RELATIONAL APPROACH IN MANAGING CONSTRUCTION PROJECT SAFETY: A SOCIAL CAPITAL PERSPECTIVE

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Abstract

Existing initiatives in the management of construction project safety are largely based on normative compliance and error prevention, a risk management approach. Although advantageous, these approaches are not wholly successful in further lowering accident rates. A major limitation lies with the approaches' lack of emphasis on the social and team processes inherent in construction project settings. We advance the enquiry by invoking the concept of social capital and project organisational processes, and their impacts on project safety performance. Because social capital is a primordial concept and affects project participants' interactions, its impact on project safety performance is hypothesised to be indirect, i.e. the impact of social capital on safety performance is mediated by organisational processes in adaptation and cooperation. A questionnaire survey was conducted within Hong Kong construction industry to test the hypotheses. 376 usable responses were received and used for analyses. The results reveal that, while the structural dimension is not significant, the mediational thesis is generally supported with the cognitive and relational dimensions affecting project participants' adaptation and cooperation, and the latter two processes affect safety performance. However, the cognitive dimension also directly affects safety performance. The implications of these results for project safety management are discussed.

Keywords: Construction project safety; Social capital; Cooperation; Adaptation; Mediation

1. Introduction

Existing initiatives and interventions in managing construction project safety are largely based on normative compliance and error detection and prevention. The former approach aims at controlling project participants' behaviours through compliance with safe conduct and prescriptive punishment upon violation of safety rules (Mitropoulos et al., 2009; Rasmussen, 1997). The latter focuses on error management with the aim of guiding behaviours with the removal of the causes of errors (Mitropoulos et al., 2009). While the two approaches have contributed to the improvement of safety performance in construction projects, they also have significant limitations. The downward trend in accident rates has plateaued in recent years and this appears to be symptomatic of such assertions in some developed regions – e.g. the Hong Kong construction industry. In these regions, a myriad of safety initiatives based on the two regimes have been introduced into construction industry.

However, measures associated with the two regimes are less effective in the face of dynamic and complex construction operations. This ineffectiveness can be traced back to the paradigmatic predilection of the two approaches in managing safety. In the normative approach, the focus is on task design and the prescription of safety rules in the performance of the task (Rasmussen, 1997). The aims are both to control the behaviours and to invoke voluntary compliance to safety rules on the part of project participants. In a somewhat related way, the error management approach focuses on the study of work behaviours that deviate from the "best" way of working. Deviation, in this line of thought, is conceptualised as error. The aim of the approach is then to control participants' behaviours by the removal of causes of errors (Mitropoulos et al., 2009). While the main tenet of both approaches is the creation and control of work behaviours, they are inevitably internally focused. They focus on the internal and static aspects of the production (construction) system – internal as in the characteristics of the participants (e.g. competence level) and static as in the nature of task (e.g. task design, the provision of protective equipment). As such, from the perspective of a total production system, the approaches lack emphasis on the dynamics and interactions among the production elements – the human operators, the tasks, and the contexts by which these elements interact and the effects of the interaction. That is, the approaches tend to disregard the characteristics of the production system and team dynamics that may potentially influence the participants' behaviours and the possibility of errors and accidents. They do not cater for factors that shape the work situations which participants must face (e.g. the tensions between adherence to safe conduct and meeting production time and cost), and which affect their ability to cope with the situations (cf. Mitropoulos et al., 2009). Simply put, a key limitation of the two approaches has to do with their lack of emphasis on the construction systems and the social and team processes inherent in construction operations (Mitropoulos et al., 2009; cf. Saurin et al., 2008). Because current safety management in the construction industry is largely based on these approaches, the industry suffers a paradigmatic trap in the quest for improved safety performance. The gap is the lack of recognition of a coherent social explication of safety management and accident prevention. We advance this line of enquiry by invoking the concept of social capital and project organisational processes, and how these phenomena impact upon construction project safety performance. We delineate the rationale of our approach in the following paragraphs.

Although previous research has pointed to the positive relation between good working relationships among construction supervisors and crew members with the reduction of accidents (Hinze, 1981; Hinze and Gordon, 1979), accidents are caused by social relations at work in other industrial settings (Dwyer and Raftery, 1991), and a few strands of research highlight the human side of managing safety (Glendon et al. 2006; Lingard and Rowlinson, 2005; Mitropoulos et al., 2009), yet insufficient attention has been paid to the human factors and social aspects in managing construction project safety. Within this context, because construction is essentially a social process (Abowitz and Toole, 2010), and people and their interactions play key roles in nearly all aspects of the construction process including safety management, the need to better understand the impact of human factors (both their relations and the quality of those relations) comes to the fore. This recognition of human and social factors is in line with the behaviourist perspective in managing construction safety. Here, the team that consists of project participants can exert considerable influence on the behaviours of its members. This influence is likely to shape the attitudes of the members. The team's expectation of members to follow safe work procedures and to abide by safety rules provides strong social control in ensuring participants' safe conduct (Lingard and Rowlinson, 2005). In addition, from the perspective of cognitive systems engineering (CSE), both the work practices – the way construction processes are organised and managed – and team processes shape the situations that project participants must face. Under these circumstances, project participants need to be concerned with not only the work practices and systems, but also their own interactions within the project organisational and production context (Mitropoulos et al., 2009). The implication of both perspectives for safety management is the recognition of the systemic connections between human interactions and other features of the operating environment that include the provision of artefacts (e.g. personal protective equipment), rule adherence (normative approach), and error prevention.

The preceding arguments have brought to the fore project team relations and processes in the management of construction project safety. Construction project organisations have unique characteristics (i.e. the congregation of individual participants from an array of disciplines) that involve a network of firms and individuals, their relationships (that are embedded in those networks), and their interactions within the socio-technical system (Koh and Rowlinson, 2007) with implied distributed organising activities. Hence, the line of conception should focus on a network view of the situation and the project participants' interaction – on how the web of relationships, especially those manifested as goodwill, facilitate the interactions of the project participants in the management of construction project safety. Goodwill, generally referred to as social capital (Adler and Kwon, 2002), has been identified as a concept that can add value to the study of network-based organisations such as a construction project. The primary premise of social capital is that the relational asset engendered in the fabric of social relations among project participants can be utilised to facilitate actions, and that social capital is a potentially valuable asset for project organisation to appropriate and exploit to achieve organisational objectives (Coleman, 1988; Nahapiet and Ghoshal, 1998) - project safety objectives. Following this line of thought, the present study aims to investigate the effect of social capital on project safety performance. Specifically, the research questions read: *How does social capital affect construction project safety performance?* Given the nature of distributed organising: *What is the role of project organising activities (e.g. adaptation and cooperation) in the relationship between project social capital and safety performance?*

1.1 Project social capital

Construction projects are network-based organisations that consist of a variety of participants taking part in the project at various times (Styhre et al., 2004). The project team that is formed by the congregation of such participants is characterised by having diverse specialties, needing to cooperate to achieve common project objectives, facing tensions between autonomy requirements and embededness within their organisational settings, and needing to constantly adapt to emergent situations resulting from the on-going flux and fluidity of the project circumstances (cf. Godé-Sanchez, 2010). Within these contexts, three characteristics of the project organisation can be discerned: extensive interactions among project participants, the informational requirements, and the network of social structure inherent in the project organisation. Because network type organisation often lacks a central authority (Podolny and

Page, 1998), the coalition that is formed by project participants seems to require social mechanisms such as trust and reciprocity to function effectively (Jones et al., 1997; Powell, 1991). The complexity of the tasks and interdependence of project participants all interacting in a network sphere require that participants uphold a sense of obligation among themselves instead of taking advantage of trust prevalent within the group (Powell, 1991). In addition, better project performance is associated with a project team that emphasises strong orientation to relationship than to the task, and attaches importance to the management of interpersonal relations (Bryman et al., 1987). Because safety performance comes under the broad domain of overall project performance, this assertion also applies to safety performance of a construction project. Indeed, previous safety scholars have recognised the need for a safety management approach that embraces the complexity of the socio-technical system. This approach focuses on the mechanisms that generate organisational complexities within the dynamic work contexts in addition to mere task errors prevention (Haslam et al., 2005; Mitropoulos et al., 2009; Rasmussen, 1997). The burgeoning research in the safety culture and climate streams is recognition of the fact that organisational and social factors do impact upon safety performance (Vinodkumar and Bhasi, 2010).

As noted, the project organisational characteristics of interdependence and interactions; diffused authority; temporality; and relative closure of project organisational membership are conducive for the invocation of the concept of social capital (Jones and Lichtenstein, 2008; Nahapiet and Ghoshal, 1998). Under these characteristics, social capital which is conceptualised as “the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit” (Nahapiet and Ghoshal, 1998: 243) – e.g. project organisation (Brookes et al., 2006) and thus provides a mechanism and means by which coordination of collaborative activities between participants can be conducted. This is because, given project works that are largely context-specific, process- and action-based, the group dynamics are likely to be the result of project participants' interactions and their pattern of social relations. Social capital that is engendered among the participants will likely affect the group interactions and ultimately project (safety) performance.

Social capital can be usefully conceptualised using Nahapiet and Ghoshal's (1998) model that consists of structural, cognitive, and relational dimensions. The structural dimension refers to the impersonal configuration of linkages between persons or social units. The important facets under this dimension are network ties between project participants and the existence of appropriable organisation which is created for one purpose that may be used for other purposes (Coleman, 1988; Nahapiet and Ghoshal, 1998). The cognitive dimension concerns those aspects that provide shared representations, interpretation, and the system of meaning among group members (Nahapiet and Ghoshal, 1998). It reflects the extent to which the project team members share a common understanding (Bolino et al., 2002) and have developed among themselves a shared cognitive scheme (Maurer and Ebers, 2006). The personal relationships people develop among themselves through the history of interaction (no less in the construction project settings) characterises the relational dimension (Granovetter, 1992). An important facet of the relational dimension is the trust that is developed among members of a group (Inkpen and Tsang, 2005; Leana and VanBuren, 1999).

The present study aims to examine the behaviours of participants under organisational settings – albeit in distributive and temporary project organisational settings. Nahapiet and Ghoshal's (1998) framework of organisational social capital is adopted with this line of investigation. Nahapiet and Ghoshal's (1998) conceptualisation of social capital integrates many of the different dimensions explored in previous works (Bolino et al., 2002; Maurer and Ebers, 2006). Their framework is useful for examining social capital in the organisational settings (Bolino et al., 2002). In an organisation, members are connected through a series of relationships in a relatively closed boundary. As this organisation and its members are bound by interactions, interdependence, and closure, these characteristics can be studied using the lens developed by Nahapiet and Ghoshal (1998). In addition, their framework includes a cognitive dimension – a dimension which has received less attention in extant literature on social capital (Bolino et al., 2002). Finally, Nahapiet and Ghoshal's framework provides a contemporary interpretation on how an organisation can utilise social capital for the achievement of an outcome (cf. Storberg-Walker, 2009), and how the dimensions can be linked to other organisational phenomena.

In project organisations, the network of participants provides access to the resources possessed among them (structural dimension). In the currency of the project, relations may have developed among participants (relational dimension). Participants negotiate, refine, and achieve a shared understanding that provides them with common interpretation scheme (Rico et al., 2008) of project conditions (cognitive dimension). Indeed, ethnographic research of construction safety indicates that safe work practices are socially and jointly constructed in the community of practice by project participants (Gherardi and Nicolini, 2002). Here, the appreciation of safety is developed through the complex interplay of the three dimensions via network ties that facilitate access among individuals, shared understanding as to what constitute safe environment, and the trust that engenders confidence on the level of appropriate adherence to safety provisions. The social capital thus engendered provides the conduit for the transfer of resources (both tangible and intangible forms) and the quality of the interactions that project participants can mobilise to facilitate project safety management processes.

1.2 Project organisational processes

Given the characteristics of construction operations that involve a multitude of human interactions in the performance of many sorts of activity as a result of specialisations, and consequently organisational and technical complexity, the project organisational processes that are pertinent are adaptation and cooperation among project participants. The inherent unpredictability, micro-diversity (Cicmil and Marshall, 2005), contextual uncertainty, imprecise information together with rapid and discontinuous changes (Godé-Sanchez, 2010; Wirtz *et al*., 2007), have necessitated constant mutual adjustments among project participants – adaptation. It is through this adaptive social function, warranting the accommodation and adjustment to each other's expectations and constraints, project works can collectively be conducted. But at the same time, as noted, construction works are fundamentally organised around the concepts and practices of specialisation and interdependence, there needs to be communication and joint actions among project participants so that common project objectives can be met – cooperation. That is, only when participants are willing to contribute their personal efforts to collaborate, interdependent jobs can then be completed (Wagner, 1995).

In the management of construction project safety, the literature has highlighted at least two phenomena that render cooperation and adaptation among project participants crucial. The first has to do with the low level of safety awareness on the part of non-safety supervisors. The second, the conflicting production and safety priorities (Haslam et al., 2005). Cooperation and adaptation among project participants provide mechanisms by which these adversities can be managed. Specifically, with cooperation, the provision and exchange of resources increase tasks resources allocation (e.g. provision of expertise for the conduct of a job, safety advice). This provision reduces task demands on project participants (e.g. reduced workload, increased safety awareness). With reduced task demand, participants can better focus on the task at hand. Participants' awareness on the task demand is also increased at the same time (Mitropoulos *et al*., 2009). Adaptation increases project participants' ability to be more in tune with the work environment. Because adaptation involves the alteration of an individual's behaviours "to meet the demands of the environment, an event, or a new situation" (Pulakos *et al*., 2000: 616), and recognising that peer influences and changing physical site conditions constantly interact to impact upon project participants' behaviours, adaptation brings about participants' awareness and response to the constraints and work affordance of the production systems (cf. Flach *et al*., 1998, cited in Mitropoulos *et al*., 2009). In the situation of conflict between adhering to safe conduct (which implied extended time consumption) on site and maintaining production time and cost, participants' adaptation become vital in compensating for safe performance amidst system deviation (cf. Mitropoulos *et al*., 2009).

Hence, to the extent that the front line supervisors and other project managerial staffs are the key personnel in accident prevention for their being in the position to control unsafe conditions and acts (Simard and Marchand, 1994), cooperation and adaptation are critical project safety organisational processes.

1.3 Safety performance

Safety performance is not improved by adopting a single initiative; it is the combined weight of a series of planned and coordinated initiatives that leads to continuous improvement (Rowlinson et al., 2009). Thus, in our line of enquiry, we seek to inform the planning of safety management of construction projects, a strategic element in the array of safety initiatives available. The scheme is forward looking in nature. Because lagging indicators are retrospective in nature and need not necessarily reflect how well safety is managed in a project, we use leading indicators to measure safety performance. As leading indicators provide positive measures for safety performance they represent a more direct proxy of the quality of safety management of construction projects (Lingard et al., 2011). In addition, this conception – i.e. the use of leading indicators – is more relevant when examining safety improvement initiatives at the project organisational level.

Adopting leading indicators, the achievement of good safety conditions on the project site and the drive for continuous improvement in safety are important aspects of safety performance. The impact of the former is that the lack of site safety is likely to lead to financial (Tang et al., 1997) and productivity loses (Mitropoulos and Cupido, 2009). While financial loss is due to the cost of industrial accidents and incidents, productivity loss is the result of unavailability of the workforce and work locations. In addition, poor safety conditions also affect workers' morale which, in turn, affects their work performance.

Continuous improvement aims to enhance the reliability and control of the production (construction) system. In construction safety management, the rationale that underpins continuous improvement is the recognition that higher safety standards can be readily linked to lower cost and improved time performance. Improved safety is attained by controlling or decreasing the processes variation in the construction operations. Continuous improvement in safety management practices engenders this reduction of variation. Research has shown that working under safe conditions often implies working efficiently with good work management (Haslam et al., 2005), and that high reliability work system often means better productivity and safer work performance (Mitropoulos and Cupido, 2009).

1.4 Hypotheses and model development

Given the relevance of social capital in project settings and project (safety) organisational processes in adaptation and cooperation, because (project) social capital represents primordial features of social activities among project participants, we postulate that the effect of social capital on project safety performance is likely to be indirect. This line of thought is predicated on the proposition that, in social settings, social affairs are conducted on the basis of the social structure, roles, norms, and trust among actors – i.e. social capital. Social capital provides the foundation for on-going interactions of actors (project participants) (cf. Orlikowski, 2002) and it serves as a substrate on which these interactions take place (cf. Nohria and Eccles, 1992). Hence, project social capital provides the conditions necessary for adaptation and cooperation among project participants to take place, and the latter processes, in turn, contribute to safety performance. In essence, we advance a mediational thesis between social capital, project organisational processes, and safety performance. In this line of conception, social capital affects first the project organisational processes in adaptation and cooperation. Hypothesis one can hence be stated as:

H1. The impact of social capital on project safety performance is mediated by organisational processes (i.e. adaptation and cooperation).

In terms of the structural dimension, the benefits of network ties can essentially be realised through the provision of work assistance and social support among project participants (cf. Gibbons, 2004; Hatala and Fleming, 2007). Within these contexts, network ties facilitate access among project participants. This access influences the type of interactions, exchanges, and communications among participants. The interactions among project participants, especially the frequent and cordial interactions, are likely to produce positive interpersonal impression. This impression, together with communication, and the absence of conflict are the basic ingredients of cooperation (Tjosvold, 1984). In addition, Pinto et al.'s (1993) study on engineering firms has indicated that nearness of individuals is likely to induce cooperation among participants (Pinto et al., 1993). Hypothesis two can hence be stated as:

H2. Network ties are positively related to cooperation.

In terms of the cognitive dimension, shared understanding that has developed brings about shared cognitive orientation and interpretation among project participants. With this shared interpretation, project participants may find it easier to discuss issues that arise in the course of project organising, transfer ideas, and share knowledge. This results in better utilisation of members' inputs that lead to successful coordination and adaptation to changing project conditions (Krackhardt, 1992). That is, the shared repertoire facilitates easier knowledge exchange and generation that have positive effects on project participants' adaptation (Maurer and Ebers, 2006; Tsai and Ghoshal, 1998). Accordingly, hypothesis three can be stated as:

H3. Shared understanding is positively related to adaptation.

In project organisations, although members' goals are often in conflict with one another, in order to accomplish project works, parties are required to sacrifice or at least compromise their primary goals (Pinto et al., 1993). To achieve this, some sharing of context among project participants are required. The shared context can often be manifested in the subscription to the project's superordinate goals which compel all parties to extend their resources and efforts in working toward a common end (Pinto et al., 1993). This shared understanding of collective benefits is likely to promote collaborative performance (Sarker et al., 1998). That is, because cooperation involves exchange of resources towards the achievement of common goals, shared understanding is likely to promote cooperation. Accordingly, hypothesis four can be stated as:

H4. Shared understanding is positively related to cooperation.

Trust building is a critical element in social exchange process. Trustworthiness is often demonstrated through social actors' commitment in the exchange relationship. Importantly, commitment is demonstrated through adapting to one another (Blau, 1964; Hallen et al., 1991). This phenomenon implies the existence of a positive relationship between trust and adaptation. In relationships that are characterised by high trust, there is a greater openness to the potential of accepting other trustworthy partner/s' request for adjustment (cf. Nahapiet and Ghoshal, 1998), and the level of trust affects adaptive behaviours of partners (Brennan and Turnbull, 1999). In the project setting, as noted earlier, project participants must continually adapt to each other's need for joint efficiency (cf. Hallen et al., 1991). Because trust allows more information exchange thereby leading to adaptive performance (Jeffries and Reed, 2000), hypothesis five can be stated as:

H5. Trust is positively related to adaptation.

In situation of high trust, there is a general confidence that participants can engage in constructive interaction without the need of guessing the hidden motives the other participants might harbour. Because trust increases participants' anticipation of value through exchange with others (Nahapiet and Ghoshal, 1998) and enhances the positive interpretation of other participants' behaviours (McEvily et al., 2003), it is likely to lead to seamless interactions among project participants in problem solving and information disclosure (Kadefors, 2004). From a socio-physiological perspective, trust is also an important element to ensure cooperation as it represents a different aspect of non-economic and uncalculated benefits that under traditional transaction perspective has ensured cooperation (Granovetter, 1985). In addition, trust is a particularly important element that affects the ability of project participants to self-organise and cooperate (Rousseau et al., 1998). Hence, the relationships of trust with cooperation can be stated as:

H6. Trust is positively related to cooperation.

In the second stage of the scheme, adaptation and cooperation affect project safety performance. The dynamics, unpredictability, and seemingly hostile construction site environments, together with the high production (construction) pressures often lead to a high likelihood of errors and unsafe conditions. Task uncertainty causes disruptions and exceptions which reduce the production reliability (Mitropoulos and Cupido, 2009). Under these situations, the performance of individuals and the reliability of the production system are influenced by the cooperation of project participants. In addition, these uncertainties also mean that project participants need to adapt their behaviours to capture the connections between actions and system elements in terms of tools, tasks, and the operating environment (Mitropoulos et al., 2009). For these reasons, cooperation and adaptation are essential for safe performance of works. Hence, hypotheses seven and eight can be stated as:

H7. Adaptation is positively related to project safety performance.

H8. Cooperation is positively related to project safety performance.

Based on the hypotheses formulated above, our conceptual model is shown in Fig. 1, a two-stage model is proposed. The model delineates the relationships among the constructs of interest. These relationships are represented by signed arrows which correspond with the developed hypotheses. The model essentially represents a mediational relationship among the three main blocks of constructs – the impact of social capital on safety performance is mediated by the project organisational processes. In the model, to be in line with the mediational and analytical conception in literature (e.g. Baron and Kenny, 1986; James et al., 2006), a direct link between independent (i.e. social capital) and outcome (i.e. safety performance) constructs is added in the conceptual model.

(Fig. 1 around here, please)

2. Method

2.1 Population and sample

To test the hypotheses, empirical studies were carried out within the Hong Kong construction industry. A questionnaire survey was used to solicit responses from industrial practitioners who were either working on on-going construction projects or had recently completed a project. These practitioners are personnel occupying the roles of project managers, site agents, architects, engineers, quantity surveyors, and supervisors/foremen in various capacities representing the client, consultant, and contractor. The names and contact details of potential respondents were randomly drawn from the membership of professional institutions (e.g. Hong Kong Institute of Engineer), trade associations (e.g. Hong Kong Contractor Association), and governmental departments (e.g. Housing Department). In all, 2186 professionals had been identified. Respondents were requested to respond to a series of questions stating various situations in relation to the research constructs of interest based upon their project experiences. The survey was conducted from January to September 2008. 376 valid responses were received and used for the analyses. The response rate is thus 17.2%.

Among the 376 respondents, 90.2% were male. 86.3% of them were in their prime working years of between 31- to 60-year old, with 41.7% of them in the age bracket of 41-50 years old. Over 90% of the respondents held bachelor degree or above, and 93.6% of them had professional status. In terms of both working experience in construction industry and project, over 90% of the respondents had more than 5 years working experience in both construction industry in general and project in particular. This statistics imply that the respondents are conversant of construction and project operations and hence are able to provide more accurate information on the phenomena of interest.

On the characteristics of project the respondents worked on, 50.8% were building projects, 47.6% were civil engineering projects. A vast majority of the projects – 78.5% - were new-built construction with the remaining redevelopment, refurbishment, renovation, and fitting-out projects. Majority of the project work group size is small (1-20 persons, 64.3% of total number of project). 20.3% with medium size of 21-50 persons, 10.7% with medium-large size of 51-100 persons, and only 4.7% with large size of over 100 persons.

2.2 Survey instrument

The measures for the study were eclectically constructed from both construction and non-construction related, and empirical and theoretical studies. Modifications were made to the statements from non-construction related literature to reflect construction settings. Items measuring social capital, project organisational processes, and safety performance together with the demographic information were included in the questionnaire.

2.2.1 Social capital

As noted, Nahapiet and Ghoshal's (1998) three-dimensional model of social capital is used for present study. The structural dimension is represented by network ties and the existence (and usefulness) of informal grouping among the project team. Two questions were used to represent network ties. One is the number of persons within the project work group the respondent asked for assistance in getting work done (Hatala and Fleming, 2007). The other is the number of persons the respondent asked for social support (Gibbons, 2004; Hatala, 2006). The two types of relations – instrumental and expressive relations, respectively – can be used to assess the supportiveness of the network within the project organisation which represents the direct contribution of the structural dimension of social capital. The third question concerned the existence and usefulness of an informal grouping with the recognition on the role of such grouping in providing rapid response to address the problem at hand (Rizova, 2007).

The cognitive dimension is represented by shared understanding. As cognitive congruence, shared understanding is manifested in the forms of normative, cultural, and procedural orientation among project team members (cf. Sarker et al., 1998). The questions under this section included the extent to which shared understanding of project requirements, of other parties' requirements, shared culture, and common thinking have developed among the project team. For these questions, the respondents were asked to choose from a six-point Likert-like scale on the degree of prevalence of the condition described in the question from "small extent" to "large extent." This six-point scale was used for most of the subsequent sections.

The relational dimension is represented by trust. In line with literature on the type of trust that is relevant in project setting, contractual, competence, and goodwill attributes of trust were explored in this study (Hartman, 2002; Pinto et al., 2009; Sako, 1992). Contractual trust deals with the obligation that project participants carry out their contractual agreements. It is based on the moral norm of honesty and promise-keeping. Competence trust has to do with the capability of project participants in carrying out project tasks. The ability of giving advice, of performing project work, of making well thought out decisions, and being reliable are the various facets of competence trust. Goodwill trust refers to the expectation that other participants will make an open-ended commitment to take initiatives that are mutually beneficial and refrain from taking unfair advantage.

2.2.2 Project organisational processes

The adaptation measure was taken from Pulakos et al. (2000). The adaptation measure that is relevant to construction project settings includes creative problem solving, dealing with uncertain and unpredictable work situations, interpersonal adaptability, and handling crisis situations. These are the main dimensions that collectively represent the adaptation construct. Because of the number of items that are included in the original scale, the items were factor analysed into forming the four dimensions. These factors (i.e. the dimensions) were then used for subsequent confirmatory and structural analyses.

The cooperation measure is operationalized through the elements of positive inter-personal relations, task interdependence, and resources exchange (Deutsch, 1949; Phua, 2004; Tjosvold, 1984, 1988). In a cooperative environment, team atmosphere is likely to be friendly and supportive. Team members hold positive attitude toward one another, are friendly, and value highly their joint product within the project. Further, with the recognition of goal interdependence, team members tend to be more willing to accept the task assigned.

2.2.3 Safety performance

As noted earlier, two project safety performance measures were used. These were the achievement of good site safety conditions , and the achievement of continuous improvement of safety targets. Unlike previous questions, a seven-point response scale was adopted for this section. The questions solicit the perception of respondents on the achievement of these safety conditions. The response categories range from “strongly disagree” to “strongly agree.” Because the number of response category is a function of the nature of the question asked (DeVellis, 2003), the seven-point scale with a neutral category is appropriate as it allows scoring the middle category if the achievement is on target.

2.2.4 Demographic information

Two types of demographic information were collected – project details and individual attributes. The former sought information on the type of project (building, civil engineering, etc.), the size of the project work group, and the nature of work (new-built, redevelopment, etc.). The latter solicit information on the respondent gender, age, work experience (in number of years), and the educational level. In line with the good practice of questionnaire design, personal details questions were placed at the last part of the questionnaire (Aldridge and Levine, 2001).

2.3 Data analysis

Structural equation modelling (SEM) is used for data analyses. A complete SEM consists of two components – a measurement and a structural model. In this respect, a two-step approach of SEM is adopted for the study. Here, the measurement model is first tested and validated. The structural model is then assessed (Anderson and Gerbing, 1988, 1992; Garson, 2009; Hair et al., 2006; Kline, 1998). The rationale for the two-step approach lies with the premise that a valid structural theory (the mediational proposition and the related hypotheses in the present study) cannot be conducted with poor measures. Essentially, the first step serves to test both the convergent and discriminant validity of the measures adopted. Only when the validity of those measures is established then the researcher’s theory envisaged in the full structural model is tested.

In terms of model testing with the aim of determining the goodness of fit of the established model and the sample data, the present study adopts a combination of alternative models and model generating strategies (Joreskog, 1993). This hybrid strategy involves the specification and testing of a few to several models, and selection of one most appropriate model that represents the data (the alternative models strategy). The process of model search proceeds in an exploratory manner in terms of model modifications and re-specifications (the model generating strategy) (cf. Byrne, 2001).

For the present study, AMOS-17 software programme was used to conduct the analyses for both the measurement and structural models.

3. Results

3.1 Construct reliability and validity

As noted earlier, the test of construct convergent and discriminant validities lies within the domain of the measurement model. For this purpose, an overall measurement model that includes all the proposed constructs (including a single item construct in informal grouping) given in the theoretical model depicted in Fig. 1 is constructed. The items of all constructs were loaded on their respective constructs. Because the inclusion of the constructs into a single model implies their interdependency, all constructs were allowed to correlate with all other constructs (Hair et al., 2006). The error terms of the items were correlated within the theoretical bound based on the reference to the modification index. The measurement model indicated that all indicators load highly and significantly on their respective constructs. Almost all of the indicators yielded standardised parameter estimates of 0.71 or above except the indicators of informal grouping (0.55 at $p<0.001$) and adaptation factor of problem solving (0.70 at $p<0.001$). While Hair et al. (2006: 777) recommend the standardised factor loading in excess of 0.71 as desirable, they also suggest the loading of 0.5 as minimum. As such, no items were dropped from the model. In addition, the measurement model has yielded adequate goodness of fit (chi-square = 363.44, degree of freedom = 226, p-value = 0.00; CFI = 0.97, TLI = 0.97; RMSEA = 0.04).

The convergent and discriminant validities of the constructs can be assessed by referring to the measurement model. Convergent validity refers to the extent that indicators of a construct converge or share a high proportion of variance in common (Hair et al., 2006: 776). This validity measure can be examined with reference to the standardised factor loadings and the variance extracted (VE) that can be calculated from those factor loadings. The VE among a set of indicators is a summary measure of convergence (Fornell and Larcker, 1981). The VE of a multi-indicator construct is calculated by summing up the squared standardised factor loadings and dividing the sum with the number of indicators forming the construct. VE of 0.5 or greater suggests adequate convergence (Hair et al., 2006: 777).

Discriminant validity represents the extent to which a construct is truly different from other construct (Hair et al., 2006: 778). Discriminant validity between constructs can be assessed by comparing the VE for any pair of construct and the squared of the correlation between these two constructs (Fornell and Larcker, 1981). The requirement is that the VE for a construct should be greater than the squared correlation between that construct and other construct in comparison. That is, when comparing with other constructs, the focal construct should explain its own indicators (via its VE) better than it explains other constructs (Hair et al., 2006). For the present study, these validity measures together with the descriptive statistics and reliability measure (via Cronbach's alpha) of the constructs are presented in Table 1.

(Table 1 around here, please)

As shown in Table 1, all pairs of constructs meet the requirement for discriminant validity – i.e. the VE for each construct is greater than the squared correlation between the construct and other construct. In addition, the VEs for almost all constructs are greater than 0.5. These results indicate that the constructs in general demonstrate sufficient convergent and discriminant validities. The one construct in question is the single item construct of informal grouping that records a VE of 0.31. Although the value is less than 0.5, but because informal grouping is an important facet of the structural dimension of social capital, it is decided that the construct is kept in the model for further analyses. On the reliability measure, with the exception of the network ties (alpha value of 0.69) and informal grouping constructs, all other constructs have yielded alpha values of greater than 0.70 (Nunnally, 1978). For the network ties, because the alpha value is only marginally lower than the threshold value, the scale is taken to be reliable. In addition, it is not uncommon that alpha value of 0.60 or above is acceptable especially for the exploratory line of enquiry (Hair et al., 2006).

3.2 Structural model and hypotheses testing

With the construct validity and reliability measures established, all the constructs were entered into forming a structural model that represents the hypothesised model depicted in Fig. 1. As established earlier, we propose, in the main, a mediational thesis between the constructs of interest. The effect of mediation is such that the impact of social capital dimensions - via network ties and informal grouping, shared understanding, and trust – on project safety performance is realised through project organisational processes (i.e. adaptation and cooperation among project participants). As mediators, adaptation and cooperation account for the relation between the predictors (in social capital) and the criterion (in safety performance). Based on Baron and Kenny’s (1986) criteria, full mediation is supported when the relationship between the predictor and criterion is rendered non-significant with the introduction of the mediator.

To test the mediational thesis (and the related hypotheses), nested models has been set up to examine the effect. Because a structural model allows for the simultaneous test of both partial and complete mediation in one single model, for the present study, a nested partial mediation model is set up by adding direct paths from the social capital constructs to project safety performance construct. A series of nested models were explored in the quest to attain a fitting model (including a trial with a path connecting from cooperation to adaptation but with no significant improvement of the model fit statistics). The final model is shown in Fig. 2.

(Fig. 2 around here, please)

Fig. 2 shows the final model with the constructs' respective indicators, their standardised factor loadings and errors terms. With structural model, however, the interest lies with the structural paths that connect the constructs for these paths enable hypotheses testing. From the figure, it can be seen that in the presence of organisational processes (adaptation and cooperation), all except one direct path from social capital to safety performance is not significant. The one direct path that is significant connects shared understanding to project safety performance. Network ties, informal grouping, and trust all have no direct impact on safety performance. H1 is hence partially supported. In addition, the two constructs (the structural dimension) have no impact on cooperation. H2 is hence not supported. Shared understanding and trust (the cognitive and relational dimensions), however, are significantly related to both organisational processes. Hence, Hypotheses 3, 4, 5, and 6 are all supported. On the impact of organisational processes on project safety performance, because the paths leading from adaptation and cooperation to safety performance are all significant, both H7 and 8 are supported. This observation further lends support to the mediational thesis although a direct path from shared understanding to safety performance is present.

4. Discussion

4.1 The mediational thesis

As shown in Fig. 2, the results of the data analyses indicate that the mediational thesis is generally supported – the effect of social capital on safety performance is channelled through project participants' adaptation and cooperation. From the structural model, it can be discerned that although the structural dimension has no impact on both adaptation and cooperation, and similarly no impact on safety performance, the cognitive and relational dimensions (via shared understanding and trust, respectively) are significantly related to adaptation and cooperation. The latter two constructs, in line with the mediational thesis, are significantly related to project safety performance. This adds to other research, in a constructive manner, by identifying positive influences on safety performance; for instance the literature has shown that negative concepts such as job pressure and competition among construction workforce are related to injuries (Hinze and Parker, 1978; Mitropoulos and Cupido, 2009; cf. Leung et al., 2010). In addition, it has been shown that work overload and poor working relationships both lead to job stress (Leung et al., 2010), which in turn, can potentially lead to unsafe work conditions due to participant's loss of concentration in the performance of their works. Under these situations, cooperation and adaptation can potentially mitigate these negative impacts thereby improving safety performance. In the case of cooperation, project participants tend to be more willing to offer assistance to other fellow participants. In addition, cooperative relationships also induce open-mindedness in understanding opposing arguments, integrate opposing ideas, and creating safer solutions (cf. Tjosvold et al., 2001). In terms of adaptation, the adaptive behaviours among the participants function to absorb the shocks brought about by the emergence of these contingencies. Aspects of adaptation envisioned within the empirical work here – crisis handling, problem solving, dealing with uncertainty, and interpersonal adjustment – all function to diffuse the tensions that may arise in the course of safety deviation and view the incident as a learning opportunity with potential to drive continuous improvement.

4.2 The impacts of shared understanding

The preceding argument on understanding opposing views highlights the importance of shared understanding. In the present study, through partial mediation modelling, the cognitive dimension – shared understanding – is related to safety performance (albeit at the lower level of impact in terms of both path loading and level of significance when the model was tested without the mediators (i.e. adaptation and cooperation)). Shared understanding enables more effective negotiation among project participants to arrive at safety goals that are acceptable to most. However, more importantly, from the empirical results (see Items C5 and C9 in Fig. 2), shared understanding that is manifested as shared culture (C5) and common thinking (C7 and C9) govern the norm of behaviour of the participants as the understanding evolves within the group thus providing a supportive protocol within which interaction can take place. These mechanisms underpin and explain the impact of (especially) the positive aspects of safety culture and climate on safety related outcomes (cf. Siu et al., 2004; Vinodkumar and Bhasi, 2010). Reflecting on the nature of the projects studied in this research, they involved the employment of a facilitator and the development of a partnering charter. Hence, the basic "infrastructure" for shared understanding had been developed and the protocols put in place to ensure that the shared understanding was reinforced throughout the duration of the project on so a share culture and common thinking were encouraged and reinforced. In the cultural line of thought, shared understanding increases the project participants' ability to anticipate and predict the actions of other members thereby reducing the scope and likelihood of safety system deviations.

Apart from the above finding, as hypothesised, shared understanding is also positively related to both adaptation and cooperation. Shared understanding increases the likelihood of empathy among project participants with one another. This leads to adaptation in accommodating others' constraints by changing one's own behaviours. In the case of cooperation, shared understanding facilitates the identification of mutual benefits realisable through cooperation. Again, reflecting on the nature of the projects studied, it is unlikely that this degree of shared understanding would have developed on a conventional, design-bid-build project with no partnering agreement.

4.3 The impacts of trust

Turning to the relational dimension of trust, similarly and as expected, trust significantly influences adaptation and cooperation among project participants. Under the dynamic project (safety) operations, adaptation among project participants is required to cater for possible contingencies that arise. The existence of trust improves the confidence that vulnerability in the course of adjustment experienced by one party would not be taken advantage of by another party. In terms of cooperation, in the situation of high trust, there is a positive expectation that members in a group are willing to cooperate thereby influencing an individual's own willingness to cooperate and commit to collective efforts (Kramer, 1991) to the benefit of all.

4.4 The managerial implications

The findings and discussion above lead to some managerial implications. Project social capital can be seen to facilitate project organisational processes by generating a climate in which unification of effort is enabled through the cognitive and relational dimensions. To realise the instrumentality of social capital in a project, the project leader (e.g. project manager), can promote the concept of social capital and increase the amount of social capital amongst the project participants. In terms of the broad relational approach in managing construction project safety, social capital thrives on good quality interactions amongst project participants. This may be, at the outset, beyond the scope of the project manager's remit and hence the role of a facilitator and the development of a project charter are instrumental in developing a climate and a culture in which social capital can be constructed. Hence, a social infrastructure developed at the very outset of the project is a pre-requisite for inducing behaviours in project participants that are associated with the characteristics of trust and the willingness to share information. This assertion has implications on the development of safety climate. Because safety climate is formed through project participants' (including the workforce) attitudes and perceptions (Flynn et al., 2000; Lingard et al., 2011), a project organisation that is characterised by trust and shared understanding is conducive for the formation of safety climate. In this respect, the positive social capital engendered within the project organisation provides a substrate on which a sense of mutuality and recognition are present among project participants that are likely to shape positive attitudes and perceptions among them (cf. Huysman and Wulf, 2006). That is, positive development of safety climate can be expected within project organisation that is endowed with high level of social capital.

As revealed by the results of the study, an important way by which social capital can be engendered is to promote shared understanding and trust among participants whereby the two dimensions intertwine leading to the participants' knowing, recognition, and consideration of one another's needs and goals; a project partnering charter is one mechanism for facilitating this. To this end, as shared understanding, adaptation, and cooperation are important antecedents to the achievement of safety performance, there is a need to highlight these aspects of project management to participants. Apart from devoting attention to these issues in regular project meetings, formally communicating these aspects – e.g. other's constraints – in project safety training sessions are also essential alongside regular safety topics in terms of safe practice, error prevention, risk assessment, trade-specific safety awareness, etc. This mix of social, technical and administrative training, education and facilitation is essential for continuous safety improvement.

Further, the implications of the results on accident analysis and prevention lie within the broad domain of the project safety management practices and the specific area of team collaborative behaviours. Shared understating is related to communication – an important element of safety management practices. Through communication, shared understanding promotes the appreciation of project participants' work and needs. This increased awareness often extends into the work physical situations that fellow participants are in thereby increase the predictability of accident. In terms of collaborative behaviours, both adaptation and cooperation among project participants reduces the workload and hence the demand of tasks. This reduction of demand increases the attention of participants on their affordance of the task and the awareness of physical surroundings. The recognition and acute awareness of the task performance factors – task inherent characteristics and the immediate proximity of its conduct – can potentially prevent accident from occurring.

5. Conclusions

In this study, we have brought to the fore an alternative view of a relational approach (via social capital and project organisational processes) to managing construction project safety. The findings reveal that although largely in line with expectation, the direct effect of the cognitive dimension on safety performance serves to add weight to our conception of the relational approach to managing construction project safety. The conceptual model developed and the empirical results highlight the fact that in construction projects, the project organisational processes, team practices, and the quality of relationships (in terms of better shared understanding and trust) between project participants shape the team capability in safety management. This is a significant step beyond the behavioural approach to safety management and the safety culture approach to behaviour modification, emphasising group working and cooperation rather than individual attributes and their manipulation.

There are at least two limitations for the present study. The study was conducted in Hong Kong. A concern is whether the results derived from the study can be generalised to other regions, cultural and institutional settings. The phenomenon of social capital involves human relations. Its application and invocation in construction projects highlights the local idiosyncrasies on its appreciation, formation, and application. Hence, the findings within the present study should be interpreted with some caution. Another limitation is the cross-sectional survey design of the current study. With this design, the data precludes definite assertion of causality. The results imply rather than prove causality (Scott-Young and Samson, 2009) but provide the basis for further, in-depth research and an opportunity for well-grounded action research.

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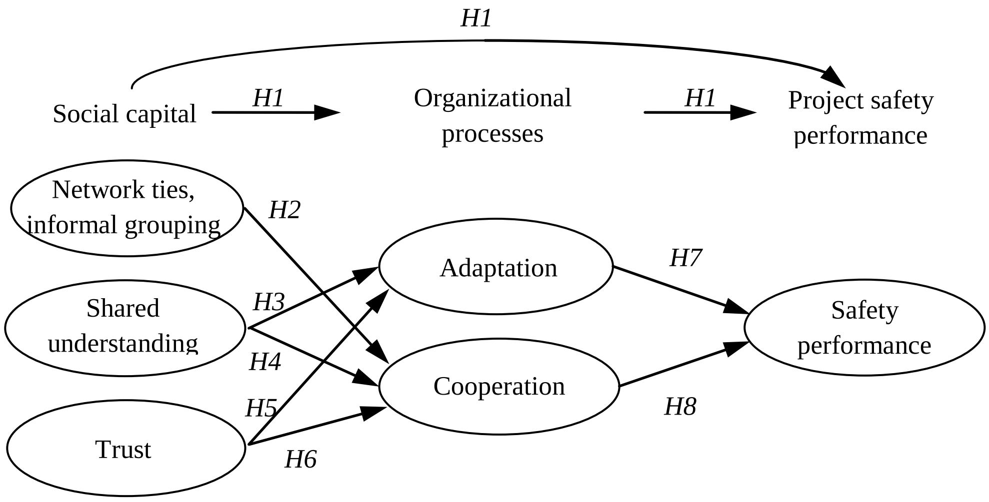

Fig. 1. The hypothesised model linking social capital, organisational processes, and project safety performance.

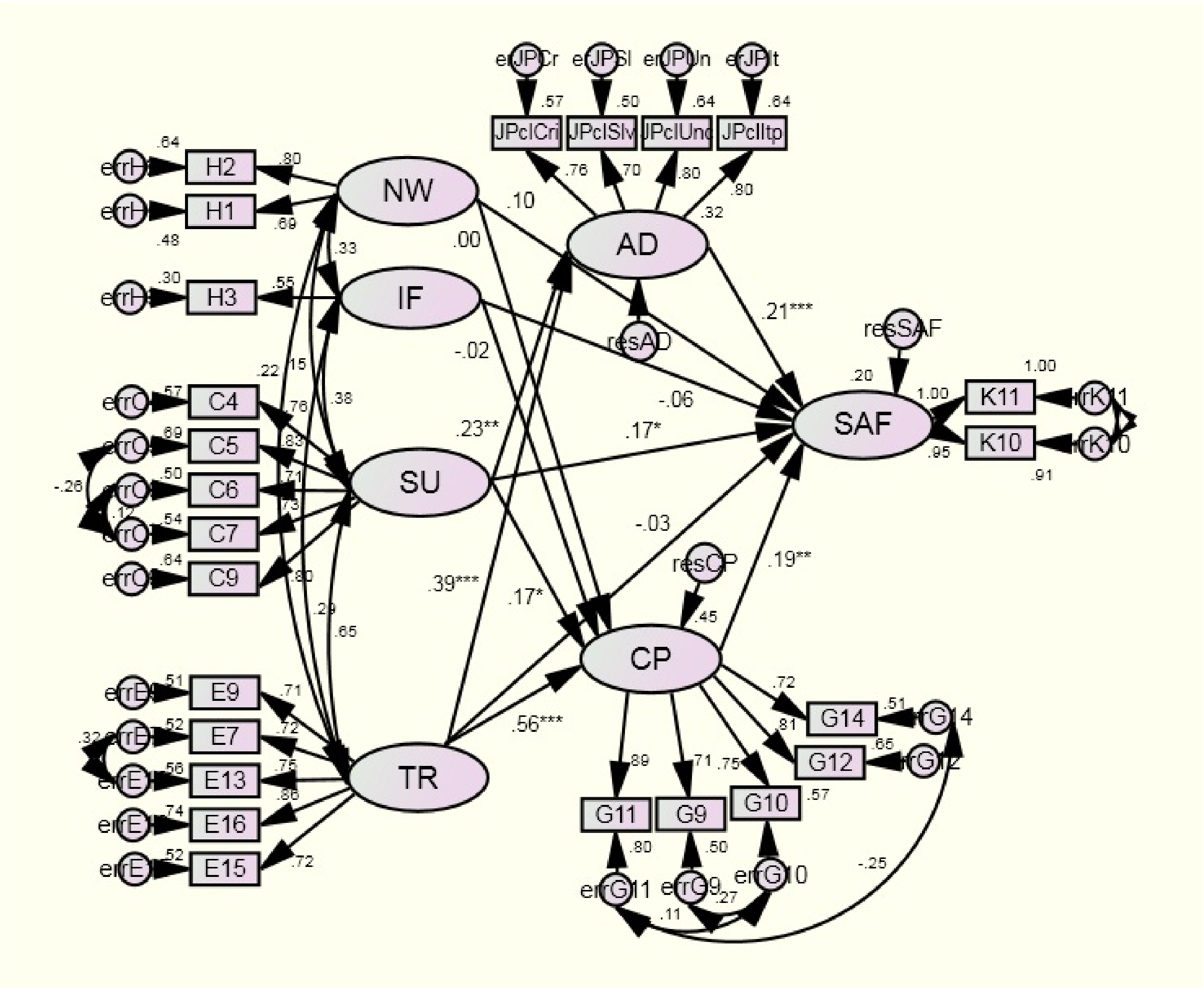

Fig. 2. Standardised parameter estimates of the final structural model (NW: network ties; IF: informal grouping; SU: shared understanding; TR: trust; AD: adaptation; CP: cooperation; SAF: safety performance. Model fit statistics: chi-square=457.80, degree of freedom=229, *p*<0.001, TLI=0.94, CFI=0.95, PCFI=0.79, RMSEA=0.05. **p*<0.05, ***p*<0.01, ****p*<0.001)

Table 1
Constructs descriptive statistics, reliability, convergent and discriminant validity.

	Cron-bach's alpha	Means	S.D.	Squared correlation between constructs (Construct VEs on diagonal in *italics*)						
				NW	IF	SU	TR	AD	CP	SAF
NW	0.69	17.04	6.61	*0.56*						
IF	n.a.	2.84	1.82	0.12	*0.31*					
SU	0.87	4.15	0.16	0.02	0.14	*0.59*				
TR	0.88	4.09	0.11	0.04	0.08	0.42	*0.57*			
AD	0.85	4.26	0.16	0.05	0.11	0.22	0.24	*0.59*		
CP	0.88	4.44	0.07	0.02	0.04	0.26	0.40	0.52	*0.60*	
SAF	0.91	5.06	0.03	0.04	0.03	0.15	0.12	0.21	0.21	*0.75*

n.a. – Not applicable
Abbreviation (number of items per construct in bracket): network ties NW (2 items); informal grouping IF (1 item); shared understanding SU (5 items); trust TR (5 items); adaptation AD (4 items); cooperation CP (5 items); safety performance SAF (2 items).