Title: Dynamic network analysis of stakeholder conflicts in megaprojects: a sixteen-year case of Hong Kong-Zhuhai-Macao Bridge

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Abstract

The stakeholder conflicts are hardly avoided in the implementation of the megaprojects due to the diverse interests and aims among stakeholders. The previous study does not provide much evidence on dynamic patterns of stakeholder conflicts in the project duration from the planning to the construction and handover stage. Therefore, this study established a network-based framework to analyze the dynamics of stakeholder conflicts by detecting the critical conflicts and the affected relationships among stakeholders, with a 16-year case study of Hong Kong – Zhuhai – Macao Bridge project. Finally, the stakeholder-conflict map was proposed to provide the management strategies considering the conflict criticalness and stakeholder participation of each stakeholder conflict. After reviewing 1748 official documents from 2003 to 2018, the chronological feature of environmental conflicts, neighboring conflicts, and traditional conflicts are detected. The changes of stakeholder relationships in the project duration are discussed by five stakeholder groups: local industry, green group, supervision group, construction group, and governmental organizations. The "Mirror Z" strategies of stakeholder conflicts are proposed in the phase of planning, construction, and handover, respectively.

1. Introduction

Conflict is defined as "expressed struggle between at least two interdependent parties who perceive incompatible goals, scarce resources, and interference from others which prevents them from achieving their goals"(Oetzel and Ting-Toomey, 2006, Jia et al., 2011). Whereas project stakeholders are defined as direct participants and affected groups of the construction projects(Guide, 2001), which could be divided into internal and external groups. Internal stakeholders (owners, contractors, suppliers) directly involve the project

implementation, while external stakeholders (local community, general public, local authority) are affected by project activities(Atkin and Skitmore, 2008). Conflicts are hardly evaded in the implementation of megaprojects due to the divergent interests and aims of the involved stakeholders(De Dreu and Weingart, 2003, Wei et al., 2016). Also, these stakeholder conflicts have caused significant losses in various stages of megaprojects(Jia et al., 2011), which calls for the longitudinal studies to detect dynamic patterns of stakeholder conflicts in the project duration. For instance, in the planning stage, the stakeholder conflicts occurred in Western bypass route (Route 29) in the USA, causing the project defunded(Doyle, 2016). In the pre-contract stage, the stakeholder conflicts caused by contract negotiations was a critical factor of project delays in large international construction projects in Vietnam(Maemura et al., 2018). In the construction stage, external stakeholder conflicts have led average delay of 3.6 years and cost overruns of 290 percent in large construction projects in Korea (Lee et al., 2017). Generally, the stakeholder conflict research is based on the integration of two classical knowledge domains: conflict management and stakeholder management.

Conflict management research has been synergized with contract management, value management, and dispute management research in the construction industry(Leung et al., 2013, Ng et al., 2007, Ock and Han, 2003) since the conflicts are unavoidable in the construction projects. The existing studies have proved the inter-organizational and inter-personal conflicts significantly affect the performance of construction projects(Wu et al., 2017, Zhang and Huo, 2015). Nevertheless, the previous studies on project conflicts show the general patterns of organizations and lacking the consideration of stakeholder divergencies(Li et al., 2012). Conflicts occur due to the contradictions of diverse interests among numerous stakeholder groups in the development of megaprojects(Mok et al., 2015). Thus, it is essential to understand the conflicts from the perspectives of stakeholders. As the megaprojects are long-term and complicated(Kardes et al., 2013),

identifying the dynamic patterns of the occurrence and escalation of conflicts is essential for decision-makers to manage conflicts during the project implementation(Ng et al., 2007). However, a study on the dynamics of stakeholder conflicts in different stages of megaprojects is still missing due to the lack of longitudinal empirical evidence to reflect the dynamic patterns in the view of various stakeholders.

Since conflict is introduced as the collision of stakeholder interests, the conflict analysis has become a critical component in the domain of stakeholder management as explained in the proposed framework of Yang and Shen (2015). Besides, as conflicts influence stakeholder relationships, it is essential to identify and manage conflicts from stakeholder perspectives. Social Network Analysis (SNA) has been used in many pieces of research to analyze the stakeholder and its associated issues by providing a comprehensive tool to reflect stakeholder patterns(Mok et al., 2015). Although SNA is widely applied in the project management for stakeholder analysis (Li et al., 2016a, Yu et al., 2017), few dynamic SNA studies are conducted in the construction projects due to the data applicability, as most data is collected via questionnaire surveys within a given time frame which besets presenting its dynamics(Mok et al., 2017b). Therefore, it is still challenging to explore the dynamics of stakeholder conflicts by using the SNA technique.

Under these circumstances, the purpose of this paper is to provide a method to measure the stakeholder conflicts and to present the management guide towards the conflicts in the dynamic project environment. In details, it intends to explore answers to three research questions. First, what the dynamics of critical stakeholder conflicts is. Second, how the stakeholder relationships are affected by the changeable conflicts. Third, how to manage the stakeholder conflicts in the dynamic project environment. To answer the questions, the study proposes the network-based framework to reveal the dynamics of critical conflict issues and their affected stakeholder relationships and to map the stakeholder conflicts for presenting management strategies

78 in different project phases. A case of Hong Kong-Zhuhai-Macao Bridge (HZMB) was presented to validate
79 the effectiveness of the proposed method with 1748 official documents from 2003 to 2018, including the
80 planning, construction, and the handover stage. The findings were discussed to show the dynamics of the
81 interactions between conflicts and stakeholders in the development of the megaprojects.

82 **2. Research background**

83 **2.1 Stakeholder conflicts**

84 In Freeman's strategy model, conflicts occur when the disagreements exist among stakeholders, which may
85 damage the strength of the stakeholder relationship(Freeman, 1984). However, the conflicts should not be just
86 considered as negative phenomenon as they might be opportunities if well resolved(Abma, 2000). Therefore,
87 analyzing the conflicts among stakeholders is one of the critical success factors for effective stakeholder
88 management in the construction projects(Yang et al., 2010). Hence, conflicts can be defined as the mutual
89 interactions among project stakeholders with divergent views on project aims, as a form of inter-organizational
90 conflicts in the construction projects(Guang-dong, 2013). Conflicts are furtherly grouped into two major
91 groups: collaborative conflicts with common goals and competitive conflicts with contradictive objectives
92 among stakeholders(Hempel et al., 2009). As most internal stakeholders (consultants, contractors, suppliers)
93 are contracting parties with the shared goals to achieve project success(Wu et al., 2018), the collaborative
94 conflict frequently occurs when the perception of tasks are varied among various stakeholders in
95 megaprojects(Wu et al., 2017), which requires stakeholders to discuss the conflicts cooperatively to address
96 the common concerns(Wong et al., 1999). However, competitive conflicts still occur among several external
97 stakeholders (i.e. residents, general public, civic groups) with strong oppositions on the construction
98 projects(Zhou et al., 2019, Li et al., 2016b, Lee et al., 2017). Causes of stakeholder conflicts varies from the

size and the duration of the project, dynamic project environment, lack of communication, distrust, limited resources, financial and labor issues(Harmon, 2003). As consequences, the stakeholder conflicts often lead to a series of the negative performance, including cost and time overrun, quality incidents and lower level of the stakeholder satisfaction(Wu et al., 2018, Kumaraswamy, 1998). These calls for collaborative efforts among stakeholders to seek efficient conflict management strategies to improve the project performance. There are several generic management strategies for stakeholders' conflict management based on the level of assertiveness and cooperativeness: avoiding, dominating, accommodating, compromising, and collaborating(Sunindijo and Hadikusumo, 2013, DeChurch and Marks, 2001). Megaprojects are in the high level of complexity and uncertainty compared with the traditional projects(Flyvbjerg, 2014), and conflicts are inevitably occurred due to the various interests and objectives among stakeholders in the project lifecycle(Wei et al., 2016). In the society level, the social conflicts in megaprojects have been highlighted as the determinants of project viability(Lee et al., 2017). In the project level, the occurrences and causes of conflicts in large construction projects have been explored through case studies and simulation models(Min et al., 2018, Ng et al., 2007). In the organizational level, the impact path between contractual flexibility, conflict and project success has been assessed to detect the level on how conflicts interfere the operation of the contract system in megaprojects(Wu et al., 2018).

Although the previous studies attempted to explore the conflict mechanism in the megaprojects, there are still two limitations remained. First, few conflict-related studies are from perspectives of each kind of stakeholder, though most conflicts are caused by the different interests among stakeholders while deteriorating the stakeholder relationships consequently (Yang and Shen, 2015, Li et al., 2012). Second, limited knowledge focuses on the dynamics of the conflicts in the long-term project duration; thus, the understanding on how the

120 conflicts change with the development of project stages is still waiting for the insightful longitudinal studies
121 (Jehn and Mannix, 2001).

122 **2.2 Network analysis on stakeholder studies in the megaprojects**

123 The concept of network analysis was first proposed by Moreno in 1934. Through the development of graphical
124 and sociological theories, the concept was finalized to be an effective approach to analyze the
125 interdependencies among various elements, systematically presented in a book published by Wasserman and
126 Faust (1994). After that, the approach was introduced into a stakeholder-related study by Rowley (1997) to
127 understand the influence mechanism among stakeholders. In the construction sector, Yang et al. (2009) pointed
128 out the significance of network analysis, which is to provide a comprehensive view of the entire relationship
129 for improving stakeholder management in construction projects.

130 Network analysis is regarded as a useful tool to reflect the complexity in the systems in the megaprojects, thus
131 highlighted by Mok et al. (2015) as a major direction for further stakeholder studies. Currently, there are two
132 kinds of network analysis applied in the research of megaprojects. One is to analyze the inter-organizational
133 ties in the projects(Mok et al., 2017a, Dogan et al., 2013), which considers the organizations as nodal elements.
134 Another is to identify the interconnected issues among various organizations and quantify their
135 interdependencies(Yang et al., 2014, Mok et al., 2017b), which considers the stakeholder-associated issues as
136 nodal elements. However, either method is to describe the stakeholder interactions with a simplified one-mode
137 network, which presents the stakeholders and its related issues separately(Opsahl et al., 2010). The advanced
138 two-mode network analysis is conducted in a way that the integrated information of each stakeholder and its
139 related issues presented in one network would reflect the reality more comprehensively(Latapy et al., 2008).
140 Another limitation on the current research is that most of the networks are established at a point of time, which

lacks the longitudinal studies to provide a full picture of stakeholder interactions in the whole lifecycle of megaprojects(Mok et al., 2017b). Because of these research limitations, this study employed the two-mode network analysis to consider the stakeholders and their conflicts as a system rather than two separate parts, and to assess their interactions in each stage of the megaprojects, for seeking better strategies to deal with conflicts in a dynamic environment.

3. Research method

3.1 Identification of stakeholder-conflict network

The identification of stakeholder groups and their relevant issues is the primary part of stakeholder theory introduced by (Freeman, 1984). Since there are two sets of components in the stakeholder conflicts; one is the group of stakeholders; another is the diverse conflicts(Ramirez, 1999). Thus, the nodes in the network are defined as two modes: stakeholders and conflicts. The link between these two nodes shows the relevance between the conflicts and the corresponding stakeholder, which means the conflict affects the stakeholder's interests or actions. In the study, we identified the conflicts and their related stakeholders by the document analysis of the 1748 official meeting minutes in the legislative council of Hong Kong government on Hong Kong-Zhuhai-Macao Bridge (HZMB) from 2003 to 2018. Based on the previous network study, the number of times in which a pair of concepts were co-occurred in the text was counted to measure the closeness between the two concepts in the network (Boutilier and Zdziarski, 2017). The built-up network is useful to assess how closely the two concepts are based on the word co-occurrence in the record (Boutilier, 2011). Following the previous work, since the frequency of council meetings are organized based on the urgency and criticalness of the focal issues, the more critical issues would appear more times in various meeting minutes. Hence, the link was determined by the co-occurrence between each conflict and its related stakeholders in one meeting.

For instance, there is one link connected when both conflict C_i and stakeholder S_k are mentioned in the record of one official meeting. The co-occurrence frequency assessed the weight of the link between each conflict and its related stakeholders in the meetings for each year. For example, if conflict C_i and stakeholder S_k are co-occurred in the records of three different meetings in the year Y_j, the weight of the link C_i - S_k is valued as three in the network of Y_j. Besides, to ensure the relationship strength between the conflict and its relevant stakeholders, the value of the link weight was finally cross validated by the experts to judge whether the link and weight reflect the closeness in reality. Under the regulations of nodes, links, and link weights mentioned above, the stakeholder-conflict networks were built annually from 2003 to 2018 for the longitudinal study on how stakeholder interactions affect the conflicts in the long-term project duration in megaprojects.

3.2 Visualization of stakeholder-conflict network

Taken in place of the traditional dyadic representations in the stakeholder theory proposed by (Freeman, 1984), network visualization is considered as a more systematic tool to show the complex relationships among stakeholders and their relevant issues (Mok et al., 2015). The proposed stakeholder-conflict network is a two-mode network. One mode of nodes represents the conflicts in each stage of the megaprojects. Another mode of nodes reflects the conflict-related stakeholders. The link of the network shows the relevance of conflicts and their related stakeholders in one year. Hence, a series of annual networks from 2003 to 2018 presents the dynamic conflicts from the perspectives of stakeholders.

Compared to the classical one-mode network, it increases the difficulties for the direct analysis of the two-mode network due to the complexity(Liang et al., 2015). Generally, the most common way to analyze the two-mode network is to make the projection(Borgatti and Everett, 1997), after which the two-mode network could be converted into two traditional one-mode networks in convenience of the network analysis. As Figure 1

183 shows, through the projection, the stakeholder network would be generated based on the co-connection
184 relationship between the stakeholder-nodes and the conflict-nodes. Similarly, the conflict network could be
185 established. With the transformation, the traditional one-mode network analysis could be made for the
186 converted stakeholder and conflict networks respectively. Unlikely to the previous studies which initially
187 established the stakeholder or stakeholder-issue networks independently, the converted stakeholder network
188 is built based on the link with conflicts in the two-mode network that contains more interaction information,
189 as well as the converted conflict network which is established with the synthesis of the stakeholder information.
190 Therefore, the converted networks are mixed with the interaction information, which is beneficial for the
191 further analysis of conflicts with the view of stakeholders

192 **< Figure 1 The projection of the two-mode stakeholder-conflict network >**

193 **3.3 Analysis of stakeholder-conflict network**

194 Stakeholder analysis is an essential part of the classical stakeholder theory (Freeman, 1984), which benefits
195 the stakeholders to understand the critical relevant issues and their affected relationships in the project.
196 Compared to the traditional statistical methods for detecting the critical issues(Yang et al., 2010), the network
197 analysis considers all the involved stakeholders as one system to make analysis rather than regarding each
198 stakeholder as an independent variable(Yang et al., 2009), which is beneficial to have a systematic assessment
199 for identifying the critical stakeholders and their relevant issues (Liang et al., 2015).

200 **3.3.1 Conflict network analysis**

201 The prioritization of conflicts in a conflict network is beneficial to understand the major conflicts that
202 happened at a given time point(Lienert et al., 2013, Yang and Zou, 2014). Since the centrality was proposed
203 by Freeman as a critical indicator to show the node importance in the network analysis(Freeman, 1978), this

study selected the degree centrality of each conflict-node for assessing the node importance. Further, node degree centrality represents the structural importance in the network as the node with higher degree centrality shares more direct links with neighbor nodes(Rowley, 1997). In the study, the calculation of nodal degree centrality in a projected conflict network is as follows.

$$N(C_i) = \frac{\sum w_{ij}}{\sum w} \ (i \neq j) \,,$$

Where C_i represents the ith conflict in the network, $\sum w_{ij}$ is the sum of link weights which are connected with the ith conflict, $\sum w$ is the sum of link weights in the whole network.

3.3.2 Stakeholder network analysis

Conflicts have a deep influence on the relationship between related stakeholders. In the stakeholder network, the link reflects the stakeholder relationship, which is built by the common conflicts in the original two-mode network with the projection, showing the stakeholder-associated consequences caused by the conflicts. Therefore, the link assessment in the stakeholder network assists in testing the impacts of conflicts towards stakeholder relationships. In the network analysis, the link betweenness centrality represents the extent of a specific link located as a bridge for all the other links in the whole network(Rowley, 1997). It is regarded as a typical indicator to evaluate the critical ties(Mok et al., 2017b). In the study, the calculation of link betweenness centrality in a projected stakeholder network is as follows.

$$B(S_{ij}) = \sum_{a,b \in S} \frac{\sigma(a,b|S_{ij})}{\sigma(a,b)} \quad ,$$

Where S_{ij} represents the link connected between the stakeholder node "i" and "j", $\sigma(a,b)$ is the number of heaviest-weight paths connecting the node a and b, $\sigma(a,b|S_{ij})$ is the number of heaviest-weight paths passing through the link S_{ij}, node a and b belong to the set of stakeholder nodes S in the network.

3.3.3 Stakeholder-conflict map analysis

As stakeholder conflict is composed by two core concepts: stakeholder and conflict, the management strategy should consider both the importance of conflict and its stakeholder proliferation. For better exploring the features of each stakeholder conflict, this study proposed a stakeholder conflict map including three steps as depicted in Figure 2. First, the node centrality degree was used to reflect the importance of the conflicts(Freeman, 1978). Second, the subgraph of the corresponding conflict-nodes in the two-mode network was extracted and then calculated the number of its related stakeholders, which was regarded as the indicator to assess the extent of stakeholder participation. Third, each stakeholder conflict was located on the map with the X-axis of stakeholder participation and Y-axis of conflict importance. Take conflict-node C1 in Figure 2 as an example, C1 has a node degree centrality (NDC) valued as 0.8 over the average level (0.6) in that particular year, while connecting 6 stakeholder groups which is also higher than the average conflict-node associated stakeholder number (5). Thus, C1 is located in Zone One in the yearly stakeholder-conflict map. Followed by the example, characteristics of each conflict were presented using the stakeholder-conflict map.

< Figure 2 The stakeholder-conflict map analysis >

3.4 Assessment of stakeholder-conflict network

3.4.1 Critical stakeholder conflicts

Based on the results of conflict network analysis, the assessment of critical stakeholder conflicts in the dynamic project environment could proceed. According to the value of nodal degree centrality of each conflict, the stakeholder conflicts are ranked in the descending order. Based on the previous study by Liang et al. (2015), the critical factors are defined as the node with high centrality value. In the study, the top 30 percent of the conflicts is selected as the critical conflicts, since the higher value represents the more critical role in the projected conflict network. The threshold setting of the top 30 percent in the study is because the mean nodal

246 degree centrality value of all the identified conflicts is around the level of 30 percent from the top (shown in
247 Appendix 1), which means the centrality values of top 30 conflicts are above average. However, the threshold
248 (30%) of critical conflicts could be varied depending on the demand of stakeholder-conflict analysis in the
249 megaprojects.

250 **3.4.2 Affected stakeholder relationships**

251 Based on the results of stakeholder network analysis, the criticalness of affected stakeholder relationships in
252 the dynamic project environment could be assessed. According to the previous stakeholder studies by Mok et
253 al. (2017b), the critical stakeholder groups are firstly identified by the rank of node centrality degree in the
254 projected stakeholder network. Then the link betweenness centrality (LBC) is employed to evaluate the
255 affected stakeholder relationships for each critical stakeholder group. In the study, the top 30 percent of the
256 stakeholder groups are selected as the critical ones, and the top 3 LBC links are considered as the most affected
257 stakeholder relationships for each critical stakeholder group. The threshold setting of the top 30 percent in the
258 study is because the mean nodal degree centrality value of all the identified stakeholders is around the level
259 of 30 percent from the top (shown in Appendix 2), which means the centrality values of top 30 stakeholders
260 are above average. The threshold setting of the top 3 links is set as the minimum number of stakeholder links
261 in the network is three, which means each stakeholder node can explore at least three close connections. The
262 threshold (30% and Top 3) of affected stakeholder relationships could be varied depending on the demand of
263 stakeholder-conflict analysis in the megaprojects.

264 **3.5 Proposed "Mirror Z" strategies for stakeholder-conflict management**

265 The stakeholder theory suggests the managerial strategies should be concise and easy for the managers among
266 stakeholder groups to employ (Freeman, 1984). Hence, based on the results of stakeholder-conflict map

analysis, quick managerial guidance is proposed for senior project managers in the combination of the network-based evaluation and conflict management theory.

As shown in Figure 3, the stakeholder-conflict map is divided into four zones, which classifies the seriousness of stakeholder conflicts with four levels. Zone One consists of the conflicts with high criticalness and stakeholder relevance, considered as the top serious stakeholder conflict. Zone Two includes the conflicts with high criticalness and limited stakeholder relevance, recognized as the second serious stakeholder conflict. Zone Three has conflicts with low criticalness and wide stakeholder relevance, regarded as the third seriousness level. While Zone Four has conflicts with low criticalness and limited stakeholder relevance as the least seriousness. Based on the seriousness level, the management priority on stakeholder conflicts follows the order from the most to the least serious, namely from Zone One to Zone Four in the map similar as the mirror image of letter 'Z'. It is now proposed as the "Mirror Z" approach to determine the management priority of stakeholder conflicts in megaprojects. With the integration of the conflict management strategies in the previous study, the managerial implication of the "Mirror Z" approach could be presented on tackling the conflicts in each zone of the map with the following strategy: collaborating, compromising, avoiding, and accommodating(Jia et al., 2011). In Zone One, the collaborating strategy is recommended as all parties faced the most serious conflicts, which requires the openness, exchange of information, and careful examination of the differences between the parties(Rahim, 2017). In Zone Two, the compromising should be optimal among stakeholders. The focal group consultation could be frequently organized as limited stakeholder participation for achieving the practical solutions with the mutually acceptable agreement(Tsai and Chi, 2009). In Zone Three, the avoiding strategy is suggested as a large number of stakeholders are involved in low criticalness conflicts. As reaching the agreement is not easy due to the wide stakeholder participation, the withdrawing

from the threatening position for all parties to postpone the conflicts would be more efficient since the issues are less critical(Sunindijo and Hadikusumo, 2013). In Zone Four, accommodating would be the best solution to solve the least seriousness conflicts under a harmony environment. As conflicts in the Zone Four is least critical with limited stakeholders, it would be better for all parties to reach the consensus as soon as possible with a high degree of cooperativeness rather than wasting time and resource(Rahim, 2017).

<Figure 3 "Mirror Z" approach for stakeholder conflicts in the megaprojects >

3.6 Framework of dynamic network analysis on stakeholder conflicts

Based on the approaches presented in 3.1-3.5, a framework is established to explore the dynamic patterns of stakeholder conflicts in megaprojects. The framework (Shown in Figure 4) is composed of four parts, including stakeholder-conflict identification and visualization, stakeholder-conflict analysis, stakeholder-conflict assessment, and stakeholder-conflict management. Combined with the longitudinal data, the network-based framework provides a systematic method to analyze the dynamics of stakeholder conflicts from identification to evaluation and management in different project stages.

<Figure 4 Framework of dynamic network analysis on stakeholder conflicts >

4. Case Study

As the case study was introduced as a method suitable for the exploration in the new research area which has inadequate existing theories by Eisenhardt (1989), it is employed to validate the framework of dynamic network analysis on stakeholder conflicts in megaprojects. The single instrumental case study is conducted since the validation results of the proposed framework have the potential to be transferred to other megaprojects and a more comprehensive understanding of the phenomenon could be gained with the investigation under a project setting (Mok et al., 2017b). The case selection is based on information-oriented

sampling (Flyvbjerg, 2006). There are two major criteria. On the one hand, the selected case involves various stakeholders and has records of conflicts among stakeholders. On the other hand, the selected case prefers the famous megaproject which has substantial impacts on society, economy, and environment, which was also echoed by similar studies in the megaprojects (Mok et al., 2017b). To follow the criteria, the Hong Kong-Zhuhai-Macao Bridge (HZMB) was selected. The HZMB is a 55-kilometer cross-boundary mega transportation project, connecting Hong Kong, Macau, and Zhuhai—three major cities on the Pearl River Delta in China to enhance the economic and sustainable development of the Greater Bay Region. It is the longest sea-crossing infrastructure on earth designed for 120 years and cost is around 127 billion RMB in total. While the HZMB involves various stakeholders and many conflicts occurred due to various incidents, including delays and budget overruns, worker deaths and injuries, faked safety testing, seawall integrity and falling number of dolphins. The case study protocol is followed by the proposed framework from stakeholder-conflict identification and visualization to the management strategies step by step. The unit of analysis is at the project level from the planning to construction and handover stage, and the observation unit is each stakeholder group which is the main actor in the research.

4.1 Research results

4.1.1 Results of data collection

The data collection was undertaken by five researchers in the field of stakeholder and conflict management in megaprojects from February to April in 2019. The official documents were searched in the legislative council library in Hong Kong where preserved the life-cycle documents of local megaprojects. The searching term was “Hong Kong-Zhuhai-Macao Bridge” and “HZMB”. Finally, 1748 official documents on Hong Kong-Zhuhai-Macao Bridge from 2003 to 2018 were collected. The stakeholder conflicts were extracted from the

documents by desktop analysis, then three experts each from government, contractor, and local community (Profiles are shown in Appendix 3) who involved in the project from the beginning to the end were invited to cross-validate the results of data collection. Consequently, 334 conflicts and 32 kinds of stakeholders were identified from the project stage of planning, construction to handover. Based on the rules stated in 3.1 and 3.2, the yearly two-mode stakeholder-conflict networks were built, then transformed to the conflict and stakeholder networks respectively. The results were visualized by Netminer 4.0 as shown in Figure 5.

To furtherly analyze the stakeholder-conflict network, the large number of identified stakeholder conflicts (334) were categorized by their causes. In general, the category of stakeholder conflicts was set according to the characteristics of megaproject development by Flyvbjerg (2014), including technology, politics, economics, and aesthetics. In the technological aspect, the causes of stakeholder conflicts are concentrated on the cost, schedule, quality, and safety issues(Nassar and AbouRizk, 2016). In terms of the political aspect, the stakeholder conflicts are around the issues of labor, transparency, legal, and politics (Doloi, 2013, Aliza et al., 2011, Pinto, 2000, Boudet et al., 2011). The cause of stakeholder conflicts related to the economics consists of regional economy, local connectivity, urban development, finance, and the toll policy (Lützkendorf et al., 2011, Liyanage and Villalba-Romero, 2015, Lee et al., 2017). Moreover, the aesthetical conflict is caused by design issues among project stakeholders(Lu et al., 2000). Besides these four aspects, the conflicts also occur when stakeholders face the challenges of the issues on environmental protection, project alignment, and operational management(Zafar et al., 2019, Irimia Diéguez et al., 2014, Zhou et al., 2019). Overall, there are 17 categories in the research based on the previous studies: cost, schedule, quality, safety, labor, environment, transparency, finance, economy, connectivity, operation, urban development, alignment, legal, design, toll, and politics.

< Figure 5 The two-mode stakeholder conflict networks on HZMB from 2003 to 2018 >

4.1.2 Results of critical stakeholder conflicts

According to the assessment of critical stakeholder conflicts stated in 3.4.1, top 30 percent of the conflicts were selected as the critical conflicts in the year based on the rank of the node degree centrality (NDC) in the projected conflict network (Supplemented data 1). The annual identified conflicts (Supplemented data 3) were furtherly interpreted by three groups: environmental conflicts, neighboring conflicts, and traditional conflicts. Among them, neighboring conflicts contain the categories of connectivity and urban development, while traditional conflicts include the categories of cost, schedule, quality, and safety. The reason for the selection of the three perspectives was from two aspects. First, these three kinds of conflicts presented the clear chronological patterns in the timeline, providing the evidence to supplement the dynamic patterns of relevant stakeholder conflicts in the previous studies(Nassar and AbouRizk, 2016, Zhou et al., 2019, Lee et al., 2017). Second, the percentage of each kind conflict was 27 percent (Traditional), 16 percent (environmental), 13 percent (neighboring), which ranked the top 3 largest groups of identified critical stakeholder conflicts. In comparison, the remaining ten categories shared the other 44 percent. It is worthwhile to explore the dynamics of the top 3 groups since they provide adequate evidence to trace the chronological patterns. Therefore, based on the annually identified conflicts (Supplemented data 3), it is shown (Figure 6) the dynamics of critical conflicts by three groups: environmental conflicts, neighboring conflicts, and traditional conflicts, which will be discussed in 4.2.1.

< Figure 6 The number of annual critical conflicts from 2003 to 2018>

4.1.3 Results of affected stakeholder relationships

According to the assessment of affected stakeholder relationships stated in 3.4.2, the critical links were

identified based on the rank of the link betweenness centrality degree (LBC) in the projected stakeholder network (Supplemented data 2). In Tables_v1, it is presented the dynamics of affected stakeholder relationships by five groups: local industry, green groups, construction groups, supervision groups, and governmental organizations, which will be explicated in 4.2.2.

< Tables_v1 Critical stakeholder relationships in HZMB from 2003 to2018>

4.1.4 Results of stakeholder-conflict map

The stakeholder-conflict maps were drawn according to the three stages in the timeline of the project duration: planning (2003-2009), construction (2010-2017), and handover (2018). A stakeholder-conflict map was developed to reflect the relationship between conflict importance and stakeholder participation. Based on the 17 categories stated in 4.1.1, the results of the stakeholder-conflict map are shown in Tables_v2, beginning from the stage of planning to construction and handover.

< Tables_v2 The results of Stakeholder-conflict map in HZMB from 2003 to 2018>

4.2 Interpretation of results

The dynamic patterns of stakeholder conflicts in HZMB are interpreted based on the results derived from the proposed framework. Moreover, the results are cross-validated by follow-up interviews with senior experts (more than ten-year working experience) who directly involved in the project. The interviewees come from the stakeholder groups listed in Tables_v1. Each interview lasted for more than 1 hour. There are two key questions in the interview: one is whether the results derived from the framework are valid; another is what the reasons behind the result of data analysis are.

4.2.1 The dynamics of stakeholder conflicts

Pioneering conflicts from the environmental issues

393 The conflicts caused by environmental issues are considered as environmental conflicts, which have been
394 highlighted in the previous megaproject studies (Lienert et al., 2013, Zhou et al., 2019). Most environmental
395 conflicts are led by the worries of potential environmental pollution in the development of the megaprojects.
396 The evidence of this study shows the chronological priority of environmental conflicts would be at the
397 beginning of the planning and construction stages as the pioneering conflicts (shown in Figure 6). The
398 evidence is validated by interviewees, who also emphasized the criticalness of the environmental conflicts at
399 the start of two stages respectively. In the early planning stage, the worries on the protection of marine life
400 had caused the conflicts between the green groups and Hong Kong SAR government in 2003, which is in line
401 with the previous opinions that environmental and ecological concerns are active among stakeholders in the
402 early site selection phase(Min et al., 2018). While environmental issues also became the first major conflict
403 group among the stakeholders in the construction stage. The interviewees highlighted one breaking event that
404 an old lady who lived in the local community filed a case against the government department to the court on
405 the potential misconduct of the environmental impact assessment (EIA) report related to HZMB in 2010,
406 which suspended the commencement of the construction work for 15 months. As the pioneering conflict, the
407 interviewees revealed that the event triggered a series of following conflicts on cost overrun, time delay, and
408 the late start of the local connectivity, indicating the amplified effects of environmental conflicts in the ongoing
409 construction stage(Lee et al., 2017).

410 **Neighboring conflicts from the connected areas**

411 The neighboring conflicts refer to the stakeholder confrontations due to the dissatisfaction of the local
412 economic development nearby the megaprojects (Lee et al., 2017). For instance, the local connectivity and
413 urban development are clearly identified as two focal sources of the neighboring conflicts in the research

results. The evidence furtherly shows the breakout point of neighboring conflicts in the mid-term of the planning and construction stages respectively, while becoming fiercer in the handover stage (shown in Figure 6). The interviewees explained that the neighboring conflicts were introduced by the worries and desires of the local community. In the planning stage, the conflict lays behind the worries of the inadequate local transport system to cope with the expected heavy traffic volume of HZMB. The conflict leads to reduced community support for the project among residents and district council representatives. With the construction of HZMB, the desires of urban development in neighboring areas triggered the "bridgehead economy" proposal designed by the Hong Kong SAR government, referring to the commercial development of the project facility and the local town. However, conflicts occurred around the change of land use, the structure safety, and the disturbance to the local community caused by the potential flourished tourism industry. When it came to the handover stage, the conflicts escalated since both worries and desires of the local communities were not carefully addressed. The time delays and the technical difficulties of local connectivity and local commercial facilities received a wide public attention leading to the doubts on the smooth integration of the bridge system and the local urban system. Hence , the interviewees pointed out that the synchronization of the local auxiliary infrastructure and urban facilities could be the critical conflict sources of a mega infrastructure project, though which is seldom identified in the earlier research.

Traditional conflicts erupted in the planned due date

The conflicts, related to the aspects of cost, time, quality, and safety, are defined as traditional conflicts in the study, which exert direct influences on project performance(Chen et al., 2014, Chen et al., 2017, Nassar and AbouRizk, 2016, Maemura et al., 2018). As Figure 6 shows, the project suffered a dramatic increase in traditional conflicts since the year 2016, when the bridge was intended to be completed. The finding

supplements the previous study by detecting the exact time for these traditional conflicts to erupt(Wu et al., 2018). The delay of the project completion stimulated the burst of traditional conflicts. Of them, the occupational safety issues account for the most critical conflicts, causing the tensions among the workers, media, council, contractors, and government in the last two years of the construction stage, though the first fatal safety accidents occurred in 2012. The suspension phenomenon implicates that the traditional conflicts would be activated by the time overrun of the megaprojects. A similar viewpoint is also indicated by interviewees that as the schedule is the common goal for most stakeholders, compromising would be inclined to reach towards the traditional conflicts in the ongoing construction stage. However, the incompletion of the planned schedule disrupts the shared goal among stakeholders, causing the burst of traditional conflicts that have been hidden since the project commences.

4.2.2 The dynamics of stakeholder relationship

Local industry

The local industry mainly consists of construction-related companies (S9, S10, S11, S12), logistic companies (S17), and tourism companies (S18). The relevant conflicts are concentrated in the early planning stage (from 2003 to 2005 shown in Tables_v1). The interviewees mentioned that the local industry made both positive and negative roles in the conflicts based on their economic benefits. On the positive side, the local industry stood with the Hong Kong government to expedite the project for exploring more job and economic opportunities from the mainland market, regarded as a supportive muscle among stakeholders in the initial stage. However, the priority level of local participation in the project caused the conflicts between government and local construction-related companies in the same period.

Green groups

456 The green groups include environmental groups (S14), fishermen (S16), and the local community (S15).
457 According to the results in Tables_v1, the green groups have the critical ties with the Hong Kong SAR
458 government, Coordination Group, council representatives, and media in 2008 and 2009, then becoming the
459 critical stakeholders in 2011 and 2014, respectively. The period covers the end of the planning stage and the
460 first half of the construction stage when the project was at the important decision-making phase. The dynamic
461 pattern is verified by interviewees, who considered the conflicts on environmental issues are frequently
462 intensified around the project bill-voting period driven by green groups. The tensions not only severely
463 affected the relationship between government, council members, and green groups (S14-S1,S15-S1,S16-
464 S1,S14-S7,S15-S7,S16-S7), but also negatively impacted on the project supportiveness from the media and
465 general public (S15-S19,S14-S20,S15-S20).

466 **Construction groups**

467 As the key project stakeholders, the construction groups, including the contractor(S9), subcontractor (S11),
468 supplier (S12) and workers (S13), played an important role in the conflicts from the beginning to the
469 completion of the construction. Of them, according to Tables_v1, the contractor is the major party listed as
470 the critical stakeholder for 5 out of 8 times (2011,2012,2015,2016,2017) during the construction period. For
471 the contractor, the top relationship was with the Hong Kong government, which was the top link for almost
472 each year (except 2017), indicating the critical tie between contractor and the government in the mega
473 infrastructure project (Deng et al., 2014). Moreover, the construction groups faced the major challenge in the
474 relationship with the construction workers and council representatives (S9-S7,S11-S7,S12-S7,S9-S13,S11-
475 S13). The interviewees pointed out the challenge was primarily caused by conflicts on safety issues. The
476 industrial injury and death in the HZMB project caused the severe conflicts between construction groups and

477 the labor union, meanwhile interfered by council representatives. The conflicts exerted the heavy pressure on
478 the construction groups in the construction stage of the project.

479 **Supervision groups**

480 As a critical stakeholder group, according to Tables_v1, media was positioned at the centre of stakeholder
481 networks especially when big conflicts happened. For instance, the media had critical links with Hong Kong,
482 Macao, and Guangdong government in 2011(S19-S1, S19-S3, S19-S4) when the severe environmental judicial
483 review occurred causing the suspension of the project construction. While in 2017, the media was critically
484 connected by the independent inspection department and consultants (S19-S31, S19-S10) as the fabrication of
485 the cement experimental report from the consultant causing the big conflict on HZMB. According to the
486 feedback of interviewees, in most cases, the media stood closely with the environmental groups, traveling
487 public and workers, whereas with different voices against the governmental organizations, contractors and
488 consultants.

489 **Governmental organizations**

490 The collaboration of governmental organizations is the determinant for the success of the cross-boundary
491 megaprojects (Andrić et al., 2019), which is also echoed by interviewees. The prominent criticalness is evident
492 by the links among three governments related to HZMB identified by stakeholder network analysis. For
493 instance, according to Tables_v1, the critical links among the governments of Hong Kong SAR (S1), Macao
494 SAR (S3), and Guangdong Province (S4) were always connected as critical links from the planning to
495 construction and handover stage of the project (S1-S3,S1-S4,S3-S1,S4-S1). The critical links indicated the
496 importance of relationship among the three governments: Hong Kong SAR, Macao SAR, and Guangdong
497 Province, as addressing the conflicts together with the coordination and collaboration. The three governments

also cooperated to tackle the challenges from the operational conflicts in the handover stage, when they occupied the top three positions in the center of the stakeholder network (shown in Table 1). With the major links connected by shuttle bus operator (S3-S22, S4-S22), insurance company(S1-S26) and district councils(S1-S8), the three governments formed the coordination coalition to address the conflicts related to cross-boundary transport arrangements.

4.2.3 The dynamics of stakeholder-conflict management strategies

Planning Stage

In the planning stage, most conflicts on financial arrangements are located in the Zone One (Tables_v2), with the high conflict criticalness and stakeholder participation, which indicates that the financial issue was the top serious stakeholder-conflict in the early stage of HZMB. Since the conflict caused by the divergent views on the selection of financial modes, fiscal distribution among three governments, financial viability of the bridge, the interviewees agreed with the significance of the wide collaboration among governmental organizations, the legislative council, the media and general public to reach the consensus. Otherwise, it would be difficult to start the project.

The conflicts on schedule, environment and local connectivity were the top three issues located in Zone Two (Tables_v2), with the high conflict criticalness and fewer stakeholder participation. As the number of involved stakeholders is limited, reaching a compromise with the frequent contacts is the best solution towards the conflicts. For instance, the interviewees revealed that public consultations were organized to effectively relief the tensions between Hong Kong SAR and green groups on environmental issues.

Most conflicts on labor issues placed in Zone Three and Zone Four (Tables_v2), implicating the less criticalness in the planning stage. The interviewees considered the corresponding avoiding and

accommodating strategies are helpful to shelve disputes on the labor conflicts. As the tendering policy would not be among the prior issues in the early stage of the project, the conflicts on the protection of local laborers would be better to put aside and cool down with the cooperative environment among stakeholders instead of escalating the tensions.

Construction Stage

In the construction stage, the conflicts caused by cost overrun were the top one conflict in the Zone one (Tables_v2), where most conflicts on safety and quality issues appeared in the same zone. The results revealed that these three kinds of conflicts should be managed at the priority, being the most serious ones. Since the issues on cost, safety and quality have a direct influence on the project performance(Flyvbjerg et al., 2003), the relevant conflicts require the collaboration among wide-range stakeholders to seek for the immediate remedy, which was also echoed by interviewees.

Conflicts on operational management were the largest group in Zone Two, Three, and Four respectively (Tables_v2), reflecting the significant role in the map. The conflicts on operational issues are barely distributed equally in each zone of the stakeholder-conflict map in the construction stage, indicating the requirement of the diversity on corresponding management strategies. For instance, most conflicts in Zone Two were caused by the transport arrangements of Hong Kong Crossing Boundary Facilities (HKCBF), which were highly critical, as HKCBF would undertake the role as a hub in the traffic system of HZMB. However, the conflicts were much focused on the technical details which referred to the limited stakeholders with professions, such as the Hong Kong Government, consultant, and council members. For ensuring the progress of the project, the interviewees agreed that the compromising strategy would be optimal for stakeholders to reach the agreement. While conflicts in Zone three referred to the arrangement of the local transport system, which was

not so urgent in the construction stage but attracting the attention from many stakeholders, especially among local communities, the general public, and media. For these conflicts, the interviewees pointed out that avoiding strategy may prove effective in postponing the conflict and keep discussions in a peaceful way rather than confrontations.

Another interesting phenomenon is from environmental issues, on which the relevant conflicts show the polarization in the map, i.e. 8 cases in Zone One whereas 9 cases in Zone Four (Tables_v2). According to the interview findings, the polarization is caused by the time divergency of the conflict occurrence since the environmental conflict was the major conflict in the initial stage of the construction period, then turning into the less-criticalness zone. As discussed in 5.1.1, the environmental issues always take the leading position among stakeholder conflicts, causing project delay and the cost overrun of the project. The eruption of environmental conflicts in the early period of the construction stage (Located in Zone One) heavily influences the wide range of project stakeholders, thus calling for the collaboration strategy among stakeholders to reach the agreement efficiently for stopping the further negative chain effects towards the project. However, as the project goes on, various conflicts erupt besides the environmental issues, which diversifies the focus among stakeholders. As a consequence, the importance of environmental conflicts downgrades from the dominating issue which determines the project's success to the ordinary issue which only affects the direct relevant stakeholders. The suggested accommodating strategy is approved by interviewees, which benefits relevant stakeholders to solve the conflict smoothly and harmoniously to keep the project forward in the middle and late phase of the construction stage.

Handover Stage

In the handover stage, the conflicts on operational arrangements, local connectivity, and legal issues were the

top three largest groups in HZMB (Tables_v2). Of them, most conflicts on local connectivity and legal issues were located in Zone One and Two, which shows the high criticalness of the two kinds of conflicts in the handover stage. In contrast, the operational arrangements received the conflicts equally distributed in each zone respectively (Tables_v2), implicating the diverse features towards conflict criticalness and stakeholder relevance. The general cross-boundary arrangements caused the severest conflicts among stakeholders located in Zone One, including the adoption of right-driving policies and 24-hour traffic arrangement. As the general arrangements refer to the contradiction of official traffic regulations between the Mainland and Hong Kong, the interviewees reminded the effectiveness of collaboration strategies among involved government departments to find feasible solutions to eliminate the contradicts in the history of HZMB. In Zone Two, the operational conflicts turn to the local traffic pressure on Hong Kong Port and Link Road. Based on the interview findings, the relevant stakeholders are mainly in Hong Kong region relieving the stress on cross-boundary negotiation, thus easier to reach a compromise among stakeholders.

Moreover, the conflicts on political issues such as the fears on the too-close integration between the regions connected by the project should be paid attention since 2 out of 3 political conflicts are in the Zone One (Tables_v2). The interviewees supported the corresponding collaboration strategy for project stakeholders to remove the political worries particularly from the media and the general public.

5. Conclusion

As there is essential but lack of evidence to show how stakeholder conflicts evolve in the megaprojects as stated in the previous study, the research proposes a framework to analyze the dynamic pattern of stakeholder conflicts throughout the whole project duration, beginning from the planning stage to the construction and handover stage. The framework is based on the two-mode network model, through which it provides the

582 method to measure the critical conflicts and the most affected stakeholder relationships, as well as to map the
583 stakeholder-conflict map to present the "Mirror Z" management strategies. Theoretically, the study proposes
584 the methodology to understand the dynamics of critical conflicts, affected stakeholder relationships, and
585 corresponding management strategies in different project phases. Therefore, the proposed method contributes
586 to the dynamic network analysis by providing a framework to extend its use on evaluating stakeholder conflicts
587 in the megaprojects based on the classical two-mode network model and stakeholder theory. Moreover, the
588 proposed "Mirror Z" approach transforms the measurement results of dynamic network analysis to the
589 management strategies of stakeholder conflicts, solving the management problem by bridging the knowledge
590 domain between conflict management and stakeholder management. Practically, the proposed method could
591 serve for the researchers and decision-makers to learn the dynamic patterns of stakeholder conflicts in the
592 historic megaprojects, summarizing the rules and lessons for the better development of megaprojects in the
593 future.
594 With the case study of Hong Kong – Zhuhai – Macao Bridge from 2003 to 2018, a set of findings are revealed
595 to reflect the dynamics of stakeholder conflicts in the sixteen-year project duration. First, through the conflict
596 network analysis, it is revealed that the environmental conflicts take the leading position in the planning and
597 construction stage respectively, the neighboring conflicts occur in the mid-term of the planning and
598 construction stage due to the imbalanced synchronization of the local auxiliary infrastructure and urban
599 facilities, and the traditional conflicts (i.e., cost overrun, time delay, safety accidents, poor quality) are
600 triggered in the planned due date. Second, through the stakeholder network analysis, dynamic features of five
601 stakeholder groups are discussed. It is found that the local industry is a major conflict participant in the early
602 planning stage, while the green group is active during the decision-making period. Besides, the media takes

603 the important role with the occurrence of big conflicts, the contactor has a critical link with the government,
604 workers, and council members among various conflicts, and the cooperation among different governments is
605 highlighted in the implementation of the cross-boundary megaprojects. Through the stakeholder-conflict map
606 analysis, the "Mirror Z" approach is proposed to manage the stakeholder conflicts by the measurement of the
607 conflict criticalness and stakeholder participation. With the "Mirror Z" approach, it benefits the decision-
608 maker to determine the management priority of stakeholder conflicts and manage them by corresponding
609 strategies, including collaborating, compromising, avoiding, and accommodating. The proposed "Mirror Z"
610 approach has the potential to be extended in various megaprojects worldwide.
611 The limitation of the study is to generalize the research findings relating to different regions worldwide.
612 Although an effective method is proposed in this study, it is still waiting for more cases to validate the findings
613 in a future study. Second, the network analysis is much dependent on the source of the stakeholder information.
614 The insufficient stakeholder information may lead to the deviated research results, which is an inborn
615 weakness of the network analysis. Although most information in the study is extracted from the official
616 documents considering to be more objective than other subjective accesses, some stakeholder information
617 may still not be fully covered if they are not mentioned in the collected official documents. Thus, more
618 information access is recommended in future studies, such as the project information on the mainstream
619 website and social media, supplementing the current dataset to make a comprehensive study.

620 **Data Availability Statement**

621 Some or all data, models, or codes that support the findings of this study are available from the corresponding
622 author upon reasonable request.

623 **Acknowledgment**

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Appendix

< Appendix 1 The comparison between various threshold settings of selecting critical conflicts>

< Appendix 2 The comparison between various threshold settings of selecting critical stakeholders>

< Appendix 3 Profiles of participants in the review of data collection >

References

ABMA, T. 2000. Stakeholder conflict: a case study. *Evaluation and Program Planning,* 23**,** 199-210.

ALIZA, A. H., STEPHEN, K. & BAMBANG, T. 2011. The importance of project governance framework in project procurement planning. *Procedia Engineering,* 14**,** 1929-1937.

ANDRIĆ, J. M., WANG, J., ZOU, P. X., ZHANG, J. & ZHONG, R. 2019. Fuzzy Logic–Based Method for Risk Assessment of Belt and Road Infrastructure Projects. *Journal of Construction Engineering and Management,* 145**,** 04019082.

ATKIN, B. & SKITMORE, M. 2008. Stakeholder management in construction. *Construction Management and Economics,* 26**,** 549-552.

BORGATTI, S. P. & EVERETT, M. G. 1997. Network analysis of 2-mode data. *Social networks,* 19**,** 243-269.

BOUDET, H. S., JAYASUNDERA, D. C. & DAVIS, J. 2011. Drivers of conflict in developing country infrastructure projects: experience from the water and pipeline sectors. *Journal of Construction Engineering and Management,* 137**,** 498-511.

BOUTILIER, R. 2011. *A stakeholder approach to issues management*, Business Expert Press.

BOUTILIER, R. G. & ZDZIARSKI, M. 2017. Managing stakeholder networks for a social license to build. *Construction management and economics,* 35**,** 498-513.

CHEN, Y. Q., ZHANG, Y. B. & ZHANG, S. J. 2014. Impacts of Different Types of Owner-Contractor Conflict on Cost Performance in Construction Projects. *Journal of Construction Engineering and Management,* 140.

CHEN, Y. T., MCCABE, B. & HYATT, D. 2017. Relationship between Individual Resilience, Interpersonal Conflicts at Work, and Safety Outcomes of Construction Workers. *Journal of Construction Engineering and Management,* 143.

DE DREU, C. K. & WEINGART, L. R. 2003. Task versus relationship conflict, team performance, and team member satisfaction: a meta-analysis. *Journal of applied Psychology,* 88**,** 741.

DECHURCH, L. A. & MARKS, M. A. 2001. Maximizing the benefits of task conflict: The role of conflict management. *International Journal of Conflict Management,* 12**,** 4-22.

DENG, X., LOW, S. P., LI, Q. & ZHAO, X. 2014. Developing competitive advantages in political risk management for international construction enterprises. *Journal of Construction Engineering and Management,* 140**,** 04014040.

DOGAN, S. Z., ARDITI, D., GUNHAN, S. & ERBASARANOGLU, B. 2013. Assessing coordination performance based on centrality in an e-mail communication network. *Journal of Management in Engineering,* 31**,** 04014047.

DOLOI, H. 2013. Cost overruns and failure in project management: Understanding the roles of key stakeholders in construction projects. *Journal of construction engineering and management,* 139**,** 267-279.

DOYLE, T. P. 2016. *Multicriteria multistakeholder decision analysis: applications to transportation planning.* Massachusetts Institute of Technology.

FLYVBJERG, B. 2006. Five misunderstandings about case-study research. *Qualitative inquiry,* 12**,** 219-245.

FLYVBJERG, B. 2014. What you should know about megaprojects and why: An overview. *Project management journal,* 45**,** 6-19.

FLYVBJERG, B., BRUZELIUS, N. & ROTHENGATTER, W. 2003. *Megaprojects and risk: An anatomy of ambition*, Cambridge University Press.

FREEMAN, L. C. 1978. Centrality in social networks conceptual clarification. *Social networks,* 1**,** 215-239.

FREEMAN, R. 1984. Edward: Strategic Management. *A Stakeholder Approach, New York*.

GUANG-DONG, W. 2013. THE RELATIONSHIP BETWEEN PROJECT TEAM DYNAMIC FEATURE, CONFLICT DIMENSION AND PROJECT SUCCESS--AN EMPIRICAL RESEARCH FROM SHANGHAI, CHINA. *Pakistan Journal of Statistics,* 29.

GUIDE, A. Project management body of knowledge (pmbok® guide). Project Management Institute, 2001.

HARMON, K. M. 2003. Conflicts between owner and contractors: proposed intervention process. *Journal of management in Engineering,* 19**,** 121-125.

HEMPEL, P. S., ZHANG, Z. X. & TJOSVOLD, D. 2009. Conflict management between and within teams for trusting relationships and performance in China. *Journal of Organizational Behavior: The International Journal of Industrial, Occupational and Organizational Psychology and Behavior,* 30**,** 41-65.

IRIMIA DIéGUEZ, A. I., SáNCHEZ CAZORLA, Á. & ALFALLA LUQUE, R. 2014. Risk management in megaprojects. *Procedia: Social and Behavioral Sciences, 119, 407-416.*

JEHN, K. A. & MANNIX, E. A. 2001. The dynamic nature of conflict: A longitudinal study of intragroup conflict and group performance. *Academy of management journal,* 44**,** 238-251.

JIA, G., YANG, F., WANG, G., HONG, B. & YOU, R. 2011. A study of mega project from a perspective of social conflict theory. *International Journal of project management,* 29**,** 817-827.

KARDES, I., OZTURK, A., CAVUSGIL, S. T. & CAVUSGIL, E. 2013. Managing global megaprojects: Complexity and risk management. *International Business Review,* 22**,** 905-917.

KUMARASWAMY, M. M. 1998. Consequences of construction conflict: A Hong Kong perspective. *Journal of Management in Engineering,* 14**,** 66-74.

LATAPY, M., MAGNIEN, C. & DEL VECCHIO, N. 2008. Basic notions for the analysis of large two-mode networks. *Social networks,* 30**,** 31-48.

LEE, C., WON, J. W., JANG, W., JUNG, W., HAN, S. H. & KWAK, Y. H. 2017. Social conflict management framework for project viability: Case studies from Korean megaprojects. *International Journal of Project Management,* 35**,** 1683-1696.

LEUNG, M.-Y., YU, J. & LIANG, Q. 2013. Analysis of the relationships between value management techniques, conflict management, and workshop satisfaction of construction participants. *Journal of*

Management in Engineering, 30**,** 04014004.
LI, C. Z., HONG, J., XUE, F., SHEN, G. Q., XU, X. & MOK, M. K. 2016a. Schedule risks in prefabrication housing production in Hong Kong: a social network analysis. *Journal of Cleaner Production,* 134**,** 482-494.
LI, T. H., NG, S. T. & SKITMORE, M. 2012. Conflict or consensus: An investigation of stakeholder concerns during the participation process of major infrastructure and construction projects in Hong Kong. *Habitat international,* 36**,** 333-342.
LI, Y., HOMBURG, V., DE JONG, M. & KOPPENJAN, J. 2016b. Government responses to environmental conflicts in urban China: the case of the Panyu waste incineration power plant in Guangzhou. *Journal of cleaner production,* 134**,** 354-361.
LIANG, X., SHEN, G. & GUO, L. 2015. Improving management of green retrofits from a stakeholder perspective: A case study in China. *International journal of environmental research and public health,* 12**,** 13823-13842.
LIENERT, J., SCHNETZER, F. & INGOLD, K. 2013. Stakeholder analysis combined with social network analysis provides fine-grained insights into water infrastructure planning processes. *Journal of environmental management,* 125**,** 134-148.
LIYANAGE, C. & VILLALBA-ROMERO, F. 2015. Measuring success of PPP transport projects: a cross-case analysis of toll roads. *Transport reviews,* 35**,** 140-161.
LU, S.-Y., CAI, J., BURKETT, W. & UDWADIA, F. 2000. A methodology for collaborative design process and conflict analysis. *CIRP Annals,* 49**,** 69-73.
LüTZKENDORF, T., FAN, W. & LORENZ, D. 2011. Engaging financial stakeholders: opportunities for a sustainable built environment. *Building Research & Information,* 39**,** 483-503.
MAEMURA, Y., KIM, E. & OZAWA, K. 2018. Root Causes of Recurring Contractual Conflicts in International Construction Projects: Five Case Studies from Vietnam. *Journal of Construction Engineering and Management,* 144.
MIN, J. H., JANG, W., HAN, S. H., KIM, D. & KWAK, Y. H. 2018. How conflict occurs and what causes conflict: conflict analysis framework for public infrastructure projects. *Journal of Management in Engineering,* 34**,** 04018019.
MOK, K. Y., SHEN, G. Q. & YANG, J. 2015. Stakeholder management studies in mega construction projects: A review and future directions. *International Journal of Project Management,* 33**,** 446-457.
MOK, K. Y., SHEN, G. Q. & YANG, R. J. 2017a. Addressing stakeholder complexity and major pitfalls in large cultural building projects. *International Journal of Project Management,* 35**,** 463-478.
MOK, K. Y., SHEN, G. Q., YANG, R. J. & LI, C. Z. 2017b. Investigating key challenges in major public engineering projects by a network-theory based analysis of stakeholder concerns: A case study. *International Journal of Project Management,* 35**,** 78-94.
NASSAR, N. & ABOURIZK, S. 2016. Introduction to techniques for resolving project performance contradictions. *Journal of Construction Engineering and Management,* 142**,** 04016027.
NG, H. S., PEñA-MORA, F. & TAMAKI, T. 2007. Dynamic conflict management in large-scale design and construction projects. *Journal of Management in Engineering,* 23**,** 52-66.
OCK, J. H. & HAN, S. H. 2003. Lessons learned from rigid conflict resolution in an organization: Construction conflict case study. *Journal of management in engineering,* 19**,** 83-89.
OETZEL, J. G. & TING-TOOMEY, S. 2006. *The SAGE handbook of conflict communication: Integrating theory, research, and practice*, Sage Publications.

OPSAHL, T., AGNEESSENS, F. & SKVORETZ, J. 2010. Node centrality in weighted networks: Generalizing degree and shortest paths. *Social networks,* 32**,** 245-251.

PINTO, J. K. 2000. Understanding the role of politics in successful project management. *International Journal of Project Management,* 18**,** 85-91.

RAHIM, M. A. 2017. *Managing conflict in organizations*, Routledge.

RAMIREZ, R. 1999. Stakeholder analysis and conflict management. *Cultivating peace: conflict and collaboration in natural resource management***,** 101-126.

ROWLEY, T. J. 1997. Moving beyond dyadic ties: A network theory of stakeholder influences. *Academy of management Review,* 22**,** 887-910.

SUNINDIJO, R. Y. & HADIKUSUMO, B. H. 2013. Emotional intelligence for managing conflicts in the sociocultural norms of the Thai construction industry. *Journal of Management in Engineering,* 30**,** 04014025.

TSAI, J.-S. & CHI, C. S. 2009. Influences of Chinese cultural orientations and conflict management styles on construction dispute resolving strategies. *Journal of Construction Engineering and management,* 135**,** 955-964.

WASSERMAN, S. & FAUST, K. 1994. *Social network analysis: Methods and applications*, Cambridge university press.

WEI, H.-H., LIU, M., SKIBNIEWSKI, M. J. & BALALI, V. 2016. Conflict and consensus in stakeholder attitudes toward sustainable transport projects in China: An empirical investigation. *Habitat International,* 53**,** 473-484.

WONG, A., TJOSVOLD, D., WONG, W. Y. & LIU, C. 1999. Cooperative and competitive conflict for quality supply partnerships between China and Hong Kong. *International Journal of Physical Distribution & Logistics Management,* 29**,** 7-21.

WU, G., ZHAO, X. & ZUO, J. 2017. Effects of inter-organizational conflicts on construction project added value in China. *International Journal of Conflict Management,* 28**,** 695-723.

WU, G., ZHAO, X., ZUO, J. & ZILLANTE, G. 2018. Effects of contractual flexibility on conflict and project success in megaprojects. *International Journal of Conflict Management,* 29**,** 253-278.

YANG, J., SHEN, G. Q., DREW, D. S. & HO, M. F. 2010. Critical Success Factors for Stakeholder Management: Construction Practitioners' Perspectives. *Journal of Construction Engineering and Management,* 136**,** 778-786.

YANG, J., SHEN, Q. & HO, M. 2009. An overview of previous studies in stakeholder management and its implications for the construction industry. *Journal of facilities management,* 7**,** 159-175.

YANG, R. J. & SHEN, G. Q. 2015. Framework for stakeholder management in construction projects. *Journal of Management in Engineering,* 31**,** 04014064.

YANG, R. J., WANG, Y. W. & JIN, X. H. 2014. Stakeholders' Attributes, Behaviors, and Decision-Making Strategies in Construction Projects: Importance and Correlations in Practice. *Project Management Journal,* 45**,** 74-90.

YANG, R. J. & ZOU, P. X. 2014. Stakeholder-associated risks and their interactions in complex green building projects: A social network model. *Building and Environment,* 73**,** 208-222.

YU, T., SHEN, G. Q. P., SHI, Q., LAI, X. D., LI, C. Z. D. & XU, K. X. 2017. Managing social risks at the housing demolition stage of urban redevelopment projects: A stakeholder-oriented study using social network analysis. *International Journal of Project Management,* 35**,** 925-941.

ZAFAR, I., WUNI, I. Y., SHEN, G. Q., ZAHOOR, H. & XUE, J. 2019. A decision support framework for sustainable highway alignment embracing variant preferences of stakeholders: case of China Pakistan economic corridor. *Journal of Environmental Planning and Management*, 1-35.

ZHANG, L. & HUO, X. 2015. The impact of interpersonal conflict on construction project performance: A moderated mediation study from China. *International Journal of Conflict Management,* 26, 479-498.

ZHOU, Y., HOU, L., YANG, Y., CHONG, H.-Y. & MOON, S. 2019. A comparative review and framework development on public participation for decision-making in Chinese public projects. *Environmental Impact Assessment Review,* 75, 79-87.

Tables_v1 Critical stakeholder relationships in HZMB from 2003 to2018

Stakeholder	Stage	Year	Critical link with link betweenness centrality
Local industry	P	2003	S9-S11(1.0);S9-S13(1.0)
		2004	S9-S1(10.0);S9-S13(5.0);S9-S12(5.0);S11-S1(10.0);S11-S13(5.0);S11-S12(5.0)
		2005	S9-S1(13.0);S9-S10(1.3);S9-S13(1.3);S11-S1(13.0);S11-S10(1.3);S11-S13(1.3);S12-S1(13.0);S12-S10(1.3);S12-S13(1.3);
		2009	S18-S1(9.3)
	C	2010	S17-S1(6.0);S17-S5(2.5);S17-S10(2.2);
		2013	S17-S15(3.6);S17-S1(3.5);S17-S7(2.2);
	H	2018	S17-S15(3.9);S17-S1(3.4);S17-S7(3.2);
Green groups	P	2008	S16-S1(8.1);S14-S1 (6.4)
		2009	S15-S19(4.1);S16-S5 (2.7); S16-S7(2.2); S14-S5(2.7);S14-S7(2.2);
	C	2011	S14-S1(4.6);S14-S24(4.6);S14-S7(3.4);S15-S1(4.7);S15-S24(3.9);S15-S7(3.5);
		2014	S14-S1(3.9);S14-S20(3.1);S14-S8(2.4);S15-S23(3.5);S15-S20(3.3);S15-S9(2.8);
	H	-	-
Construction groups	P	-	-
	C	2011	S9-S1(5.0);S9-S7(3.0);S9-S13(2.9);S10-S17(4.5);S10-S24(4.4);S10-S1(3.8);
		2012	S9-S1(3.8);S9-S13(3.7);S9-S6(3.2);S11-S1(4.6);S11-S13(2.7);S11-S7(2.6);S12-S1(4.9);S12-S10(2.3);S12-S7(2.2);
		2013	S10-S14(6.4);S10-S9(6.4);S10-S1(5.6)
		2015	S9-S1(4.3);S9-S3(3.5);S9-S7(3.3);S11-S1(5.4);S11-S7(4.4);S11-S20(2.5);S12-S1(5.2);S12-S7(4.2);S12-S21(2.5);S10-S30(4.3);S10-S15(4.3);S10-S17(3.6)
		2016	S9-S1(6.5); S9-S16(5.8); S9-S21(5.3);
		2017	S9-S12(3.6);S9-S21(3.6); S9-S13(1.7);S11-S13(1.5);S11-S12(3.4);S11-S21(3.4);
	H	-	-
Supervision groups	P	2008	S19-S8(4.2);S19-S24(3.1);S19-S9(2.7);
		2009	S19-S15(4.1);S19-S8(3.1);S19-S9(2.9);
		2011	S19-S1(4.6);S19-S3(3.2);S19-S4(3.2);
		2014	S19-S6(5.3);S19-S29(4.7);S19-S24(4.3);
		2016	S19-S1(4.7);S19-S24(4.0);S19-S13(3.5);
		2017	S19-S31(3.7);S19-S22(3.5);S19-S10(3.5);
	H	2018	S19-S22(4.8);S19-S15(4.3);S19-S10(4.3);
Governmental organizations	P	2003	S1-S9(9.0);S1-S11(9.0);S1-S13(9.0);
		2005	S1-S10(13.3);S1-S9(13.0);S1-S11(13.0;
		2006	S1-S14(10.0);S1-S10(5.5);S1-S2(4.7); S3-S1(3.7);S3-S5(2.7);S3-S20(2.0)
		2007	S1-S10(8.0);S1-S15(7.0);S1-S29(7.0);
		2008	S1-S16(8.1);S1-S14(6.4);S1-S8(4.4);S3-S1(3.2);S3-S5(2.4);S3-S19(2.3);S4-S1(3.2);S4-S5(2.4);S4-S19(2.3)
		2009	S1-S18(9.3);S1-S21(5.3);S1-S9(4.4); S3-S10(3.5);S3-S1(3.5);S3-S7(2.6)
	C	2010	S1-S13(11.0);S1-S28(9.5);S1-S27(9.5);S3-S19(5.6);S3-S1(4.8);S3-S7(3.1)
		2011	S1-S28(25.0);S1-S18(25.0);S1-S13(14.5);

		2012	S1-S16(18.0);S1-S14(13.0);S1-S3(10.2);
		2013	S1-S23(11.8);S1-S8(8.5);S1-S27(7.6);
		2014	S1-S3(8.6);S1-S4(8.6);S1-S17(8.6);
		2015	S1-S8(17.5);S1-S30(8.8);S1-S6(8.4);
		2016	S1-S21(19.3);S1-S16(17.8);S1-S23(10.9);S3-S1(6.9);S3-S24(3.4);S3-S20(2.9);S6-S1(6.4);S6-S24(3.4);S6-S20(2.8)
		2017	S1-S8(18.0);S1-S13(7.7);S1-S12(7.6);
	H	2018	S1-S8(16.2);S1-S26(13.5);S1-S12(10.5);S4-S1(4.3);S4-S7(3.2);S4-S22(3.0);S3-S1(4.3);S3-S7(3.2);S3-S22(3.0);S6-S24(4.1);S6-S13(3.9);S6-S1(3.6);

Note:

P: Planning stage (2003-2009), C: Construction stage (2010-2017), H: Handover stage (2018)

Sn-Sm (value): Link Stakeholder n to Stakeholder m (value of link betweenness centrality)

Stakeholder group: S1.Hong Kong SAR; S2.Central Government; S3.Macao SAR; S4.Guangdong Province; S5.Coordination group; S6.HZMB Authority; S7.Legislative Council; S8.District council; S9.Contractor; S10.Consultant; S11.Subcontractor; S12.Supplier; S13.Worker; S14.Environmental group; S15.Local community; S16.Fishermen; S17.Logistic industry; S18.Tourism industry; S19.Media; S20. General public; S21.Tender; S22.Shuttle operator; S23.Aviation; S24. Travelling public; S25.Immigration; S26. Insurance; S27.Financial group; S28. Ruling party; S29. Opposition party; S30. Chief Executive; S31. Independent Commission Against Corruption; S32. Ferry Company

Tables_v2 The results of Stakeholder-conflict map in HZMB from 2003 to 2018

Stage	Zone	Cost	Schedule	Quality	Safety	Labor	Environment	Transparency	Finance	Economy	Connectivity	Operation	Urban	Alignment	Legal	Design	Toll	Politics
Planning (2003-2009)	Ⅰ	2	1	0	0	0	0	0	7	1	1	1	0	2	1	0	2	1
	Ⅱ	1	10	0	0	0	7	1	3	4	8	6	3	1	1	6	3	1
	Ⅲ	1	1	0	0	5	3	0	0	5	0	2	0	1	0	0	0	1
	Ⅳ	0	4	1	0	4	7	1	2	4	2	2	0	0	0	0	3	0
Construction (2010-2017)	Ⅰ	12	3	6	7	2	8	2	0	0	1	6	4	0	0	1	1	0
	Ⅱ	4	3	1	1	2	0	1	0	2	3	10	9	0	1	0	0	1
	Ⅲ	0	0	2	0	1	3	2	1	1	2	11	1	0	0	2	1	1
	Ⅳ	4	8	3	4	4	9	1	0	4	5	13	2	0	0	0	0	0
Handover (2018)	Ⅰ	0	0	0	1	0	0	0	0	1	2	2	0	0	2	0	1	2
	Ⅱ	2	0	0	0	0	0	0	0	1	2	2	1	0	1	0	0	0
	Ⅲ	0	1	0	1	0	0	0	1	0	0	3	0	0	0	0	0	1
	Ⅳ	1	1	0	0	0	0	0	0	0	1	3	1	0	1	0	0	0

Note: The value in the table represents the number of stakeholder-conflicts under each category

Strategy for the conflicts in Zone Ⅰ: Collaboration

Strategy for the conflicts in Zone Ⅱ: Compromising

Strategy for the conflicts in Zone Ⅲ: Avoiding

Strategy for the conflicts in Zone Ⅳ: Accommodating

Appendix 3 Profiles of participants in the review of data collection

Participant Type	Quantity	Job Experience (years)	Job Position	Project Involvement Period
Government officer	1	25	Senior	2003-2018
Contractor	1	23	Senior	2003-2018
Community leader	1	22	Senior	2003-2018

Figure 1

Click here to access/download;Figure;figure 1.pdf

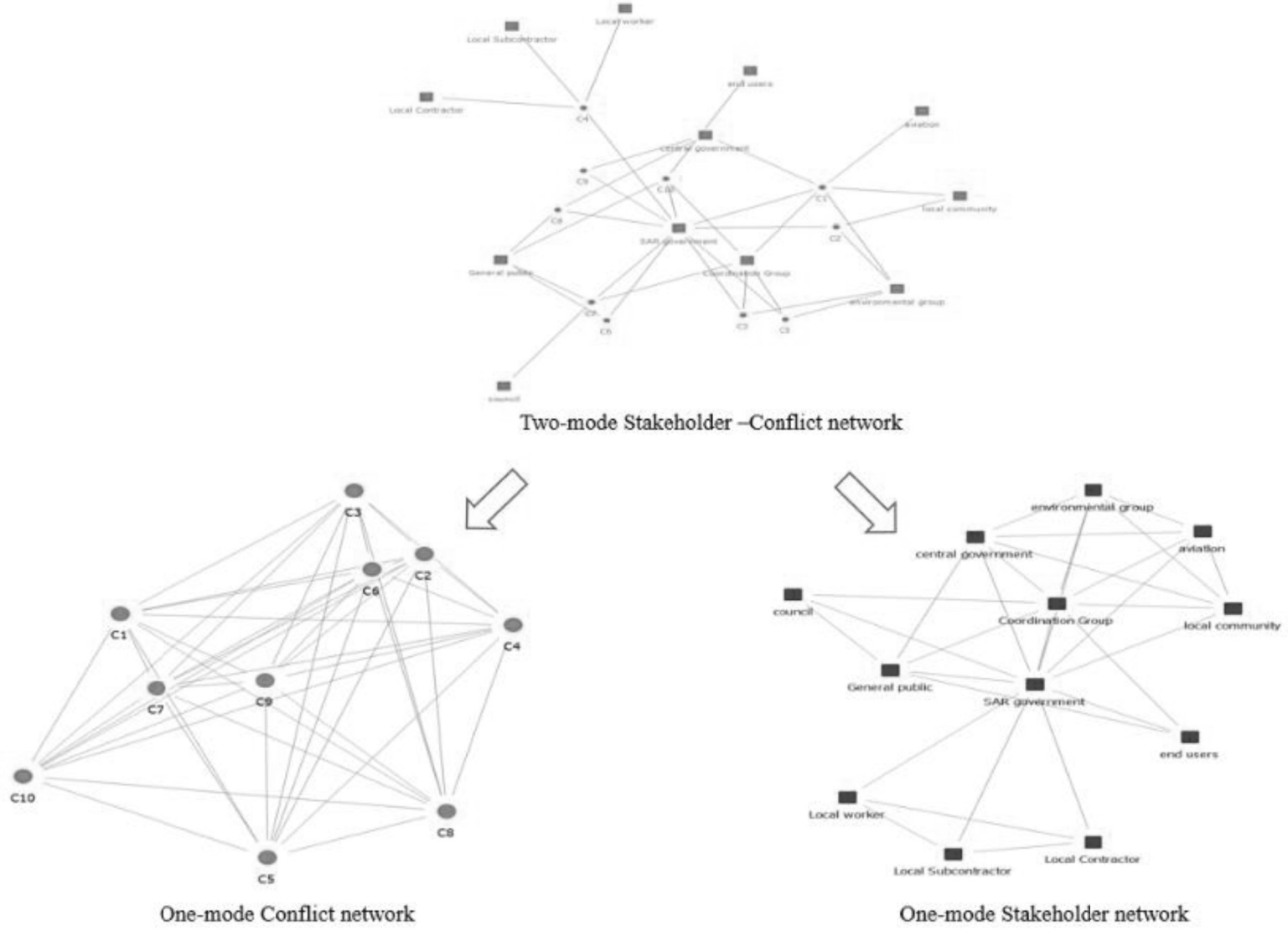

Figure 1 The projection of the two-mode stakeholder-conflict network

Figure 2

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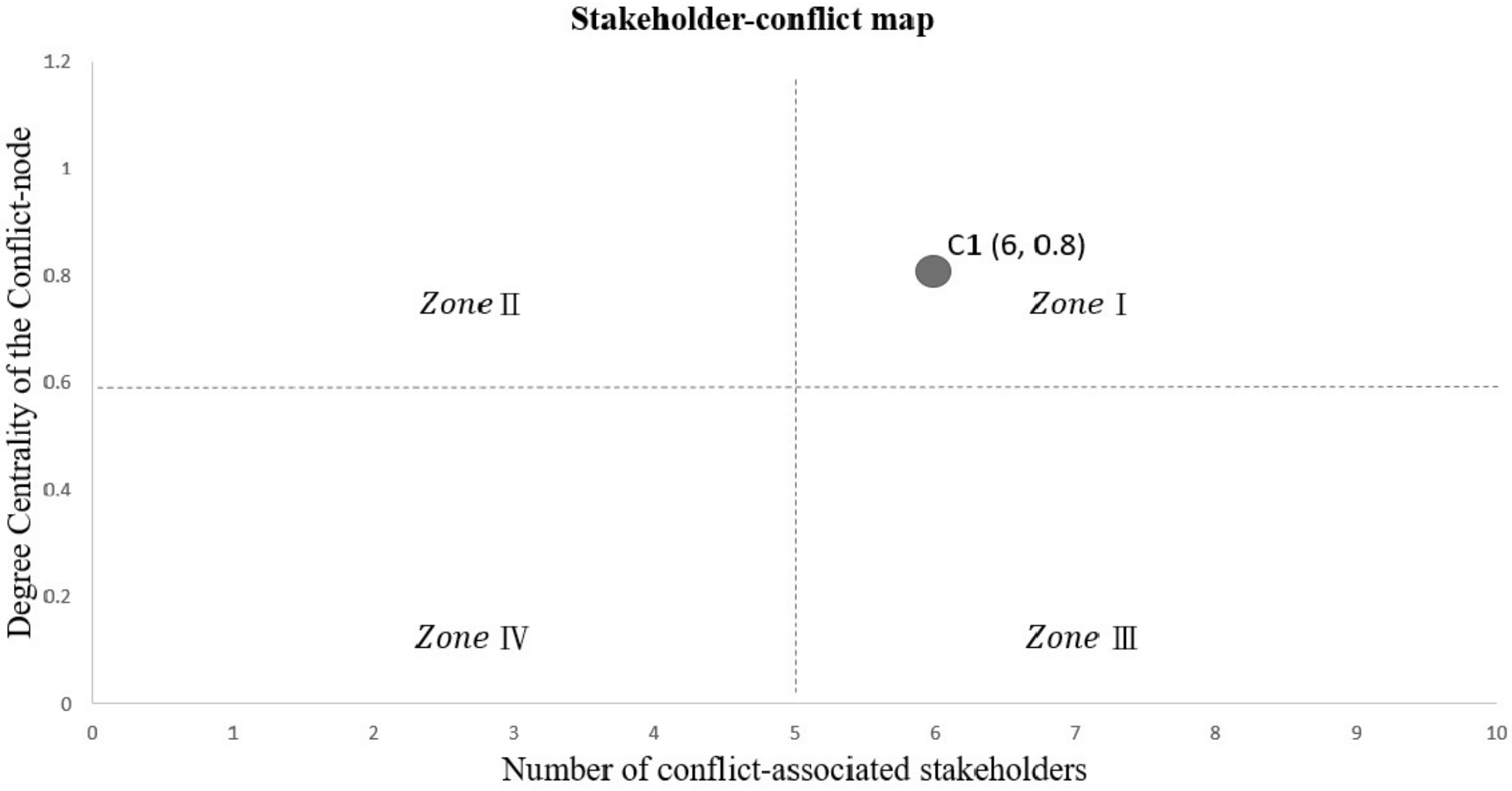

Figure 2 The stakeholder-conflict map analysis

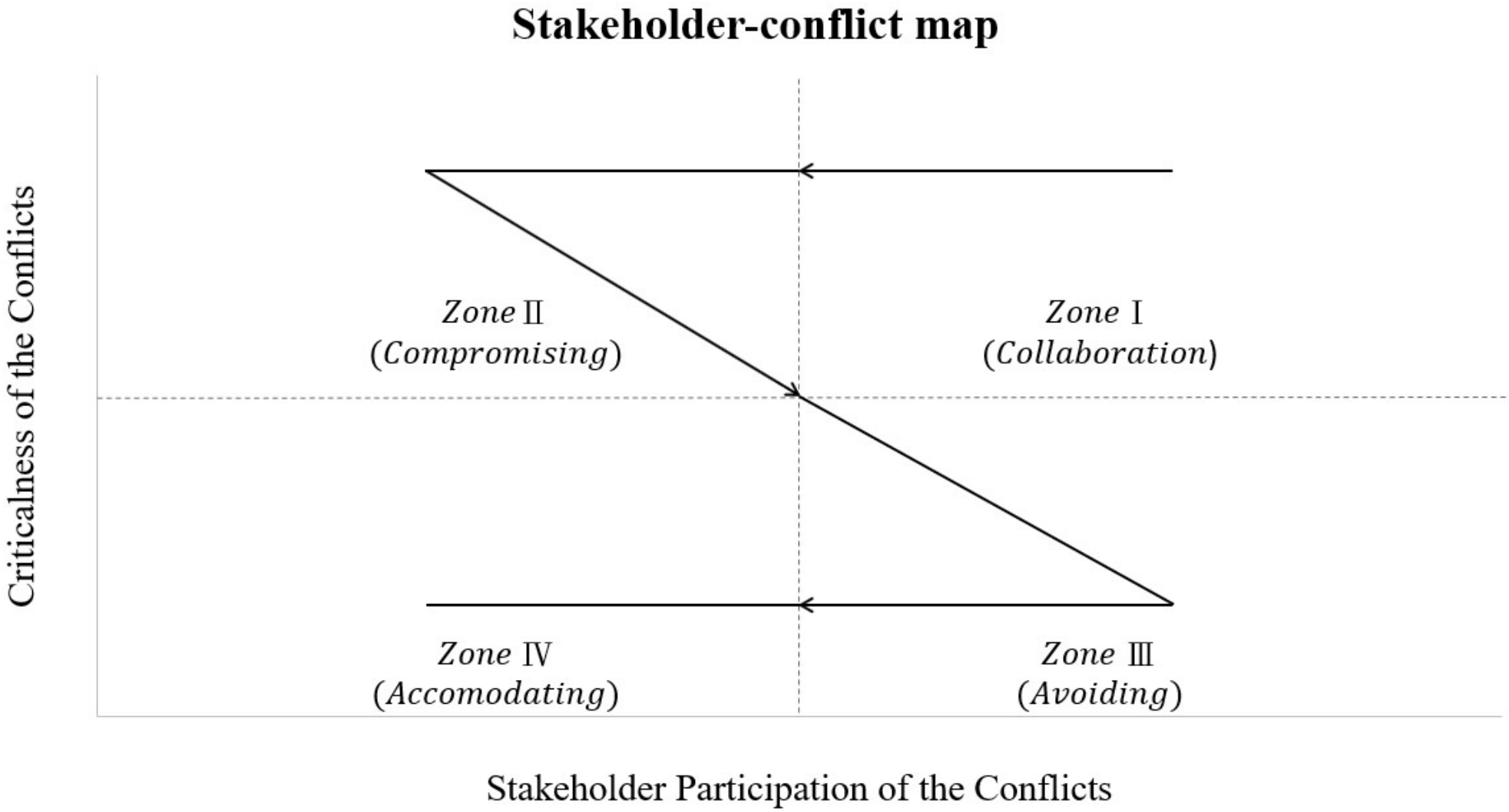

Figure 3 “Mirror Z” approach for stakeholder conflicts in the megaprojects

Figure 4

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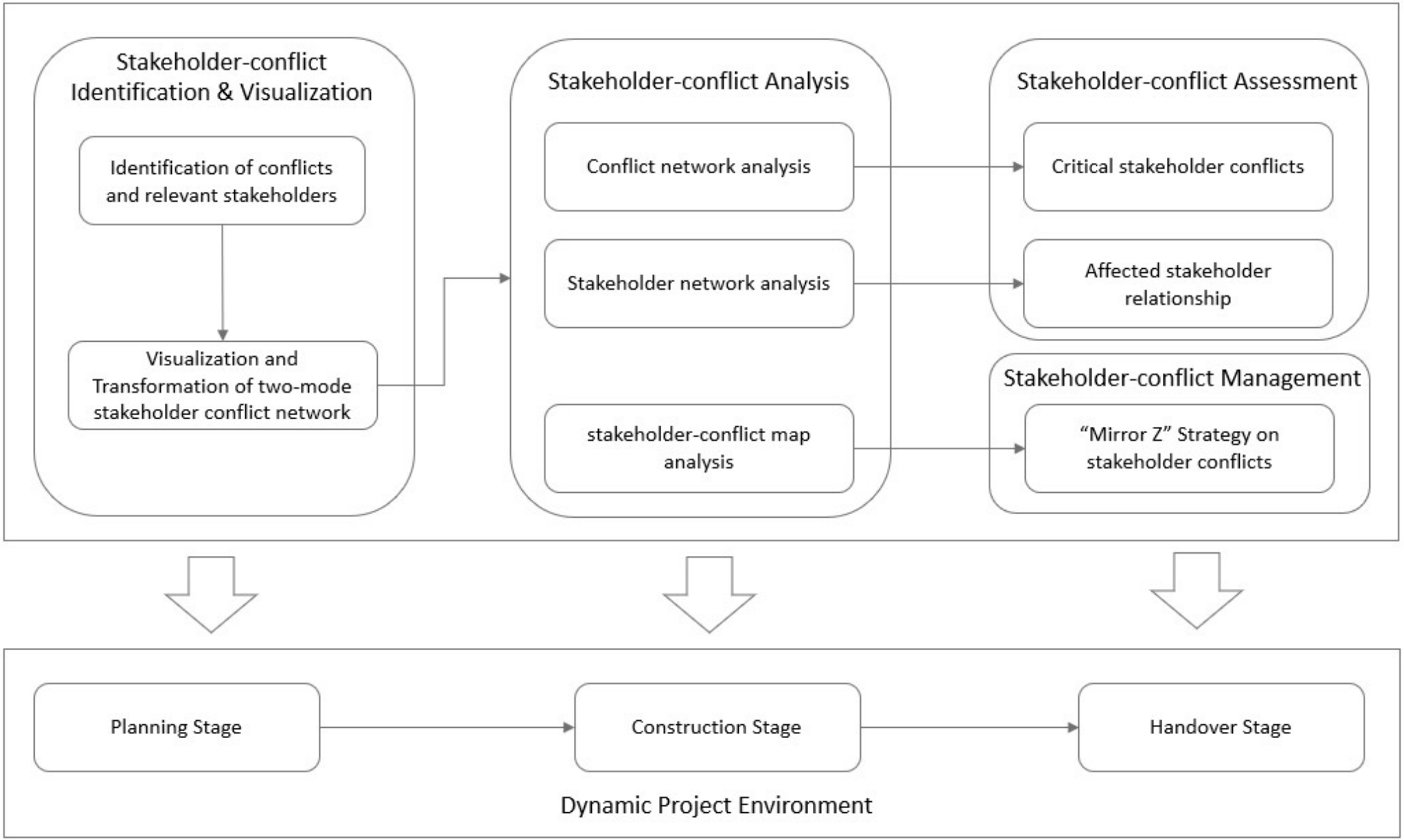

Figure 4 Framework of dynamic network analysis on stakeholder conflicts

Figure 5

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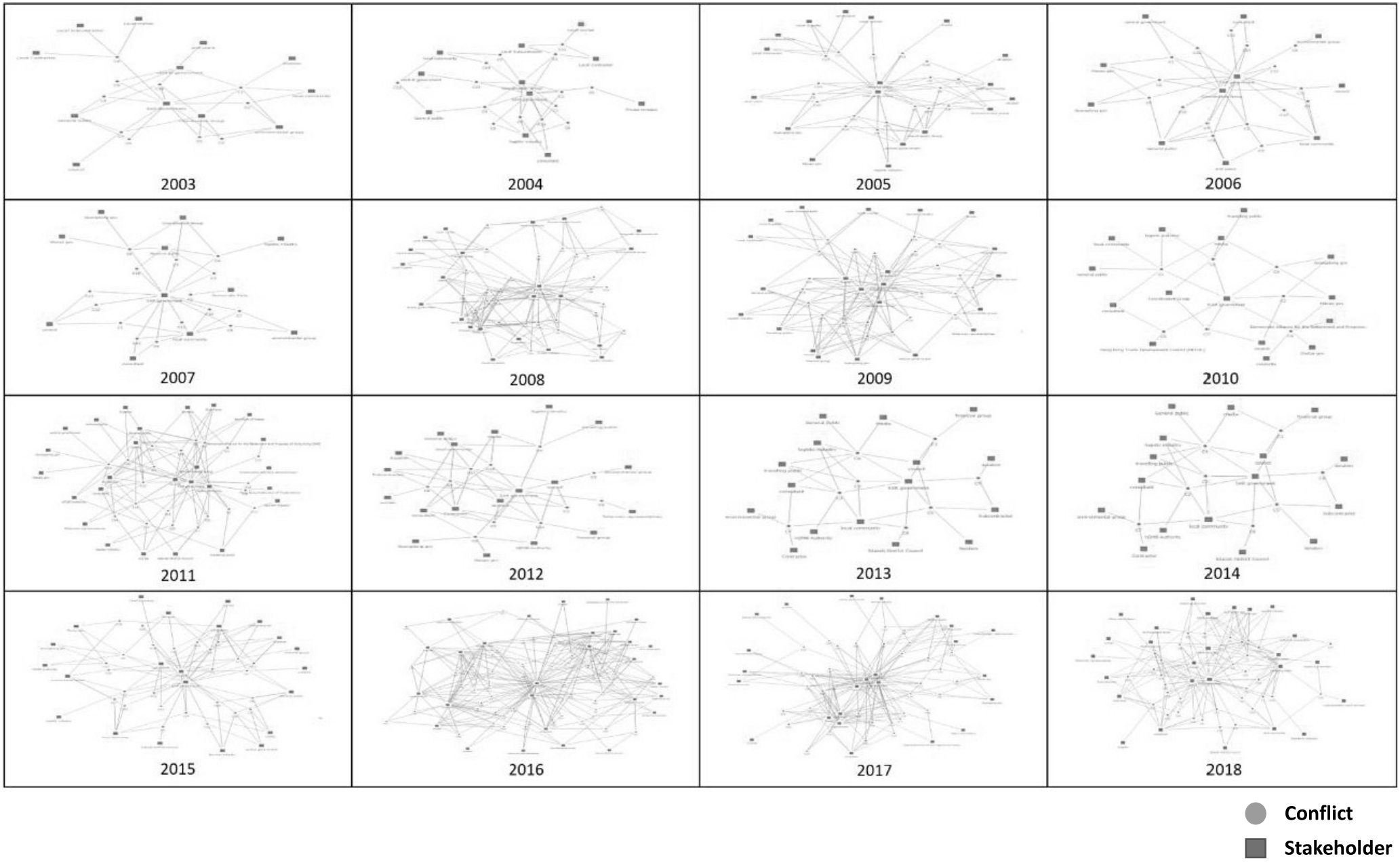

Figure 5 The two-mode stakeholder conflict networks on HZMB from 2003 to 2018

Figure 6

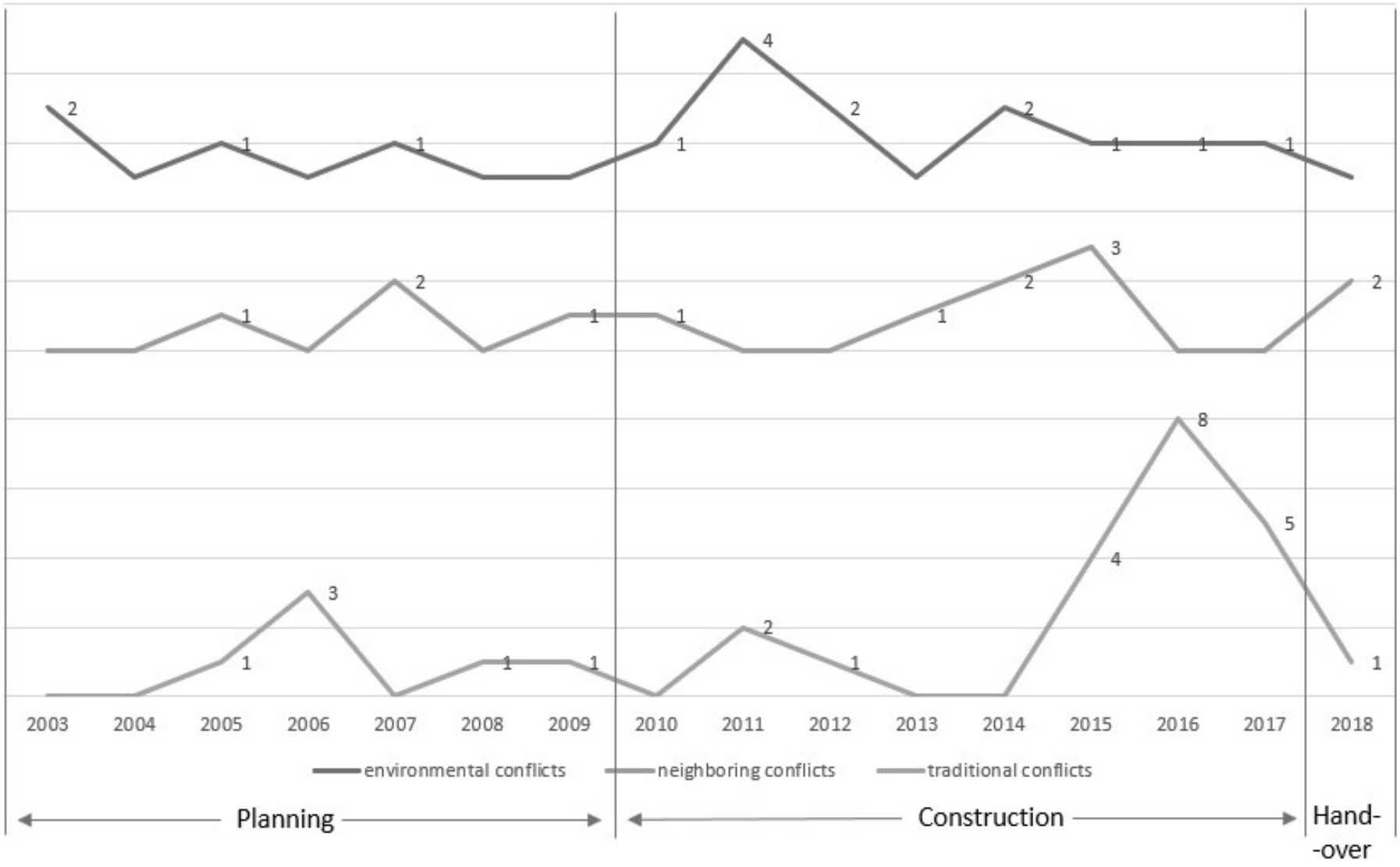

Figure 6 The number of annual critical conflicts from 2003 to 2018

Appendix 1

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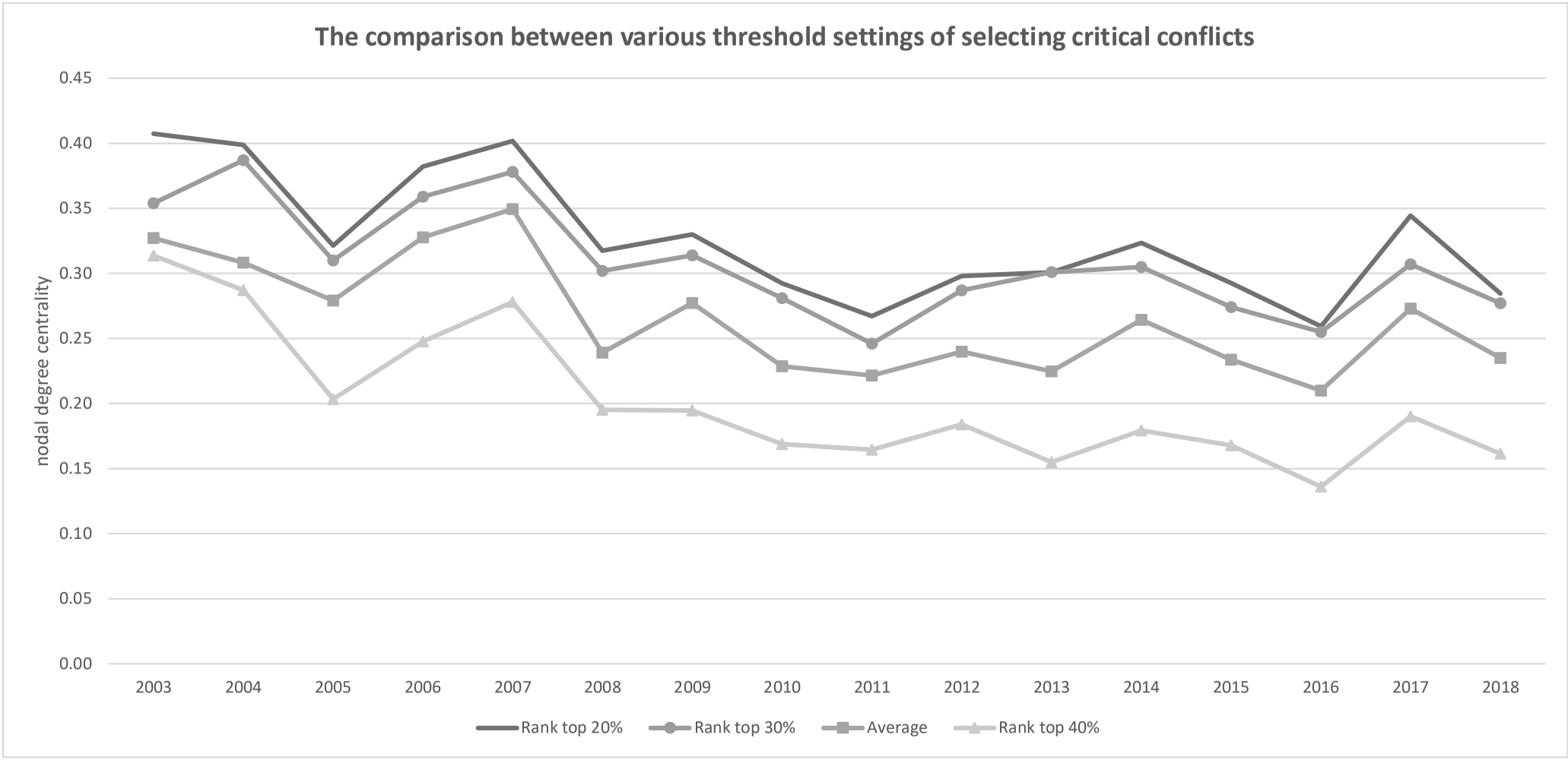

Appendix 1 The comparison between various threshold settings of selecting critical conflicts

Appendix 2

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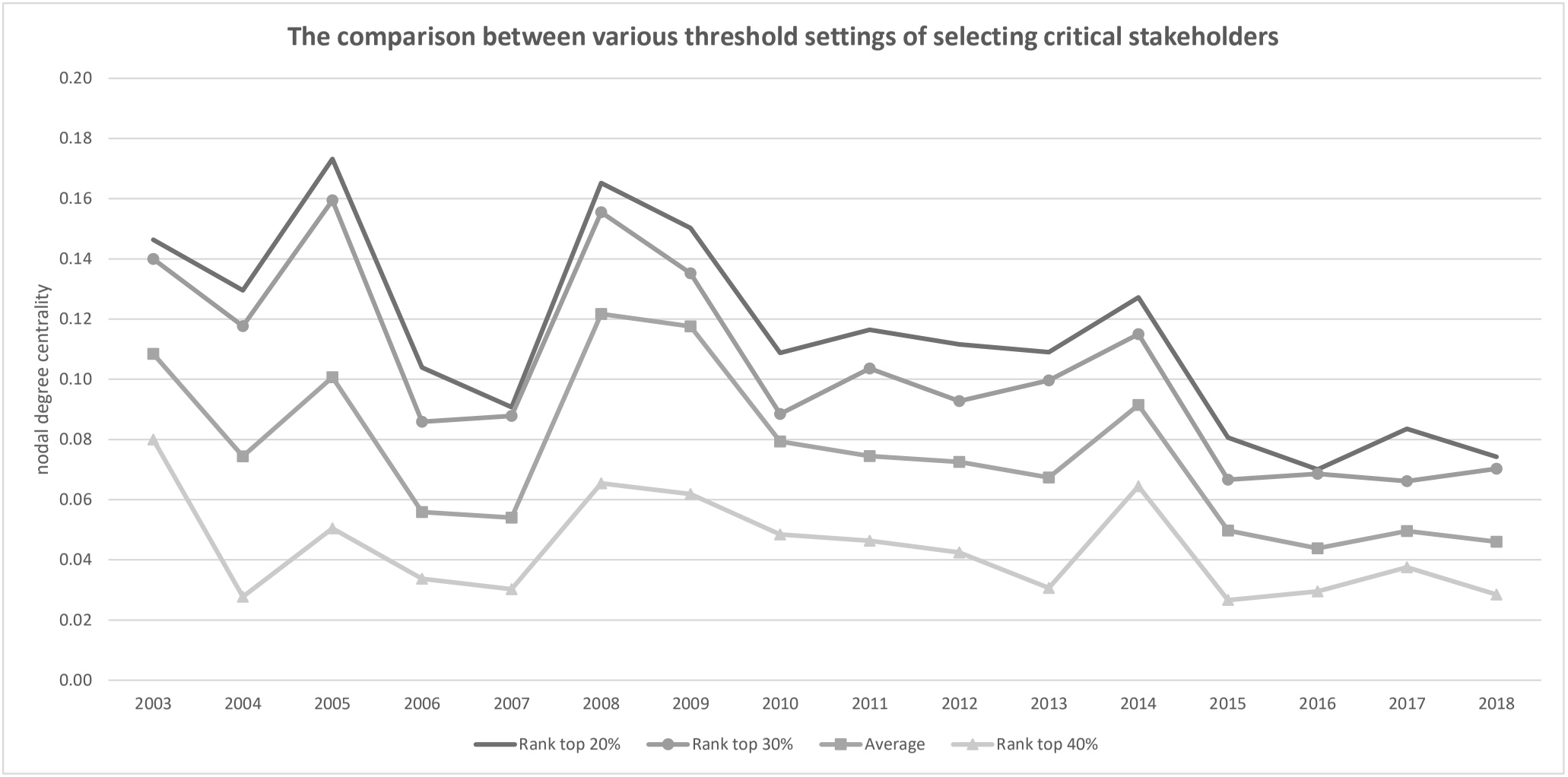

Appendix 2 The comparison between various threshold settings of selecting critical stakeholders

Figure Caption List