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1 **Managing Participants' Behaviours: A Framework to Improve** 2 **the Process Efficiency of Public-Private Partnerships**

3 **Xiaowei Dong¹, Yali Du², Henry J. Liu³, Michael C.P. Sing⁴ and Jin Wu⁵**

4

5 **Abstract:** Public-Private Partnerships (PPPs) are critical for delivering infrastructure assets
6 worldwide. They encompass a variety of public and private organisations and, therefore, the
7 participants' behaviours can significantly affect the life-cycle performance of the projects.
8 However, extant literature lacks attention to investigating the process efficiency of PPPs from
9 the behavioural and economic perspectives. Thus, we developed a managerial framework in
10 this study, which is pivotal to understanding and managing the relationships between the
11 participants' behaviours and project process efficiency in PPPs. By using the Social Network
12 Analysis, a total of two case studies of transport PPPs have been undertaken to examine and
13 refine the developed paradigm. This study expands the knowledge of the organisational
14 management of PPPs and is useful for enhancing the project's delivery through an improved
15 management of the participating organisations' behaviours.

16

17 **Keywords:** PPPs, Infrastructure projects, Participant behaviour, Process efficiency, Case study

18

19

¹ PhD, Lecturer, School of Economics and Management, Changshu Institute of Technology, 99 South Third Ring Road, Changshu, Jiangsu 215500, P.R. China, Email: xiaowei_d@126.com

² PhD, Lecturer, School of Investment and Construction Management, Dongbei University of Finance and Economics, 217 Jianshan Street, Dalian, Liaoning 116025, P.R. China, Email: duyali@dufe.edu.cn

³ PhD, Assistant Professor, School of Design and the Built Environment, University of Canberra, 11 Kirinari Street, Bruce, ACT 2617, Australia, Email: henry.liu@canberra.edu.au

⁴ PhD, MASCE, Associate Professor, School of Architecture and Built Environment, The University of Newcastle, Callaghan, NSW 2308, Australia, Email: michael.sing@newcastle.edu.au

⁵ PhD, Lecturer, School of Investment and Construction Management, Dongbei University of Finance and Economics, 217 Jianshan Street, Dalian, Liaoning 116025, P.R. China, Email: wujin@dufe.edu.cn

20 **Introduction**

21 Public-Private Partnerships (PPPs) have been adopted worldwide to procure infrastructure
22 assets, due to the era of austerity. For example, in Australia and the United Kingdom (UK),
23 many social and economic infrastructure PPP projects have undergone financial close since
24 2012 (e.g., public housings, schools, roads, social care centres and hospitals) (HM Treasury,
25 2013; WA Department of Treasury, 2015). In China, delivering infrastructure assets via PPPs
26 is dated back to the 1980s and there has been a sequence of PPPs initiated over the past five
27 years. PPPs are beneficial for infrastructure projects through not only financing but also the
28 expertise of management and technologies from the private sector (Yong, 2010; Pu *et al.*, 2020).

29
30 The use of PPPs, however, has been being plagued with controversy in the last two decades, as
31 they have been prone to experience inefficient delivery and unsatisfactory process management
32 (Liu *et al.*, 2018a). This has led to a reduced value for money (VfM) provided for taxpayers.
33 For example, the *Southern Cross Station*, Melbourne, and the *Eastern Goldfield Regional*
34 *Prison* in Western Australia were subjected to construction schedule overrun of more than 2
35 years. In the UK, 30% of PPPs were subjected to schedule overrun as a result of delayed pre-
36 construction or construction stages (UK Treasury Committee, 2011).

37
38 PPPs comprise a variety of organisations from the public and private sectors, which are essential
39 for the life-cycle performance of the projects (Love *et al.*, 2015). As such, a defining feature of
40 PPPs relates to the sophisticated stakeholder networks and a complex transaction and
41 development process (Liu *et al.*, 2018b). Thus, the theoretical base underpinning PPP research
42 is relevant to the theories of agency, transaction cost and stakeholder management, which are
43 originated from behavioural economics (Derakhshan *et al.*, 2019). Such theories have been used
44 in a wider context with an attempt to explain the participants' behavioural impacts on project

45 performance (Zwikael and Smyrk, 2015). This places a sound context (behavioural economics)
46 to further exploit and examine how the performance of PPPs (delivery efficiency) can be
47 determined by key participants' behaviours. But extant literature lacks empirical evidence of
48 improving PPP delivery by managing key participants' relationships from the behavioural
49 science perspective (Kivilä *et al.*, 2017; Liu *et al.*, 2018a). In acknowledging this void, this
50 study aims to develop a framework that is useful for managing the behaviours of the participants
51 (e.g., public authority and private entity) to improve the project process efficiency of PPPs. The
52 process efficiency concept in this case emphasizes the efficiency of the project implementation
53 process. According to Dong *et al.* (2018), an effective cooperation enables process efficiency,
54 which is an integrated part of production efficiency. The contributions of this study are twofold:
55 (1) identification of the relationships between the behaviours of the participating organisations
56 and the process efficiency in PPPs; and (2) a new paradigm for managing such relationships.

57

58 **Literature Review**

59 ***Public-Private Partnerships (PPPs)***

60 PPPs are fundamentally viewed as the long-term contractual arrangements formed between the
61 public and private sectors for the delivery of infrastructure projects and the provision of the
62 assets' public services (European Investment Bank, 2011). They have been a critical vehicle
63 for delivering public projects, due to the following benefits to be provided: (1) timely project
64 implementation; (2) reduced life-cycle cost and government risks; and (3) improved service
65 quality and public fund management (European Commission, 2003).

66

67 With the advantages above, a plethora of studies have been undertaken to manage PPPs over
68 the past decade. They have been focused on the following areas: (1) critical success factors
69 (e.g., Hardcastle *et al.*, 2005; Osei-Kyei and Chan, 2015); (2) concessionaire selection (e.g.,

70 Zhang, 2004; 2005); (3) project efficiency under different contracts (e.g., Zietlow, 2005;
71 Raisbeck *et al.*, 2010); (4) roles and responsibilities of governments (e.g., Soomro and Zhang,
72 2013; Wu *et al.*, 2016); (5) PPP performance evaluation (e.g., Yuan *et al.*, 2009; Teo and
73 Bridge, 2016; Liu *et al.*, 2018a,b); (6) project finance (e.g., Regan *et al.*, 2011; Engel *et al.*,
74 2013); (7) project risk management (e.g., Wu *et al.*, 2020). Furthermore, in PPPs, stakeholders
75 are individuals or organisations that are either affected by or affect the development of the
76 projects. The participants (or called stakeholders) may include clients, project managers,
77 supplies, funding bodies, end-users and the community at large (Newcombe, 2013). According
78 to De Schepper (2014), an early involvement of stakeholders becomes important and also keeps
79 them throughout the project cycle. Stakeholder management thus play an important role in
80 PPPs, especially in understanding and managing the relationships between the stakeholders
81 (i.e., participants' behaviour) and the project's process efficiency.

82

83 ***Theories and Conceptual Perspectives of PPPs***

84 ***PPP Participating Organisations' Behaviours***

85 Based on the "*Hypothesis of Economic Man*", profit is a fundamental stimulating private
86 organisations to run businesses. In this stance, the self-interest of private entities is an incentive
87 for them to pursue the efficiency of public project delivery. It is identified from the Hypothesis
88 of Economic Man that there is a 'mismatch' between risks and profits when the business process
89 of PPPs is not 'perfect'. Risk-free-profit opportunities can occur in certain circumstances,
90 resulting in participants' opportunistic behaviour to maximise their profits.

91

92 Apart from self-interest and opportunism, PPPs are underpinned by a collaboration between the
93 participants from the public and private sectors (Yong, 2010). Hence, cooperative behaviour is
94 acknowledged as being pivotal for the delivery of PPPs. In this case, a sequence of assumed

95 restrictions regarding cooperation has been imposed. These include, in a PPP: (1) there are some
96 degrees of cooperation between the involved organisations that are connected by formal
97 contracts; (2) if two organisations within a *Special Purpose Vehicle* (SPV) (i.e., between main
98 concessionaire and subcontractors) do not have a direct contractual arrangement, but the
99 specific works under the project requires their joint action or decision making, a cooperation
100 exist in between them; (3) the administrative affiliation between the involved public authorities
101 is also considered to be a form of cooperation; and (4) there is a particular (i.e., direct or indirect)
102 form of cooperation existing in any two organisations within the SPV.

103
104 The behaviours and assumptions identified above are also aligning with the bounded rationality
105 of the Behavioural Economics. The bounded rationality describes that: (1) participants'
106 behaviour in an organisation (i.e., project) can be either rational (i.e., self-interested behaviour
107 and cooperation) or irrational (opportunistic behaviour) in a long-term context (i.e., 20- to 30-
108 years project cycle); and (2) their decisions probably bring present benefits but cause relevant
109 costs in the future, thereby leading to a compromise between long-term (cost) and short-term
110 (interest) benefits, which is referred to as the opportunistic behaviour (Baumeister, 2002).

111
112 *Delivery Process Efficiency and Pareto Optimality*
113 Efficiency, which describes the degree of consuming resources and reflects project actual
114 duration and quality, is a major concern of this study. The public authority of a PPP safeguards
115 the allocative efficiency of public resources, while the private-sector entity enables the
116 efficiency of project delivery and use of allocated public sources (Wu *et al.*, 2016). Considering
117 this point of view, the concept of process efficiency originated from the Pareto Efficiency (i.e.
118 Pareto Optimality) has been applied. The Pareto Optimality is unobservable in empirical
119 modelling. However, the allocation of resources generated by the market can be viewed as being

120 efficient (i.e., Pareto optimal) if there is no alternatively feasible resource allocation (Stiglitz,
121 1981). Theoretically, there is a set of conditions (e.g., complete competition and information,
122 zero transaction cost and externality) needed to be satisfied within a price system to efficiently
123 coordinate economic activities. Once these conditions are met, the ‘links’ between participants’
124 behaviours and business process efficiency will be enhanced. However, if economic activities
125 are impelled to be away from above conditions, process efficiency will deviate from the Pareto
126 Optimality. Put simply, there is an inverse relationship between process efficiency and the
127 ‘room’ of Pareto Improvement, i.e., the larger ‘room’, the lower process efficiency.

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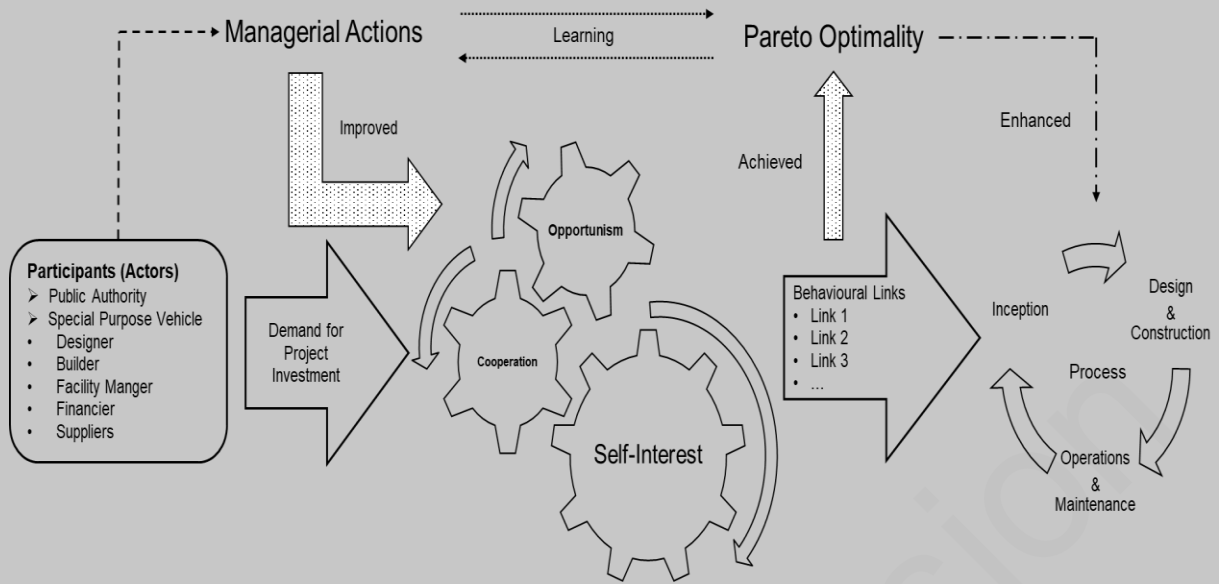
129 ***Developing a Conceptual Framework to Improve Process Efficiency***

130 According to the theories and conceptual aspects above, a total of three types of participants’
131 behaviours (e.g., self-interest, opportunistic and cooperative) can be identified in PPPs, which
132 may significantly influence the efficiency of the project’s delivery process. Furthermore, the
133 participants engaging in a PPP will be interacted with each other over the project’s lifecycle.
134 Such participating organisations and their interdependencies can be referred to as the ‘actors’
135 and ‘links’ as per the networks and graph theories. Considering the perspective of the Pareto
136 Optimality, a conceptual framework is developed for PPPs (Figure 1), which incorporates the
137 relationships amongst the organisational behaviours in terms of self-interest, opportunism and
138 cooperation as well as process efficiency and the Pareto Improvement.

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140

141



142

143 Figure 1. Conceptual framework for managing participants' behaviours to enhance process

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145 **Research Methodology**

146 The case-study approach is applied to examine the developed conceptual framework, as it has
 147 been acknowledged as being suitable for all stages of a research process, cascading from
 148 hypothesis generation to paradigm testing (Flyvbjerg, 2006; Gerring *et al.*, 2016). Moreover,
 149 the Social Network Analysis (SNA) has been selected for the case studies. SNA is robust in
 150 indicating social attributes and processes by developing an interactive perspective simulating
 151 and visualising sophisticated phenomena (Knoke, 2013). It is suitable for interpreting the
 152 projects with complex stakeholder networks and, therefore, has been widely applied to PPP
 153 research (He *et al.*, 2018). The group structure within the SNA is described by relationships,
 154 which refer to the interactions between individuals. Hence, the SNA consists of a set of nodes
 155 (also known as the actors) connected by multiple 'links'. In PPPs, the project's participating
 156 organisations (i.e., participants) are viewed as the 'actors' and their behavioural interactions are
 157 considered as the 'links' in the SNA.

158

159 We designed a SNA-oriented process for this study with the following stages: (1) selection of
160 case projects; (2) identification of the behavioural networks of the selected projects using the
161 SNA; (3) evaluation of the characteristics of the networks; (4) a further analysis applying the
162 *Quadratic Assignment Procedure* (QAP) regression. This process focuses on the three types
163 of behaviours (e.g., self-interest, opportunism and cooperation) presented above, which are
164 interconnected by the ‘links’ represented as an adjacency matrix. Besides, the ‘centrality’ of
165 SNA has been adopted. It measures the degree to which the ‘actors’ are involved within the
166 ‘links’ as illustrated by Figure 1 (Freeman *et al.*, 1991). Through the centrality, the influence
167 of the participants on the behavioural network can be quantitatively determined. In this stance,
168 if the public sector has a greater influence on the network, the project is regarded as the public-
169 sector-led PPP. Otherwise, it is viewed as the private-sector-led PPP where the private entity
170 has more ‘power’ to deliver the asset. Notably, the ‘outdegree’, ‘indegree’ and ‘betweenness’
171 centralities was used to examine the participants’ impacts. While the ‘outdegree centrality’
172 indicates the degree to which one participant sends behaviour to others, the ‘indegree centrality’
173 describes the extent to which this participant receives behaviour from others. However, the
174 ‘betweenness centrality’ describes the ability of one participant to contact others. Having
175 evaluated and compared the centralities of the chosen case projects could help to identify series
176 of relationships between the behavioural variables and process efficiency of PPP projects.

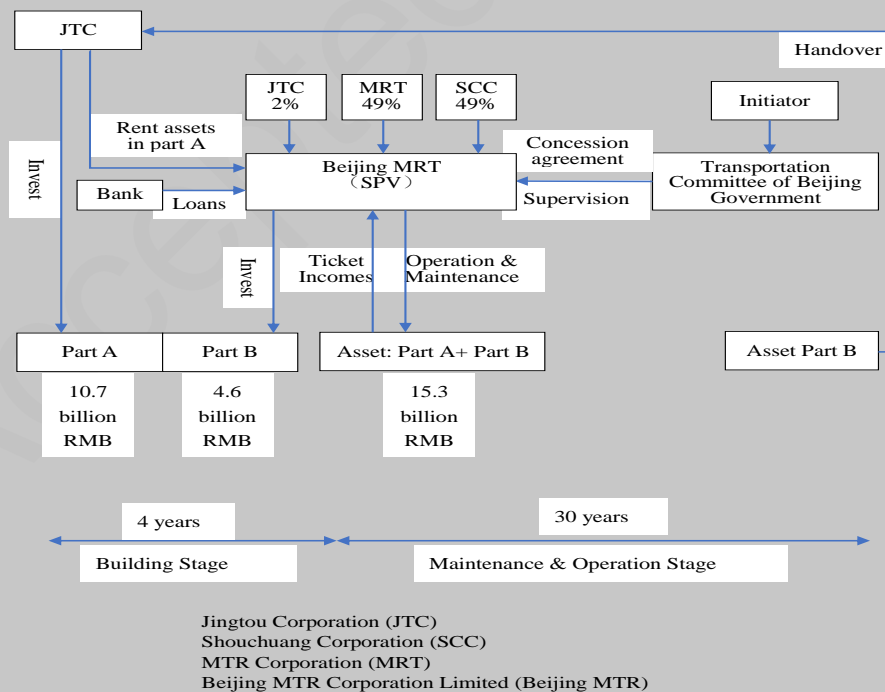
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178 Two transport PPPs have been selected for case studies, including the *Beijing Subway Line 4*
179 and *Hangzhou Bay Bridge*. The cases were selected against three criteria: (1) the selected
180 projects are under same scheme with similar structure (i.e., project type and payment
181 mechanism); (2) the projects significantly influence local development, which is justified on
182 the basis of the investment value and utility; and (3) the projects are currently in operations.

183

184 The chosen projects are under the BOT (Build-Own-Transfer) arrangement with a user-charge
 185 payment mechanism for a concession period of 30 years (Figure 2). The demand risks of the
 186 projects have been transferred to the private-sector entities. The total investment of both
 187 projects exceeded RMB ¥10 billion (US\$145 million), which has been acknowledged as being
 188 significant for local economy. The projects have been operated since 2008 and 2009,
 189 respectively. Essentially, the Beijing Subway Line 4 is acknowledged as a successful PPP due
 190 to its cost efficiency and quality services (Wu *et al.*, 2016). However, the Hangzhou Bay bridge
 191 was subjected to legal disputes and changes of private contractors. Its traffic volume is much
 192 lower than expected, failing in meeting the predetermined profits. Thus, the project is relying
 193 on financial subsidies of the local government and has been reported by local public media as
 194 an unsuccessful PPP. As indicated by Tables 1 and 2, a total of 16 and 13 participants are
 195 engaging in the Beijing Subway Line 4 and Hangzhou Bay Bridge projects.

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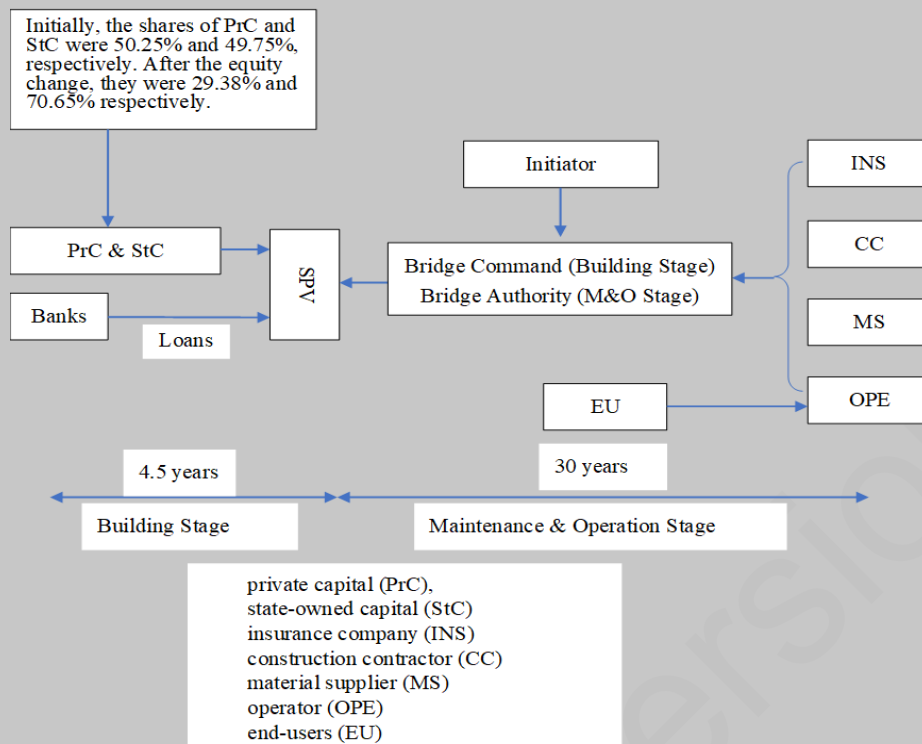


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a. Project structure of the Beijing Subway Line 4

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a. Project structure of the Hangzhou Bay Bridge

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Figure 2. Structure of the chosen case projects (Adapted from Wu *et al.*, 2016)

203

204

Table 1. The information of participants in the two case projects

Participants	Sector	Description in corresponding projects
Public Authority/Client	Public	The public authority perceives the need for a project and determines whether the project is suitable for being financed on a PPP basis. In some cases, governments will provide the projects with support in some forms (e.g. land provision, incentives for investment and grant of license).
Initiator	Public	The initiator of a PPP project in China is host government. For example, the initiators of the two case projects are the municipal governments (e.g. Beijing and Hangzhou cities).
Sponsors	Public/Private	The project sponsors are referred to as the financiers. The Jingtou Corporation, Shouchuang Corporation and MTR Corporation are three sponsors in the Beijing Subway Line 4. As a representative of the MRT, the MRT-4-line company (MRT-4) directly participates in the daily operation of the formed SPV. And the state-owned capital and private capital are summarized as the sponsors of the Hangzhou Bay Bridge.
SPV	Private	The SPV is capitalized by the sponsors through equity funding, and their relationship is defined by a shareholders' agreement.
Private Investors	Private	The SPV comprises of private equity investors other than sponsors. The MRT Corporation is one of the private investors in the Beijing Subway Line 4, and the PrC illustrated in Figure 4 above is the private investor financing the project of Hangzhou Bay Bridge.

General Contractor	Private	The two case projects were integrated with a construction contractor, the suppliers of equipment and material and an asset operator. They are appointed by the SPVs in accordance with the fixed price turnkey contracts.
Suppliers	Private	
Operator	Private	
Banks	Private	The banks fundamentally finance projects on either a non-recourse or a limited recourse basis. This means that they are only concerned with revenues of the projects. The banks of the chosen projects have evaluated whether the projects' finances are robust to attract non-recourse finance.
Insurers	Private	Insurance is a risk mitigation strategy in PPPs. In addition to risk transfer, the implication of the potential impacts of the identified risk is captured at risk premium. Sponsors made decisions for selecting insurance instruments to mitigate risks, such as owner's liability and/or force majeure events. Also, insurance will lead to the Moral Hazard and Adverse Selection.
Public Purchaser	Public	Risk sharing mechanism has been applied to both case projects. This implies that financial subsidies have been agreed by local municipal governments, if the actual traffic volumes of the projects are under expectation. In other words, the host governments are acting as the public purchaser within the context of the Beijing Subway Line 4 and Hangzhou Bay Bridge. Bearing this in mind, public purchaser is viewed as an independent participant in the case study.

205

206

Table 2. The abbreviations of the participants of two case projects

The Beijing Subway Line 4 Project		The Hangzhou Bay Bridge Project	
Participants	Abbr.	Participants	Abbr.
Public Authority/Client	PuA	Public Authority/Client	PuA
Initiator	INI	Initiator	INI
Special Purpose Vehicle	SPV	Special Purpose Vehicle	SPV
Jingtou Corporation	JTC	State-owned Capital	StC
MTR Corporation	MTR	Private Capital	PrC
Shouchuang Corporation	SCC	Material Supplier	MS
MTR-4-Line company	MTR-4	Construction Contractor	CC
Equipment supplier	ES	Operator	OPE
Material supplier	MS	Bank	BAN
Construction Contractor A	CCa	Insurer (insurance company)	INS
Construction Contractor B	CCb	(Asset) End-Users	EU
Operator	OPE	Public purchaser	PuP
Bank	BAN		
Insurer (insurance company)	INS		
(Asset) End-Users	EU		
Public Purchaser	PuP		

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210

211 The data collected for the case study of this paper relate to the four variables of the chosen
212 projects: (1) cooperative behaviour; (2) self-interested behaviour; (3) opportunistic behaviour;
213 and (4) process efficiency. As the documentary sources available are adequate, the archival data
214 method was adopted. This approach enables data collection to be conducted in a cost-effective
215 and efficient way, which covers the whole lifecycle of a PPP, cascading down from project
216 preparation to operation and maintenance.

217

218 The SNA in this research is based on an adjacency matrix (Appendix 1). The structural variables
219 (e.g., self-interested, opportunistic and cooperative behaviour) were measured by the pairwise
220 links between two actors, which are also the behavioural interactions to be observed. The links
221 between the actors in relevant adjacency matrix is represented as '1', otherwise '0'. The variable
222 of cooperation represents undirected relationships, and its adjacency matrix is thus symmetrical.
223 However, there is a directed relationship in both self-interested and opportunistic behaviours,
224 presenting an asymmetric adjacency matrix. For instance, the relationship between the initiator
225 (INI) and public client (PuA) is the authorities governing the Beijing Subway Line 4; thus, there
226 is a cooperative connection between them. Thus, the link between them in its matrix is assigned
227 to '1'. Furthermore, the SPV of the Beijing Subway Line 4 comprises JTC, SCC, and MTR,
228 which are profit-driven. In this stance, there is a self-interested link between each of them;
229 therefore, '1' is assigned to relevant links in the matrix. Notably, an elevator accident as a result
230 of the faults of MTR and ES was reported in the subway's operation. Hence, they can be
231 identified as the entities behaving opportunistically. Other participants associated with them are
232 passively exposed to the effects of their actions. Thus, '1' is assigned to these links in relevant
233 adjacency matrix.

234

235 The matrix of process efficiency described by the Pareto Optimality that reflects the efficiency
236 of the actors' links has also been constructed. By reviewing the grey literature such as official
237 audit reports issued by the Chinese governments, we identified whether a 'room' for the Pareto
238 Improvement exists in the delivery process of the projects. If existed, the value of the link will
239 be set to '-1' in the matrix. If there is no room existed, the value of the link will be assigned as
240 '1'. In a case where there is no linkage between the participants, the value of their links is '0'.
241 In summary, the process efficiency of the case projects was measured by using '-1' (low
242 efficiency linkage), '0' (no linkage) and '1' (high efficiency linkage). For example, after
243 examining the project documents of the Hangzhou Bay Bridge Project, "-1" was assigned to
244 the matrix of the SNA to reflects its low efficiency linkage between the PuA and SPV.

245

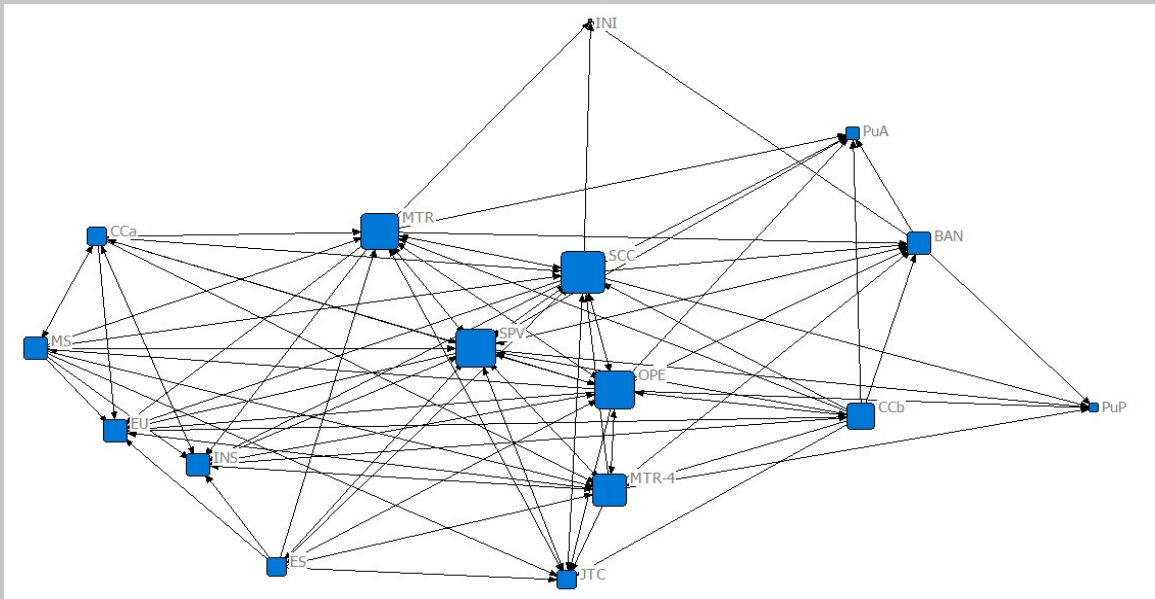
246 **Research Findings**

247 ***SNA-Findings: Network Characteristics of Self-interested Behaviour***

248 The SNA modelling was performed by adopting the software package of UCINET6. Figure 3
249 depicts the network of the self-interested behaviour of the two case projects. A large square
250 icon indicates that the corresponding participant has a high degree of centrality. Table 3 reports
251 the relevant indicators in terms of the centrality of all participants in both projects.

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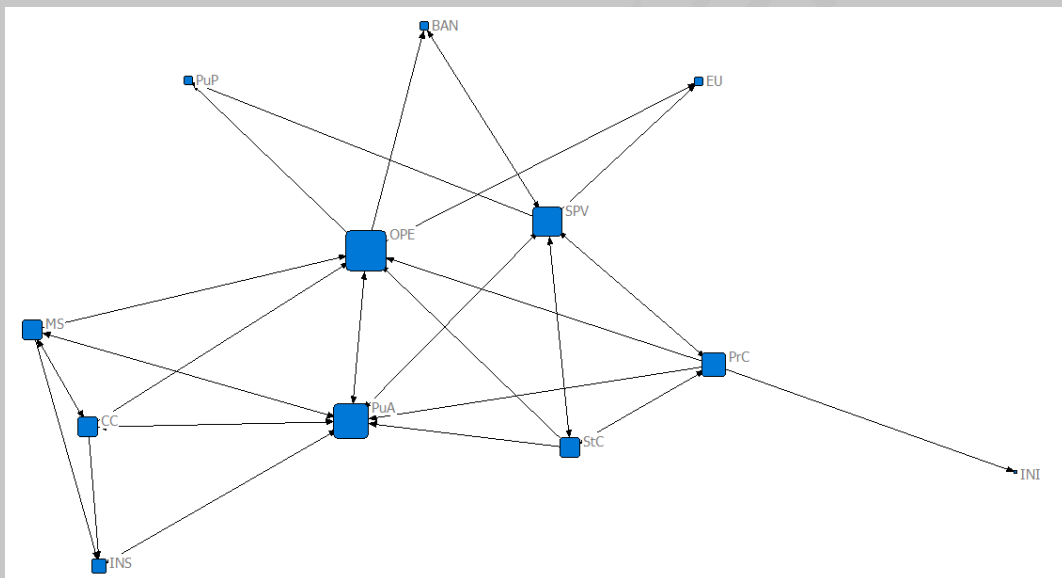
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a. Beijing Subway Line 4



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b. Hangzhou Bay Bridge

Figure 3. The networks of the self-interested behaviour of the case projects

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Table 3. The centrality of participants on self-interest behaviour

the Beijing Subway Line 4 project				the Hangzhou Bay Bridge project			
parties	OutDegree	InDegree	Betweenness	parties	OutDegree	InDegree	Betweenness
PuA	0	6.00	0	SPV	6.00	4.00	31.00
INI	0	3.00	0	PuA	5.00	7.00	35.67
SPV	12.00	11.00	5.84	PrC	5.00	2.00	8.67
JTC	8.00	3.00	0.44	StC	4.00	2.00	0.67
MTR	9.00	8.00	7.59	OPE	4.00	5.00	12.00
SCC	10.00	9.00	10.92	MS	4.00	2.00	0
MTR-4	8.00	7.00	3.80	CC	4.00	2.00	0
ES	8.00	2.00	0.43	BAN	1.00	2.00	2.00
MS	8.00	3.00	0.60	INS	1.00	3.00	0
CCa	8.00	4.00	0.19	INI	0	1.00	0
CCb	10.00	2.00	1.67	EU	0	2.00	0
OPE	14.00	7.00	5.84	PuP	0	2.00	0
BAN	4.00	6.00	3.17				
INS	5.00	9.00	0.72				
EU	0	9.00	0.72				
PuP	0	5.00	0				

Descriptive Statistics for Each Measure

Mean	6.19	6.19	2.62	Mean	2.83	2.83	7.50
Median	8.00	6	0.72	Median	4.00	2.00	0.34
Std Dev	4.43	2.70	3.20	Std Dev	2.15	1.62	12.19
Sum	99.00	99.00	41.91	Sum	34.00	34.00	90.00
Variance	19.65	7.28	10.27	Variance	4.64	2.64	148.47
Minimum	0	2.00	0	Minimum	0	1.00	0
Maximum	14.00	11.00	10.92	Maximum	6.00	7.00	35.67

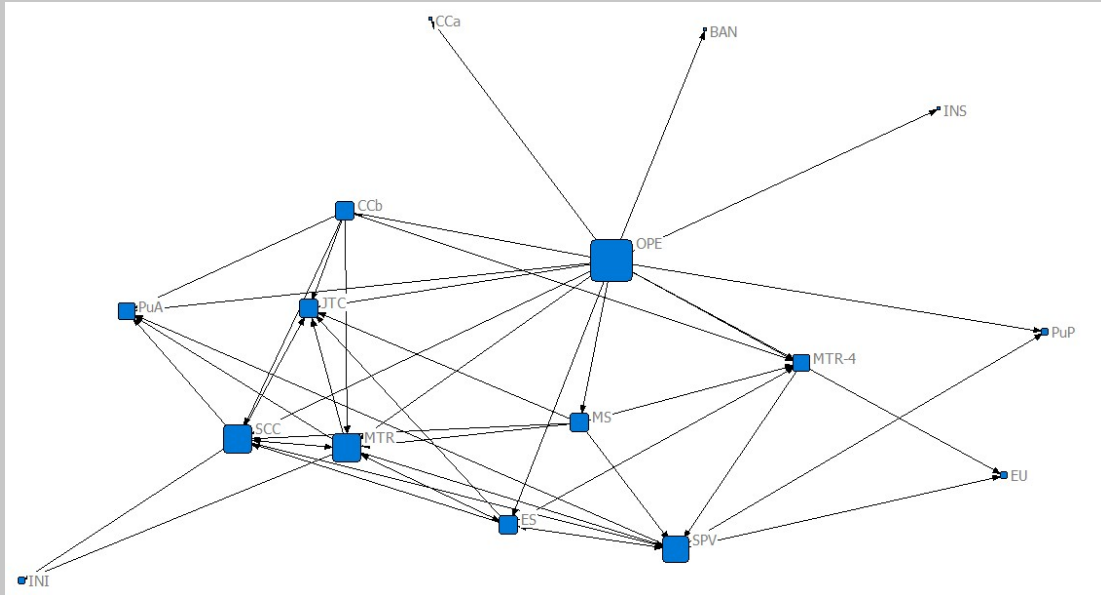
267 The mean and median values have been used for analysis. Regarding the outdegree centrality
268 indicators (Table 3), the top participants in the Subway project include OPE, SPV, CCb, SCC
269 and MTR. This implies that such organizations had a higher level of self-interest. The indegree
270 shows that the following participants have been ranked top, e.g., SPV, SCC, INS, EU, MTR
271 and OPE, which possess a higher prestige of self-interested behaviour, However, the
272 betweenness results reflect that the participants with more intensive self-interested behaviour
273 involve SPV, OPE, SCC, BAN and MTR. They dominated the link of the self-interest of other
274 participants. Further, the outdegree of the Bridge project reports the top-ranked participants
275 with an intensive self-interest, e.g., SPV, PuA and PrC. It is also noted from the indegree that
276 the ranking cascades down from the PuA and OPE to the SPV and INS. Similarly, the
277 betweenness indicators that the top-ranked participants include PuA, SPV, PrC and OPE. Based
278 on the centrality above, the government behaved more self-interestedly in the Hangzhou Bay
279 Bridge, while the private entity's self-interested behaviour is more active in the Subway project.
280

281 ***SNA-Findings: Network Characteristics of Opportunistic Behaviour***

282 According to the values of the outdegree (Figure 4 and Table 4), the top-ranked participants in
283 the Subway project encompass the OPE, MTR, CCb, SCC, MS, ES and SPV. Based on the
284 indegree, a series of participants expressed a higher-level prestige of opportunistic behaviour,
285 e.g. JTC, PuA, SPV, SCC, MTR, ES and MTR-4. Given by the betweenness, the participants,
286 e.g. OPE, SPV, SCC and MTR, overwhelmed others in the project. However, in the Bridge
287 project, the leading participants in the context of the outdegree include the CC, MS, PuA, PrC)
288 and StC. From the indegree perspective, a total of four participants have committed more to
289 opportunistic behaviour, e.g., PuA, BAN, SPV and INI. However, the top-ranked participants
290 in terms of the betweenness centrality are of PuA, CC, PrC and SPV. As indicated by Table 4,
291 the participants with intermediary functions play an important role in the governance of PPPs.

292 The two case projects share a common situation that the public sector acted as the “bearer” of
293 the opportunistic behaviour from the private sector. But, in the Hangzhou Bay Bridge project,
294 the public sector is also act as a ‘sender’ of opportunistic behaviour.

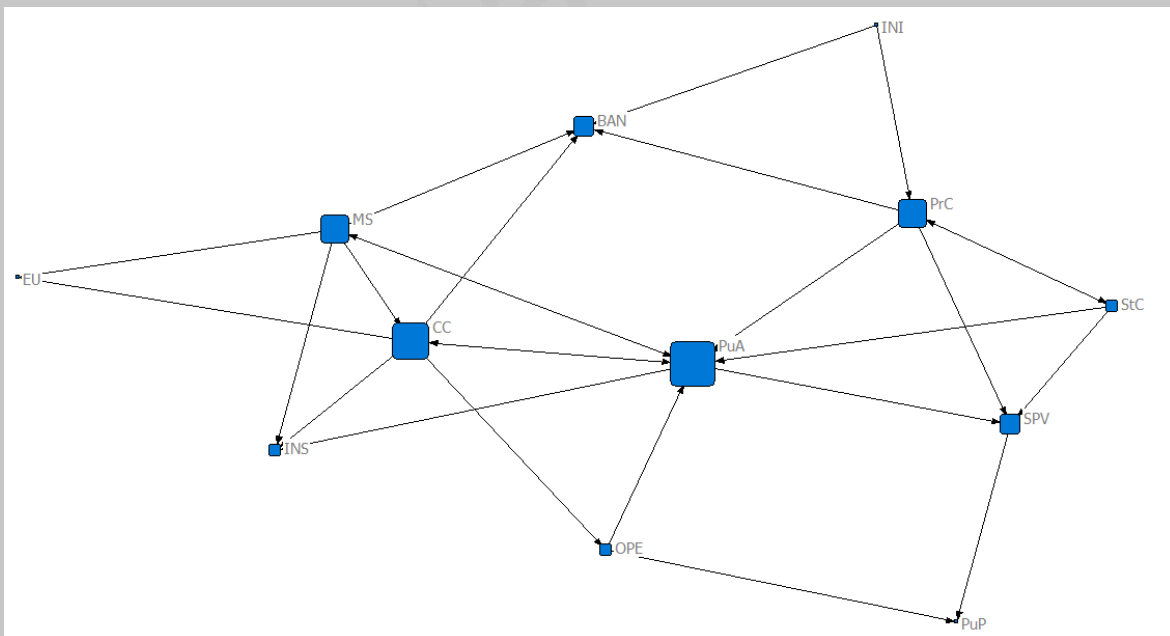
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296

297

a. Beijing Subway Line 4



298

299

b. Hangzhou Bay Bridge

300 Figure 4. The networks of the opportunistic behaviour of the case projects

301

Table 4. The centrality of participants on opportunistic behaviour

the Beijing Subway Line 4 project				the Hangzhou Bay Bridge project			
parties	OutDegree	InDegree	Betweenness	parties	OutDegree	Indegree	Betweenness
PuA	0	5.00	0.71	CC	5.00	2.00	9.00
INI	0	2.00	0	MS	5.00	1	3.50
SPV	4.00	5.00	8.67	PrC	4.00	2.00	10.00
JTC	0	6.00	0.54	PuA	4.00	5.00	24.50
MTR	6.00	5.00	8.40	StC	3.00	1.00	0
SCC	5.00	5.00	8.40	INI	2.00	0	0
MTR-4	1.00	4.00	1.25	OPE	2.00	1.00	1.50
ES	5.00	3.00	1.52	SPV	1.00	3.00	4.50
MS	5.00	1.00	1.52	BAN	0	4.00	0
CCa	0	1.00	0	INS	0	3.00	0
CCb	5.00	1.00	1.37	EU	0	2.00	0
OPE	13.00	0	50.48	PuP	0	2.00	0
BAN	0	1.00	0				
INS	0	1.00	0				
EU	0	2.00	0.48				
PuP	0	2.00	0.48				

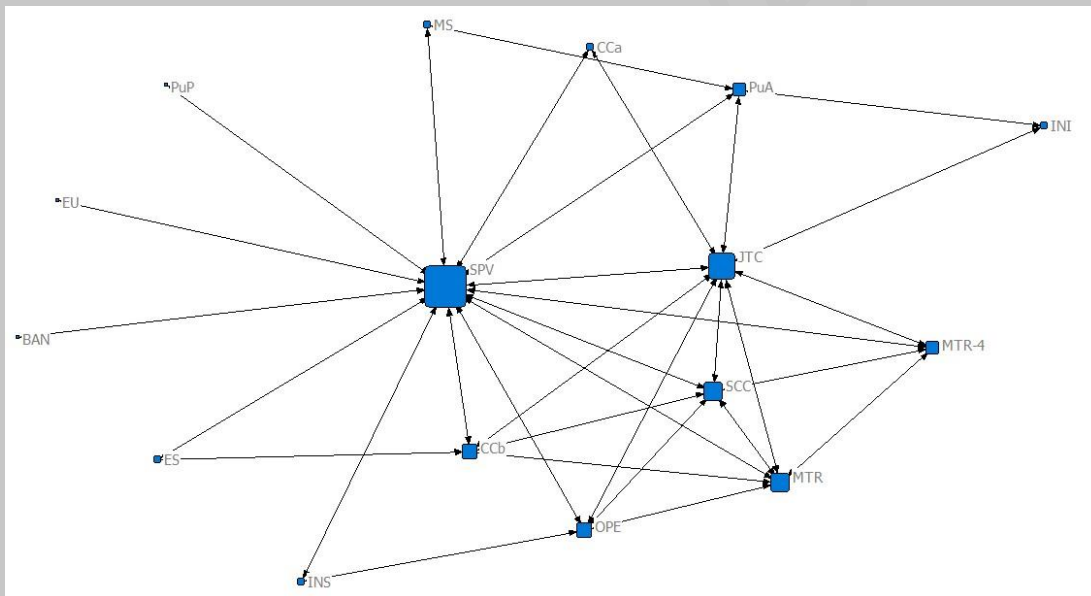
Descriptive Statistics for Each Measure

Mean	2.75	2.75	5.24	Mean	2.17	2.17	4.42
Median	0.50	2.00	0.98	Median	2.00	2.00	0.75
Std Dev	3.54	1.89	12.08	Std Dev	1.91	1.34	6.96
Sum	44.00	44.00	83.81	Sum	26.00	26.00	53.00
Variance	12.56	3.56	145.89	Variance	3.64	1.81	48.49
Minimum	0	0	0	Minimum	0	0	0
Maximum	13.00	6.00	50.48	Maximum	5.00	5.00	24.50

305 **SNA Findings: Network Characteristics of Cooperation**

306 The network of cooperation within the case projects have been examined by utilising the
307 centrality (Figure 5 and Table 5). As the cooperation behaviour is undirected, there is a
308 symmetric adjacency matrix regarding the network being observed. Based on Table 5, the
309 participants committing to higher indegree and outdegree in the Beijing Subway Line 4 include
310 the SPV, JTC, MTR, SCC, CCb and OPE. This result is similar to that of the betweenness,
311 where the SPV and JTC have been clarified as the significant ones. In the Hangzhou Bay Bridge
312 project, while the participant ranking that is specific for the degree centrality is cascading down
313 from the PuA)/SPV/StC to the OPE, such organisations as the PuA and SPV are ranked top.

314



315

316 a. Beijing Subway Line 4

317

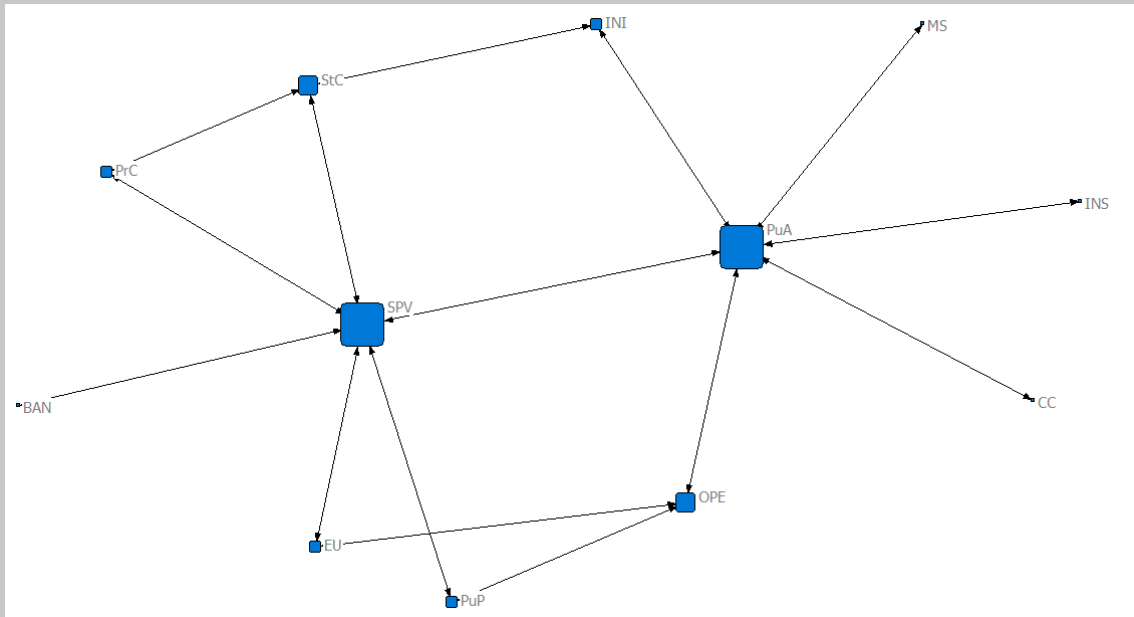
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321

322



b. Hangzhou Bay Bridge

Figure 5. The networks of the cooperative behaviour of the case projects

Table 5. The centrality of the participants' cooperative behavioural network

the Beijing Subway Line 4 project			the Hangzhou Bay Bridge project		
parties	Degree	Betweenness	parties	Degree	Betweenness
PuA	26.67	3.97	PuA	54.55	57.88
INI	13.33	0	INI	18.18	4.09
SPV	93.33	63.89	SPV	54.55	68.75
JTC	60.00	14.84	StC	27.27	4.85
MTR	40.00	0.71	PrC	18.18	0
SCC	40.00	0.71	MS	9.09	0
MTR-4	26.67	0	CC	9.09	0
ES	13.33	0	OPE	27.27	9.39
MS	13.33	0	BAN	9.09	0
CCa	13.33	0	INS	9.09	0
CCb	33.33	1.75	EU	18.18	2.27
OPE	33.33	1.75	PuP	18.18	2.27

BAN	6.67	0
INS	13.33	0
EU	6.67	0
PuP	6.67	0

Descriptive Statistics for Each Measure

Mean	27.50	5.48	Mean	22.73	10.91
Median	20	0	Median	18.18	2.27
Std Dev	22.47	15.50	Std Dev	15.53	19.53
Sum	440.00	87.62	Sum	272.73	130.91
Variance	504.86	240.32	Variance	241.05	381.32
Minimum	6.67	0	Minimum	9.09	0
Maximum	93.33	63.89	Maximum	54.55	57.88

328

329 ***Comparison between the Behavioural Networks of the Case Projects***

330 A sequence of findings can be identified from the empirical evidence above. Regarding the
331 Beijing Subway Line 4, the participants with the self-interested characteristics (e.g., sending,
332 transferring and receiving the self-interested behaviour) are those organisations from the private
333 sector. However, the self-interest of the public authority is manifested in the Hangzhou Bay
334 Bridge. Additionally, the participants from the public and private sectors are pivotal in the
335 cooperative network of both case projects. As what is illustrated by Figure 5, the organisations
336 from the private sector (e.g., SPV) dominate the network of cooperation in the Beijing Subway
337 Line 4, while the participants from the public sector are active in the Hangzhou Bay Bridge.
338 Third, the participants sending and transferring opportunistic behaviour are those from the
339 private sector in the Beijing Subway Line 4. However, both the public- and private-sector
340 participants have committed to opportunism in the Hangzhou Bay Bridge. As such, the public
341 sector and end-users received opportunistic behaviour in these two case projects, indicating that

342 they are the bearers of opportunistic behaviour. Thus, the Beijing Subway Line 4 is a private-
343 sector-led PPP, while the Hangzhou Bay Bridge is the public-sector-led.

344

345 ***Testing of Hypotheses from the SNA-based Cases Study***

346 The Hypothesis of Economic Man argues that while the public sector is not an inherent pursuer
347 of maximum profits, maximising profit values through a higher efficiency is a self-interest of
348 the private sector (Soomro and Zhang, 2016; Boardman and Vining, 2012). As per the Welfare
349 Economics, private organisations' self-interested behaviour relates to competition, which leads
350 to the Pareto optimality and then enables process efficiency. The public sector in PPPs has an
351 aspiration (i.e., self-interested behaviour) for value for money to maximize project value that
352 ensuring certain extents of the effectiveness of the process (Pollitt and Bouckaert, 2017).
353 However, competing in the market to achieve the Pareto optimality is always a challenge for
354 the public sector, due to their weak incentive on business environment and incompetency. Put
355 simply, making profits is neither the purpose of the public sector, nor is what they are good at.
356 Therefore, when the self-interested behaviour of the public sector is obvious, it deviates from
357 the Pareto optimality. Consequently, in a PPP project where the public and private sectors
358 cooperate to provide taxpayers with high-quality products/services, there should be a significant
359 relationship between the self-interest of the participants and the efficiency of the project. For
360 example, the empirical evidence above regarding the Beijing Subway Line 4 indicates that the
361 private entities in the project dominated the self-interested behavioural network. This would be
362 the determinant of an enhanced efficiency of the project's delivery. Conversely, the government
363 plays a dominant role in the self-interested behavioural network of the Hangzhou Bay Bridge,
364 possibly resulting in a project delay and inefficiency. Based on these points of views, two
365 hypotheses of the participants' self-interested behaviour can be established as follows.

366

367 • **Hypothesis 1a** – In the private-sector-led PPPs, self-interested behaviour is positively
368 correlated with the process efficiency; and

369

370 • **Hypothesis 1b** – In the public-sector-led PPPs, self-interested behaviour is negatively
371 correlated with the process efficiency.

372

373 Opportunistic behaviour, as addressed previously, relates to business partnership, which are
374 motivated by the maximisation of economic self-interest in a case of the low-risk (or risk-free)
375 profit opportunities. This viewpoint is supported by the results generated from the SNA above.
376 It is noted that the private sector in the Beijing Subway Line 4 behaved opportunistically, while
377 the public authority and end-users act as the “receiver” of opportunistic behaviour. Similarly,
378 the public authority of the Hangzhou Bay Bridge committed to an intensive opportunistic
379 behaviour but has been affected by such behaviour of other participants. According to Laan *et*
380 *al.* (2011) and Mohamed *et al.* (2011), opportunistic behaviour within PPPs is undesirable and
381 may negatively impact the project efficiency and quality, as it is a result from the defects of
382 contractual arrangements. Combining with the bounded rationality of Behavioural Economics,
383 opportunistic behaviour caused by the pursuit of short-term benefits undermines the long-term
384 value of a project, which leads to lower efficiency of the process (i.e., Pareto Optimality).
385 Hence, two hypotheses regarding the relationships between participants’ opportunism and PPP
386 project efficiency can be identified, respectively.

387

388 • **Hypothesis 2a** – In the private-sector-led PPPs, opportunistic behaviour is negatively
389 correlated with the project process efficiency; and

390

391 • **Hypothesis 2b** – In the public-sector-led PPPs, opportunistic behaviour is negatively
392 correlated with the project process efficiency.

393

394 Obviously, cooperative behaviours between the participating organisations of PPPs is critical
395 for project's delivery, and the SNA results support this perspective (Table 5 and Figure 5).

396 According to the First Fundamental Theorem of Welfare Economics, participants' cooperation
397 can alleviate their information asymmetry and reduce transaction costs, then enabling the Pareto
398 Optimality of process efficiency. Thus, a hypothesis about the relationship between cooperation
399 and project process efficiency is proposed.

400

401 • **Hypothesis 3** – Cooperative behaviour is positively correlated with the process
402 efficiency of both the private-sector- and public-sector-led PPPs.

403

404 The QAP regression has been applied to test the identified hypotheses. While the process
405 efficiency matrix is set as the dependent variable, the cooperative, opportunistic and self-
406 interested behaviours are developed as the independent ones. All these variables are represented
407 in the form of a matrix. The regression equation is as follows:

$$408 \text{Eff} = F(C, \text{Coo}, \text{Opp}, \text{Sel})$$

409 where "*Eff*" represents the process efficiency matrix, "*Coo*" represents the cooperative
410 relationship matrix of the participants, "*Opp*" is the representation matrix of opportunistic
411 behaviour, "*Sel*" is the representation matrix of self-interested behaviour, and "*C*" is the
412 intercept term matrix.

413

414 As shown by Table 6, empirical evidence indicates that a two-tailed test process has been
 415 performed. The coefficient of the standardized regression is 0.33 under the 5% significance
 416 level, indicating that the cooperative behaviour within the Subway project is positively and
 417 significantly correlated with the process efficiency. Nonetheless, the coefficients of the
 418 opportunistic and self-interest behaviours are insignificant. In terms of the Bridge project, the
 419 cooperative behaviour is significant for and positively correlated with the process efficiency,
 420 due to the coefficient of 0.29 significant at 5% level. But the self-interested behaviour is
 421 negatively correlated with the process efficiency, i.e., -0.28 under the 5% significance level.
 422 Also, the coefficient of the opportunistic behaviour and efficiency is -0.16, which is at the
 423 significant level of 5% as well.

424

425 Table 6. The regression of process efficiency determined by participants' behaviours

Dependent Variable		The Process Efficiency				
The Beijing Subway Line 4 Project						
Independent Variables	Non-Standardized Coefficient	Standardized Coefficient	Proportion Significance	Proportion As Large	Proportion As Small	
Intercept	-0.019	0.000				
Cooperation	0.305	0.331	0.002 ***	0.002	0.998	
Opportunism	0.067	0.063	0.222	0.222	0.779	
Self-interest	-0.005	-0.006	0.489	0.511	0.489	
R ²	0.120		0.002 ***			
The Hangzhou Bay Bridge Project						
Intercept	0.047	0.000				
Cooperation	0.359	0.288	0.023 **	0.023	0.978	
Opportunism	-0.210	-0.160	0.043 **	0.958	0.043	
Self-interest	-0.338	-0.283	0.014 **	0.987	0.014	
R ²	0.111		0.000 ***			

426 Note: * p<10%, **p< 5%, *** p< 1%.

427

428 **Findings of the Regression Analysis**

429 The regression results in Table 6 indicate that the Hypothesis 3 has been accepted. This implies
 430 that a cooperation between the participants in PPPs is significant for the efficient delivery of
 431 the projects. Also, the Hypotheses 1b and 2b have been accepted, while the Hypothesis 2a was
 432 rejected. These results did not only partially support the finding of past studies what the

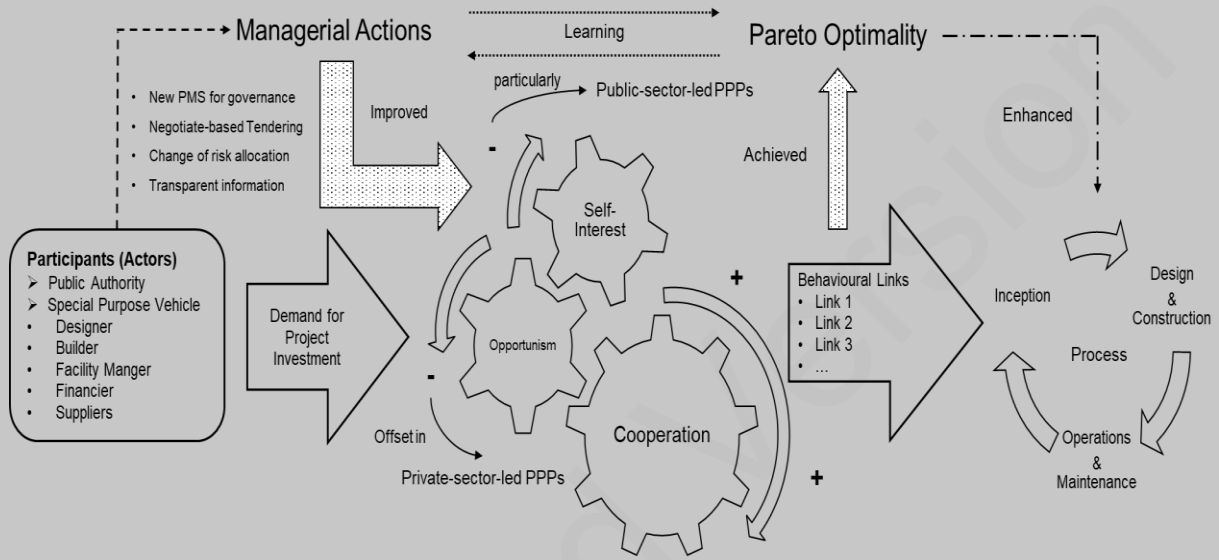
433 opportunistic behaviour can undermine project process efficiency in PPPs (Laan *et al.*, 2011).
434 Furthermore, it offered a new implication that opportunism can be substantially minimised in
435 the private-sector-led PPPs. In other words, the government should act as a governor, rather
436 than a controller, in PPPs throughout the project's lifecycle. The QAP regression results also
437 did not support the Hypotheses 1a. The reason for this 'reject' is that 'boundary' between self-
438 interest and opportunism under the Hypothesis of Economic Man is unclear. This finding also
439 challenges the principle that private sector's self-interests in pursuing profits can ensure an
440 efficient delivery of a public project procured via PPPs.

441

442 **Implications: Managerial Actions to Improve Participants' Behaviours**

443 To ensure an effective governance, a life-cycle performance measurement system (PMS) is
444 needed for PPPs (Liu *et al.*, 2018a, b). Having an efficient PMS in place can aid the contract
445 management and monitoring of the asset's construction/operations and then decrease the
446 probability of negative effects of any self-interested behaviours (i.e., opportunistic behaviour).
447 Additionally, greater transparency of information can help to minimise opportunistic
448 behaviours, and this can be achieved by making more information of PPP projects to the general
449 public (HM Treasury, 2012). To reduce opportunism, it will be also possible to replace
450 competitive tendering for major capital work projects with the negotiation-based approaches
451 that utilise pre-tender estimates (PTE) (Aibinu and Pasco, 2008). For example, in Brazil, the
452 PTE is fundamentally generated from a national database of costs, to prevent unreasonable bids.
453 Given that opportunistic behaviour stems from low-risk (or risk-free) profit opportunities, an
454 effective governance and management of opportunistic behaviour can be enabled through a
455 reasonable risk allocation according to above findings. A change of conventional risk allocation
456 in transport PPPs, which encourages a complete transfer of commercial risks to concessionaire,
457 will be useful for reducing the negative impacts of the self-interested behaviour of the private

458 sector on project process efficiency. In practice, it takes time for government to negotiate with
 459 the private sector to finalise an arrangement of completely commercial-risk transfer. If the
 460 public authority could share a significant volume of such risks as financing and utility in a PPP,
 461 the efficiency of the project's delivery process will be improved (HM Treasury, 2012).
 462



463
 464 Figure 6. Refined framework for managing the relationships between participants' behaviours
 465 and project process efficiency in PPPs
 466

467 Considering the QAP-generated results and the viewpoints demonstrated above, the conceptual
 468 framework (Figure 1) can be refined and developed, i.e., Figure 6. This finally developed
 469 paradigm can act as a foundation that is useful for governments, particularly those in developing
 470 countries, to develop appropriate policies and/or strategies to improve the governance of their
 471 PPs and then enhance the efficiency of the project's process, which in turn will provide
 472 taxpayers with a higher VfM.

473
 474
 475

476 **Conclusions**

477 PPPs have been widely adopted for infrastructure procurement worldwide, but they have been
478 being plagued with controversy since many projects were subjected to inefficient delivery. A
479 defining feature of PPPs is their complex stakeholder network and delivery process comprising
480 participants from the public and private sectors. However, research that attempts to empirically
481 identify the relationships between the behaviours of the participating organisations and project
482 process efficiency from the behavioural network perspective within the context of PPPs is
483 limited. Therefore, we developed a managerial framework of PPP participants' behaviour for
484 government to improve their practice in delivering the projects.

485

486 A case study of two transport PPP projects in which a SNA followed by the QAP regression
487 has been undertaken to empirically examine and refine the framework. The empirical evidence
488 supports the appropriateness of the developed framework. They further indicate that the
489 participants' self-interested behaviour is negatively correlated with the process efficiency in the
490 public-sector-led PPPs, while there is an insignificant correlation between self-interest and the
491 process efficiency in the private-sector-led PPPs. Moreover, cooperation can significantly
492 contribute to the project process efficiency of PPPs (both the public-sector-led and the private-
493 sector-led PPPs). Nonetheless, opportunism can undermine process efficiency, particularly in
494 the public-sector-led PPPs, but there is an insignificant linkage in the private-sector-led PPPs.

495

496 This study has contributed to the literature by expanding the knowledge that is useful for
497 managing the relationships between process efficiency and key participants' behaviours in
498 PPPs. It is also practical for enhancing practice in project management, as it is based on a case
499 study of two real-world transport projects. Future research should examine the developed
500 framework by conducting a comparative study between developing and developed countries.

501 **Data Availability Statement**

502 Some or all data, models, or code that support the findings of this study are available from the
503 corresponding author upon reasonable request, i.e., data for SNA modelling and regression.

504

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