compliance prevails. Instead, they believe that more thought is still needed in finding ways to balance the composition of participants to prevent the decision being hijacked by certain political groups.

As perhaps the only sufferer when delivering a MIC project, the project-affected group representatives considered the modeling approach to be an important channel through which their grievances and social and environmental concerns could be better heard and understood. They favor the concept of participatory decision-making and co-determination delivered from the model. They also find it easier to accept the results due to the changed role of the previous executors who negatively cooperate with, and support the government in, the implementation of projects by the current co-decision-makers. This appears to be true even if their influence in making project decisions is different (Table 2) and the government remains the highest authority. A core issue is the standard according to which a project decision is made, i.e. considering the benefits and costs involved from a multi-stakeholder perspective, and in a comprehensive and thorough manner.

CONCLUSIONS

The Central Government of China and the Hong Kong Special Administrative Region (HKSAR) Government are moving towards a more transparent, democratic and comprehensive participatory decision making process to cope with the rapid increase in MIC projects. Simultaneously, there are increasing expectations of social equality and an enlarged influence of stakeholder groups other than the government in making project decisions can be expected. It is important, therefore, to ensure the any consensus reached emphasizes and respects the rights of all concerned.

In this research, numerous decision models previously developed are critically reviewed and, for various reasons, their applicability in the decision process during stakeholder participation in contemporary MIC projects is still in question. The decision rule approach, however, offers the closest to a human rational approach to decision analysis and therefore performs well in encouraging different interest groups with diverse educational backgrounds and intelligence levels to contribute to decision process/outcomes. This technique therefore served as theoretical basis for modeling complicated multi-stakeholder multi-objective project decisions. Thorough but concise appropriate "*rules*", are set accordingly to quantify the stakeholder influence in project decision-making and prioritize conflicts/consensus between stakeholder group pairings. Modeling procedures with the accessible mathematical basis are also "*rules*" established to cope with the stakeholder conflicts involved, and therefore facilitate the process of consensus building, during public participation in MIC projects. The major modeling steps comprise: (i) identifying the dominant opinions of different groups of their major concerns; (ii) quantifying the degree of conflict/consensus between any two groups involved through a conflict function ($F_u^{conflict}(x, y)$) and consensus function ($F_u^{consensus}(x, y)$); (iii) quantifying the acceptance level of any paired groups ($SAI_u^{(x,y)}$) by combining the calculated functions of conflict and consensus; (iv) adjusting the acceptance index ($Adjusted\ SAI_u^{(x,y)}$) between any two groups by taking into account of their influence in project decision making ($SI_{conflict}^{(x,y)}$ and $SI_{consensus}^{(x,y)}$); and (v) determining the overall acceptance level of the stakeholders ($SAI_u^{overall\ stakeholders}$) by summing the adjusted acceptance index for each paired stakeholder group.

The model was finally validated through a focus meeting exercise and by representatives from the government, general public, project-affected groups, private sector, academia and NGOs. The results indicate the satisfactory performance of the model in the multi-stakeholder multi-objective context of MIC projects, with regard to criteria of transparency, simplicity, robustness and accountability. It is also confirmed that the overall modeling methodologies are suitable for both local and international application when facing complicated decision problems involving multiple stakeholders with various concerns. Some issues however need attention when applied in different social-political contexts, e.g. the influence of different stakeholder groups in MIC project decision making. The influencing factors of the Chinese stakeholder groups (Table 2) may differ from those with different social-political backgrounds such as in the US and UK. Moreover, the cultural differences between the east and the west also determine the quality of the decision process/outcome. In Eastern societies such as Hong Kong and mainland China, where a traditional culture of compliance prevails, it is still a challenge to encourage the silent majority to take part in any participatory decision activities. On the other hand, the maturity of group decision practice in some Western countries may be attributed to a more liberal culture. In view of this, it would be interesting to further explore the impact of different social-political-cultural contexts on the participatory decision process/outcome, especially with the growing globalization of the engineering and construction industries and the increasing cultural integration between East and West.

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Table 1 Extremely important concerns of MIC project stakeholders

Group		***Extremely Important Stakeholder Concerns***
General Public	F8.	Availability of amenities, community and welfare facilities and provision of public open spaces
	F6.	Access to work and locations of activities
	F2.	Availability of local job opportunities
Government Departments	F3.	Economic benefits to government and local citizens
	F1.	Adaptability of development to the changing needs
	F4.	Harmonious development of different local economic activities
	F16.	Compensation and relocation plan/strategy
Pressure groups	F10.	Green and sustainable design and construction
	F5.	Value-for-money of the proposed project(s)
	F15.	Conservation of local cultural and historical heritage
Project Affected Groups	F16.	Compensation and relocation plan/strategy
	F12.	Building design in terms of aesthetics, density, height and visual permeability
	F14.	Unique local characteristics
	F7.	Creation of a safe, convenient, comfortable and legible pedestrian circulation and transport network

(Li *et al.*, 2012b)

Table 2: Influence of different stakeholder groups in MIC project decision making

Stakeholder groups	***Attributes***			***Stakeholders' influence***				
	Power (P)	*Legitimacy (L)*	*Urgency (U)*	*Stakeholder attribute value (A)*	*Mean value of the vested interest levels (v)*	*Mean value of the influence impact levels (i)*	*The vested interest–impact index (ViII)*	*Stakeholder influencing factor (SIF)*
General public		1/3	1/3	2/3	3.565	3.696	0.726	0.484
Government departments	1/3	1/3	1/3	1	4.696	4.826	0.952	0.952
Pressure groups (NGOs)		1/3		1/3	3.783	2.609	0.628	0.209
Project affected groups		1/3	1/3	2/3	4.826	2.826	0.739	0.493

Table 3: Prioritization of conflicts/consensuses between each two stakeholder groups

Conflicts/consensuses between each two stakeholder groups	***Stakeholder influencing factor***				***Paired stakeholder group influence (conflict/consensus based)***	***Rank***
	General public	*Government departments*	*Pressure groups*	*Project affected groups*		
Between general public and government department	0.484	0.952			0.461	2
Between general public and pressure groups	0.484		0.209		0.101	6
Between general public and project affected groups	0.484			0.493	0.239	3
Between government department and pressure groups		0.952	0.209		0.199	4
Between government department and project affected groups		0.952		0.493	0.469	1
Between pressure groups and project affected groups			0.209	0.493	0.103	5

Table 4: Certainty index (CER) reflecting stakeholder conflict and/or consensus

Viewpoints of agent / ***Indices***	***Favorable (+)***	***Neutral (0)***	***Opposing (–)***
Certainty (CER)	Favorability certainty factor, i.e.: $CER_v^+(G_j) = \frac{O_v^+(G_j)}{M(G_j)}$ where $CER_v^+(G_j)$ stands for the favorability certainty factor of agents in group *j* for the discussed issue *v*; $O_v^+(G_j)$ means the number of agents holding the favorable opinion in group *j* towards the discussed issue *v*; and $M(G_j)$ is the number of agents from group *j*.	Neutrality certainty factor, i.e.: $CER_v^0(G_j) = \frac{O_v^0(G_j)}{M(G_j)}$ where $CER_v^0(G_j)$ stands for the neutrality certainty factor of agents in group *j* for the discussed issue *v*; $O_v^0(G_j)$ means the number of agents holding the neutral opinion in group *j* towards the discussed issue *v*; and $M(G_j)$ is the number of agents from group *j*.	Opposition certainty factor, i.e.: $CER_v^-(G_j) = \frac{O_v^-(G_j)}{M(G_j)}$ where $CER_v^-(G_j)$ stands for the opposition certainty factor of agents in group *j* for the discussed issue *v*; $O_v^-(G_j)$ means the number of agents holding the opposing opinion in group *j* towards the discussed issue *v*; and $M(G_j)$ is the number of agents from group *j*.

(Tam *et al.*, 2009; Tam and Tong, 2011; Pawlak, 2005; 1998)

Table 5: The views of project stakeholders towards the design proposal A

Extremely important concerns of MIC project stakeholders		***General public***			***Government department***			***Pressure groups***			***Project affected groups***		
		Favorable (+)	*Neutral (0)*	*Opposing (–)*	*Favorable (+)*	*Neutral (0)*	*Opposing (–)*	*Favorable (+)*	*Neutral (0)*	*Opposing (–)*	*Favorable (+)*	*Neutral (0)*	*Opposing (–)*
i)	Adaptability of development to the changing needs	30	4	40	52	3	0	13	30	8	39	11	12
ii)	Harmonious development of different local economic activities	51	6	17	48	1	6	37	8	6	36	18	8
iii)	Access to work and locations of activities	19	40	15	42	3	10	15	26	10	41	2	19
iv)	Creation of a safe, convenient, comfortable and legible pedestrian circulation and transport network	39	10	25	31	4	20	13	29	9	15	36	11
v)	Availability of amenities, community and welfare facilities and provision of public open space	51	16	7	49	4	2	33	10	8	43	12	7
vi)	Green and sustainable design and construction	49	20	5	51	1	3	12	31	8	33	8	21
vii)	Building design in terms of aesthetics, density, height and visual permeability	24	41	9	37	5	13	27	2	22	33	3	26
viii)	Unique local characters	14	21	39	10	31	14	8	29	14	10	38	14

Table 6: Dominant opinions of different stakeholder groups toward each concern factor involved in the three alternative conceptual plan options

Extremely important concerns of MIC project stakeholders	***Design Proposal A***				***Design Proposal B***				***Design Proposal C***			
	General public	*Government department*	*Pressure groups*	*Project affected groups*	*General public*	*Government department*	*Pressure groups*	*Project affected groups*	*General public*	*Government department*	*Pressure groups*	*Project affected groups*
i) Adaptability of development to the changing needs	–	+	0	+	+	–	+	–	0	–	0	–
ii) Harmonious development of different local economic activities	+	+	+	+	+	+	–	0	–	–	0	0
iii) Access to work and locations of activities	0	+	0	+	0	0	0	+	0	0	–	0
iv) Creation of a safe, convenient, comfortable and legible pedestrian circulation and transport network	+	+	0	0	+	–	0	0	–	0	–	0
v) Availability of amenities, community and welfare facilities and provision of public open space	+	+	+	+	+	+	0	+	–	0	–	0
vi) Green and sustainable design and construction	+	+	0	+	+	+	0	0	0	–	–	–
vii) Building design in terms of aesthetics, density, height and visual permeability	0	+	+	+	+	+	0	0	+	0	–	0
viii) Unique local characters	–	0	0	0	+	0	0	+	+	+	0	+

Table 7: Factors reflecting stakeholders' voting distribution in the design proposal A

Extremely important concerns of MIC project stakeholders			*General public*			*Government department*			*Pressure groups*			*Project affected groups*		
			Favorable (+)	*Neutral (0)*	*Opposing (–)*	*Favorable (+)*	*Neutral (0)*	*Opposing (–)*	*Favorable (+)*	*Neutral (0)*	*Opposing (–)*	*Favorable (+)*	*Neutral (0)*	*Opposing (–)*
i)	Adaptability of development to the changing needs	Strength	0.124	0.017	0.165	0.215	0.012	0.000	0.054	0.124	0.033	0.161	0.045	0.050
		Certainty	0.405	0.054	***0.541***	***0.945***	0.055	0.000	0.255	***0.588***	0.157	***0.629***	0.177	0.194
		Coverage	0.224	0.083	0.667	0.388	0.063	0.000	0.097	0.625	0.133	0.291	0.229	0.200
ii)	Harmonious development of different local economic activities	Strength	0.211	0.025	0.070	0.198	0.004	0.025	0.153	0.033	0.025	0.149	0.074	0.033
		Certainty	***0.689***	0.081	0.230	***0.873***	0.018	0.109	***0.725***	0.157	0.118	***0.581***	0.290	0.129
		Coverage	0.297	0.182	0.459	0.279	0.030	0.162	0.215	0.242	0.162	0.209	0.545	0.216
iii)	Access to work and locations of activities	Strength	0.079	0.165	0.062	0.174	0.012	0.041	0.062	0.107	0.041	0.169	0.008	0.079
		Certainty	0.257	***0.541***	0.203	***0.764***	0.055	0.182	0.294	***0.510***	0.196	***0.661***	0.032	0.306
		Coverage	0.162	0.563	0.278	0.359	0.042	0.185	0.128	0.366	0.185	0.350	0.028	0.352
iv)	Creation of a safe, convenient, comfortable and legible pedestrian circulation and transport network	Strength	0.161	0.041	0.103	0.128	0.017	0.083	0.054	0.120	0.037	0.062	0.149	0.045
		Certainty	***0.527***	0.135	0.338	***0.564***	0.073	0.364	0.255	***0.569***	0.176	0.242	***0.581***	0.177
		Coverage	0.398	0.127	0.385	0.316	0.051	0.308	0.133	0.367	0.138	0.153	0.456	0.169
v)	Availability of amenities, community and welfare facilities and provision of public open space	Strength	0.211	0.066	0.029	0.202	0.017	0.008	0.136	0.041	0.033	0.178	0.050	0.029
		Certainty	***0.689***	0.216	0.095	***0.891***	0.073	0.036	***0.647***	0.196	0.157	***0.694***	0.194	0.113

		Coverage	0.290	0.381	0.292	0.278	0.095	0.083	0.188	0.238	0.333	0.244	0.286	0.292
vi)	Green and sustainable design and construction	Strength	0.202	0.083	0.021	0.211	0.004	0.012	0.050	0.128	0.033	0.136	0.033	0.087
		Certainty	***0.662***	0.270	0.068	***0.927***	0.018	0.055	0.235	***0.608***	0.157	***0.532***	0.129	0.339
		Coverage	0.338	0.333	0.135	0.352	0.017	0.081	0.083	0.517	0.216	0.228	0.133	0.568
vii)	Building design in terms of aesthetics, density, height and visual permeability	Strength	0.099	0.169	0.037	0.153	0.021	0.054	0.112	0.008	0.091	0.136	0.012	0.107
		Certainty	0.324	***0.554***	0.122	***0.673***	0.091	0.236	***0.529***	0.039	0.431	***0.532***	0.048	0.419
		Coverage	0.198	0.804	0.129	0.306	0.098	0.186	0.223	0.039	0.314	0.273	0.059	0.371
viii)	Unique local characters	Strength	0.058	0.087	0.161	0.041	0.128	0.058	0.033	0.120	0.058	0.041	0.157	0.058
		Certainty	0.189	0.284	***0.527***	0.182	***0.564***	0.255	0.157	***0.569***	0.275	0.161	***0.613***	0.226
		Coverage	0.333	0.176	0.481	0.238	0.261	0.173	0.190	0.244	0.173	0.238	0.319	0.173

Table 8: ***Consensus function and conflict function for the design proposal A***

Paired stakeholder groups	***Positive consensus***	***Positive consensus function***	***Neutral consensus***	***Neutral consensus function***	***Negative consensus***	***Negative consensus function***	***Strong conflict***	***Strong conflict function***	***Weak conflict***	***Weak conflict function***
General public *vs*. government department	ii, iv, v, vi	0.500	N/A	0.000	N/A	0.000	i	0.125	iii, vii, viii	0.188
General public *vs*. pressure groups	ii, v	0.250	iii	0.125	N/A	0.000	N/A	0.000	i, iv, vi, vii, viii	0.313
General public *vs*. project affected groups	ii, v, vi	0.375	N/A	0.000	N/A	0.000	i	0.125	iii, iv, vii, viii	0.250
Government department *vs*. pressure groups	ii, v, vii	0.375	viii	0.125	N/A	0.000	N/A	0.000	i, iii, iv, vi	0.250
Government department *vs*. project affected groups	i, ii, iii, v, vi, vii	0.750	viii	0.125	N/A	0.000	N/A	0.000	iv	0.063
Pressure groups *vs*. project affected groups	ii, v, vii	0.375	iv, viii	0.250	N/A	0.000	N/A	0.000	i, iii, vi	0.188

Table 9: Stakeholder acceptance index and its adjusted value of the three design proposals for WKCD

Paired stakeholder groups	***Design Proposal A***			***Design Proposal B***			***Design Proposal C***		
	Stakeholder acceptance index	*Paired stakeholder group influence index*	*Adjusted stakeholder acceptance index*	*Stakeholder acceptance index*	*Paired stakeholder group influence index*	*Adjusted stakeholder acceptance index*	*Stakeholder acceptance index*	*Paired stakeholder group influence index*	*Adjusted stakeholder acceptance index*
General public *vs*. government department	0.187	0.461	0.086	0.187	0.461	0.086	–0.313	0.461	-0.144
General public *vs*. pressure groups	–0.063	0.101	-0.006	–0.313	0.101	-0.032	–0.625	0.101	-0.063
General public *vs*. project affected groups	0.000	0.239	0.000	–0.188	0.239	-0.045	–0.250	0.239	-0.060
Government department *vs*. pressure groups	0.125	0.199	0.025	–0.500	0.199	-0.100	–0.563	0.199	-0.112
Government department *vs*. project affected groups	0.687	0.469	0.322	–0.375	0.469	-0.176	–0.188	0.469	-0.088
Pressure groups *vs*. project affected groups	0.187	0.103	0.019	–0.375	0.103	-0.039	–0.500	0.103	-0.052

Overall stakeholders	0.446	-0.304	-0.519
Ranking	1	2	3

Table 10 Profiles of the focus group members for model validation

Group	***No.***	***Position***	***Organization***
Government Departments	V01	Policy Advisor	Provincial Bureau
	V02	Deputy Secretary-general	Municipal Bureau
	V03	Deputy Director	Municipal Commission
General Public	V04	The Lay Public	N.A.
	V05	The Lay Public	N.A.
	V06	The Lay Public	N.A.
Project Affected Groups	V07	Project affected people	N.A.
	V08	Project affected people	N.A.
	V09	Project affected people	N.A.
Private Sector	V10	Engineering Director	Construction Company
	V11	General Manager	Real Estate Corporation
Professional Organizations / Universities	V12	Associate Professor	Educational Institution
	V13	Senior Research Fellow	Educational Institution
	V14	Director	Research Center
Pressure Groups (NGOs)	V15	Member	NGO
	V16	Executive Director	NGO
	V17	Director	Environmental Group

Table 11 Validation results

Criteria	***Panel Members***																	***Mean Ratings***
	Government Departments			***General Public***			***Project Affected Groups***			***Private Sector***		***Academia***			***Pressure Groups (NGOs)***			
	V01	V02	V03	V04	V05	V06	V07	V08	V09	V10	V11	V12	V13	V14	V15	V16	V17	
Transparency	4	3	5	4	3	5	3	4	5	3	4	3	3	5	3	3	5	3.82
Simplicity	4	4	3	4	4	5	3	3	5	4	3	5	5	4	4	4	4	4.00
Robustness	4	5	4	4	3	4	3	4	3	4	3	3	4	5	2	4	4	3.71
Accountability	3	4	4	5	3	4	4	4	4	3	5	4	5	5	4	3	3	3.94