TASK CHARACTERISTICS, COORDINATION MODES AND DESIGN COORDINATION PERFORMANCE, AN INFORMATION PROCESSING PERSPECTIVE

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Building design is an information intensive activity, in which information exchange between multi-disciplinary professionals is the key to success. Applying the information processing perspective, a project coalition can be interpreted as an information processing system that facilitates information gathering, processing and distribution. Dynamic in nature, building design projects involve a great deal of uncertainty and equivocality and thus have high information processing requirement. Information processing capacity, in terms of coordination mode, is the key to meeting the information processing requirement. A model is proposed in which information processing theory is used to explaining design coordination. Uncertainty and equivocality originated from design coordination task characteristics in terms of task variety and task analysability requires participants in design coalition to frequently process information to reduce uncertainty and equivocality. Coordination modes enable information process to reduce uncertainty and equivocality by certain information amount and information richness. The model serves three aims: the fit between task characteristics and coordination modes, whether the fit is a predictor for coordination performance, and to which extent a better coordination performance lead to better project performance will be tested under the model. In practice aspect, research results will be helpful in guiding the establishing coordination mechanism in building design project coalition.

Keywords: coordination mode, coordination performance, task analysability, information processing.

INTRODUCTION

The complexity of modern construction projects creates intense interrelations and interdependencies among building systems and construction participants, which increase the need for design coordination. Coordination and integration of different design processes are fundamental as the lack of communication among designers can result in suboptimal solutions and thus inadequate project performance.

Up to 75 per cent of the problems happened on construction site were generated at the design phase (Mendelsohn, 1997). This is especially so in China where the design quality problem has become more serious along with the booming construction market since the 1990s (Arditi, Elhassan, and Toklu, 2002; Chen, 1997).In Latin American countries, it is estimated that 20 to 25 per cent of the total construction period is lost as a product of design deficiencies (Undurraga, 1996). Common types of design

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deficiencies include design information inconsistency (e.g. location of a specific wall is not identical when comparing the architectural and structural drawings), mismatch/physical interference between connected comments(e.g. air conditioning duct dimensions in building service drawing do not match the dimensions of the related pass-hole in structural drawings), and components malfunction (e.g. electric supply in a room is designed to serve a classroom activity while architectural drawings indicate the same room has been redesigned as computer lab(Korman, Fischer, and Tatum, 2003; Mokhtar, 2002).

Different professionals (e.g. architects, structure engineers, building service engineers, quantity surveyors, BIM consultants) form a design coalition. Coalition refers to such a temporary multiple organization in which subunits have different interests but work to realize a common goal which is to complete qualified tender drawing within time and budget in the context of building design. The increase of complex and non-routine projects require better coordination to deal with design change during design stage. Design project coalition is more difficult to coordinate when subunits are from different organizations due to specialization and outsourcing. How to coordinate design project coalition to complete coordinate design and enhance the project performance is the question leading this research.

DEVELOPMENT OF RESEARCH FRAMEWORK

Structural perspective was applied by early researchers to study coordination in organizations (March and Simon, 1958; Simon, 1976).The focus was on organizational and job design. At that time, the coordination capability of organizational hierarchies, i.e. formal, vertical coordination mechanisms, were emphasized. Later on, research found that more formalization and stricter authority structures alone are not enough. Formal hierarchy is easy to be overloaded although its coordination efficiency is high (Mintzberg, 1979). Acknowledging there is no best way to organize, researchers began to consider the fit between structure and internal contingencies (e.g. technology) as well as external contingencies (e.g. environment) (Galbraith, 1977; Lawrence and Lorsch, 1967; Thompson, 1967; Van de Ven and Walker, 1984).This approach is called structural contingency perspective. They predict what coordination mode would be efficient rather than what coordination mode would be observed. A well acknowledged proposition of this approach is that the fit between contingencies and coordination mode predict performance. However, these contingencies (e.g. technology and interdependency) and coordination mode could not be compared directly (Egelhoff, 1982).

The emergency of information processing perspective provides an opportunity to address this problem. Organizations can be seen as information processing system (Cyert and March, 1992; Tushman and Nadler, 1978). Further, Winch (2010) put forward that project could also be viewed as information processing system. As such, it is argued that design coalition could be viewed as information providing system under three assumptions following Tushman and Nadler (1978). Firstly, organizations are open social systems which deal with work related uncertainty. Design coalition exchanges information with client and authorities. Hence, they must be able to cope with environmental-based uncertainty (e.g. changed design requirement by client, policy adjustment by administrative authorities). Design coalition is not a closed system under the perspective of information processing. Secondly, the basic function of organization structure is to facilitate the effective collection, processing and distribution of information. Borrowing Winch (2010)'s analogy of river, although we are interested in the information flow (water flow), which forms the final delivery, it is through altering the design coalition structure (bank) that we manage information flow. Design coordination mode, as a structure mechanism, facilitates the effective collection, processing and distribution of information across professional groups. Thirdly, organizations is comprised of groups or departments (Tushman and Nadler,1978). That is particularly true for design coalition. In design coalition, there are architecture group, structure group, building service group, quantity surveying group, and other consultants (e.g. BIM consultant). Different from a corporate organization, groups in design coalition could come from more than one organizations. These groups are interdependent as their activities are linked together. This perspective shift unit of analysis to subunit/department/group, which well suit the aim of this research to investigate into coordination between different professional groups in this study.

Long ago in history, people lived in a self-feeding style. They built up a small house on their own, with little dependence on other people in society. There was little need for coordination. In the process of industrialization, division of labour appeared. As observed by Adam Smith (1976), the specialization and concentration of the workers leaded to more sophisticated skill and greater productivity on their particular subtasks. Also, the time to educate a person to become a professional was shorten. A task group have high specialist capability but low trans-specialist understanding could come to poor performance (Postrel, 2002). Specialization requires compatible coordination. Coordination can be seen as the process of managing dependencies among activities (Malone and Crowston, 1994). From information processing perspective, coordination activity could be viewed as additional information processing activity when a set of actors (two or more) who perform tasks in order to achieve goals (Malone, 1988). Coordination is a function of project management and should be distinguished from production. In this study, design coordination is additional information processing activity when more than one disciplines work together in order to complete a qualified tender drawing in time and within budget.

The gap between information processed and information required to complete a task constitutes information processing requirement. Coordination mode has certain information processing capability by enabling and directing information flow. Coordination mode is composed of two components: people and communication channel. People refer to participants in design coalition who need to process information in order to make sure design information from different disciplines is consistent. Communication channel is the media used by participants to process information, including face to face, video, voice, email, web-based tools, etc.

Generally, activities in organizations can be coordinated by two approaches: by programming or by feedback (March and Simon, 1958). Following taxonomy given by Van de Ven, Delbecq, and Koenig Jr (1976), all forms of coordination by programming are classified as impersonal coordination mode. It refers that participants rely on pre-established procedures, standards, policies, manuals, plans, schedules to integrate design information. Few verbal communication is required when design information is integrated by impersonal coordination mode. Coordination by feedback was classified into a personal mode and a group mode. In personal mode, individual role (such as supervisor, liaison person) serves as the mechanism for integrating and processing information through either vertical or horizontal communication channels. In group mode, information integration and processing are vested in a group of roles through scheduled and unscheduled staff or committee meetings.

In this research, as showed in figure 1, the concept of information processing will be used to explain the fit between contingencies and coordination mode by translating contingencies and coordination modes into information processing requirement and information processing capability. Whether fit between the two predict performance, will be tested based on Daft and Lengel (1986)'s theoretical framework.

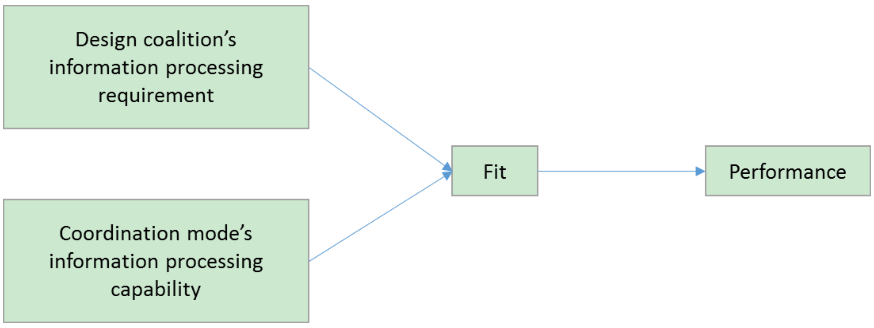

Figure 1 Research framework

DEVELOPMENT OF RESEARCH MODEL

Information processing requirement

Although uncertainty is well recognized as a determinant of information processing requirement persists in organization theory (Sherman and Keller, 2011; Tushman and Nadler, 1978) ,it is debatable whether uncertainty covers all sources of information processing requirement. If uncertainty is defined as absence of information following early work in communication theory (Shannon and Weaver, 1949) and laboratory experiment based psychology research, it is only one kind of factor influencing information processing (Daft and Lengel, 1986). Sometimes, the real situation is co-existence of multiple and conflicting interpretations rather than absence of information. The second factor influencing information processing is equivocality (Daft and Macintosh, 1981). High equivocality means confusion and lack of understanding. Uncertainty has received much attention in project management (McLain, 2009). Compared to the uncertainty, equivocality is a less familiar perspective (Chang and Tien, 2006). Actually, equivocality contributes a lot to construction project problems, such as mismatched or misunderstood expectations (Fallon, 1995), the need for planning and coordination through meetings (Cohenca-Zall et al., 1994), client ability in managing equivocality(Levander, Engström, Sardén, and Stehn, 2011) and the tolerance for ambiguity (Ylinen and Gullkvist, 2012).

Project that faces high uncertainty could reduce level of uncertainty by acquiring more information, while project that faces high equivocality shall rely on processing rich information (Lengel and Daft, 1984). Information richness is defined as the ability of information to change understanding within a time interval. Characteristics of high richness includes immediate feedback, the number of cues and channels utilized, personalization, and language variety (Daft and Wiginton, 1979). Hence, personal coordination mode has higher capability to reduce equivocality than impersonal mode. Impersonal coordination modes such as rules and regulations, formal information systems and special reports have larger capability to reduce uncertainty by providing larger amount of data with higher efficiency (Chang and Tien, 2006; Daft and Lengel, 1986). The relationship has not been empirically tested in AEC industry. Uncertainty (equivocality) is defined as the difference between the amount(nature) of information required which stimulates information processing amongst different professionals following Daft (2009).

The hypothesis H1a, H1b, H1c are

With the increase of uncertainty, the use of impersonal coordination mode increases.

With the increase of equivocality, the use of personal coordination mode increases.

With the increase of equivocality, the use of group coordination mode increases.

Task technology as a source of information processing requirement

One fundamental source of information processing requirement in organization study was labelled as technology by early researchers (Daft and Lengel, 1986; Galbraith, 1973; Perrow, 1967; Thompson, 1967; Tushman and Nadler, 1978). By technology means the actions that an individual performs upon an object, with or without the aid of tools or mechanical devices, in order to make some changes in that object (Perrow, 1967). Several studies of organizational structure and process applied routine-nonroutine dimension which originally was an aggregation of the two underlying task characteristics, i.e. task variety and task analysability identified by Perrow (1967) (Galbraith, 1977;Tushman and Nadler, 1978). Therefore, dimensions of technology used in this research include task variety and task analysability.

Task variety refers to the degree to which stimuli is perceived as familiar or unfamiliar (Perrow, 1967). Task variety is the frequency of unexpected case that occurs in the conversion process of task (Perrow, 1967; Van de Ven and Delbecq, 1974). In design coordination, task variety refers to the frequency of unexpected case that occurs in the process of coordination.

Task analysability concerns the nature of search process for solution when cases with a degree of exception occur (Perrow, 1967). Unanalysable task means the problem/task is so vague and poorly conceptualized that participant draws upon unanalysed experience or intuition, or relies upon chance and guesswork (Perrow, 1967). Participants may have to spend time thinking about what to do, and they may actively search for solutions beyond normal procedures (Cyert and March, 1992). In the context of design coordination, task analysability refers to the extent to which coordination solution could be pre-planned.

Daft and Macintosh (1981) proposed that the two task characteristics (task variety and task analysability) may be systematically related to the amount and equivocality of information processing. Understanding task relationships in a relatively complete way, participants do not need to exchange large amount of information (Galbraith, 1973). Empirical research result demonstrated that the amount of task information processed by participants has a positive relationship with task variety, while equivocality of information have a negative relationship with task analyzability. This research will test these relationship in the context of design coordination.

The second hypothesis includes:

H2a The amount of information processed by participants in order to coordinate multi-discipline design is positively related with task variety.

H2b The equivocality of information processed by participants in order to coordinate multi-discipline design is negatively related with task analyzability.

Information processing capability of coordination mode

Coordination mode could facilitate information flow and enable debate and clarification of interpretation on information. The information processing capability of coordination mode depends on the quantity and quality of information flowed in communication channel. In other words, information processing capability of coordination mode is limited by the information amount and richness of communication channel. Information processing amount and richness are two dimensions used to represent the information processing capability of coordination mode.

Information processing amount of coordination mode
Information amount is a frequently discussed dimension of information processing in organization theory (Galbraith, 1973; Keller, 1994; Tushman and Nadler, 1978). Following Daft and Macintosh (1981), information processing amount is defined as the volume or quantity of data about project activities that is gathered and interpreted by project participants. According to Daft and Lengel (1986), impersonal coordination modes such as rules and regulations, formal information systems and special reports have larger capability to reduce uncertainty by providing larger amount of data. For example, design participants could access to large amount of information through formal information system.

Information processing richness of coordination mode
Richness refers to the quality dimension of information. Information richness is defined as the ability of information to change understanding within a time interval (Daft and Lengel, 1986). Rankings of various communication channels used in coordination mode along information richness have been given by a number of empirical studies (Schmitz and Fulk, 1991; Trevino et al.,1990; Zmud, Lind, and Young, 1990). A continuum of communication channel from a low to high richness scale is: face to face, video, telephone, voice conferencing, group meeting, e-mail. An increasing number of communication media are available in AEC industry (e.g. BIM), while understanding new communication channel is limited(Fox, Leicht, and Messner, 2009). Information richness of available communication channels will be measured by user's perception in design coalition.

Coordination performance and project performance

Coordination performance and project performance will be distinguished in this study. Performance is defined as the extent of achieving goal. Coordination performance is used to evaluate the coordination activity's performance. Subjective measurement of coordination performance will be evaluated by participants representing subunits with a five-item scale developed by Sherman and Keller (2011).The scale examines 1) the extent to which the focal unit a had an effective working relationship with others; 2) the extent to which others fulfilled its responsibilities to unit A; 3) the extent to which unit A fulfilled its responsibilities to others; 4) the extent to which the coordination was satisfactory, and 5) the positive or negative effect on productivity as a result of the coordination. Project performance refers to the performance of the whole design project in terms of quality, cost and schedule. In this study, design coordination is viewed as a management mechanism to meet client's requirement. Hence the cost refers to client's expenditure to complete the building rather than the cost to complete design drawings. To which extent coordination performance is a predictor of project performance will be empirically examined in this study.

H3: coordination performance is positively related with project performance.

Fit

The proposition of fit between information processing requirement and coordination mode's information processing capability has not been empirically tested in architecture, engineering and construction (AEC) industry yet. The notion of fit, congruence or match (fit for short) has been very popular in management studies since the1960s (Parker and Witteloostuijn, 2010) .Two approaches to understand fit are applied in this study, one is the selection approach, and the other is the interaction approach. Selection approach is based on natural selection argument, in which fit is the result of an evolutionary process of adaption, so that the surviving organization at least has modest fit (McKelvey, 1982) .This approach only focuses on the fit between context and structure, while does not examine whether the fit affect performance (Drazin and Van de Ven, 1985). It implies that the effective combination between context and behaviour are more frequent than ineffective combination in surviving organizations (Sicotte and Langley, 2000). Specifically, when a information processing theory suggests that a mechanism is more appropriate in some contexts than others, we expect the intensity of use of the mechanism to be higher. Egelhoff (1982, 1991) applied information processing theory to explain the fit between strategy and structure in multinational companies. In project level research, Oke and Idiagbon-Oke (2010) reported innovation task analyzability was negatively related to richness in horizontal communication channel. Hypotheses H4a and H4b reflect this idea.

H4a: Coordination mode processing larger amount of information are used more than those processing smaller amount of information under high task variety than low task variety.

H4b: Coordination mode processing high richness information are used more than those processing low richness information under high task analyzability than low task analyzability.

The second approach to understand fit is called interaction perspective by Drazin and Van de Ven (1985). It interprets fit as an interaction effect of the context and structure of an organization on performance. From information processing perspective, fit is viewed as the interaction effect of information processing requirement and information processing capability on performance. Amongst survival organizations, some of them are higher performers than others. Managers imperfectly adjust their coordination to project context either because they are unaware of information processing requirement or because they take into account concerns other than efficiency would deviate optimal fit and thus prohibit performance (Sicotte and Langley, 2000). Rice (1992) reported modest support for the contingent effect of task analyzability on the relationship between the use of new media (i.e. online data base, voice mail and video conference) and performance components. Based on the analysis of five existing organizational level research, he found that the use of low processing richness channel (information-lean media) was more strongly associated with positive performance effectiveness in analyzable task environments than in unanalyzable task environments, while the use of high processing richness channel was more strongly associated with positive performance effectiveness in unanalyzable task environments than in analyzable task environments. Keller (1994) applied the fit as an interaction concept to investigate into the contingency effect of task technology on performance. Task non-routineness in his study is exactly task variety. Based empirical study on 98 R&D project groups, he reported that project groups with a level of task non-routineness closely matched their information processing amount were higher performers than those lacking such a match. The relationship was significant when performance was measured by quality, while not significant when performance was measured by budget-schedule dimension. In the context of design coordination, it is hypothesized:

H5a: Subunits with a level of task variety closely matched with information amount of coordination mode will have higher coordination performance than those lacking such a match.

H5b: Subunits with a level of task analysability closely matched with richness of coordination mode will have higher coordination performance than those lacking such a match.

Research model applied in this research is shown in Figure 2.

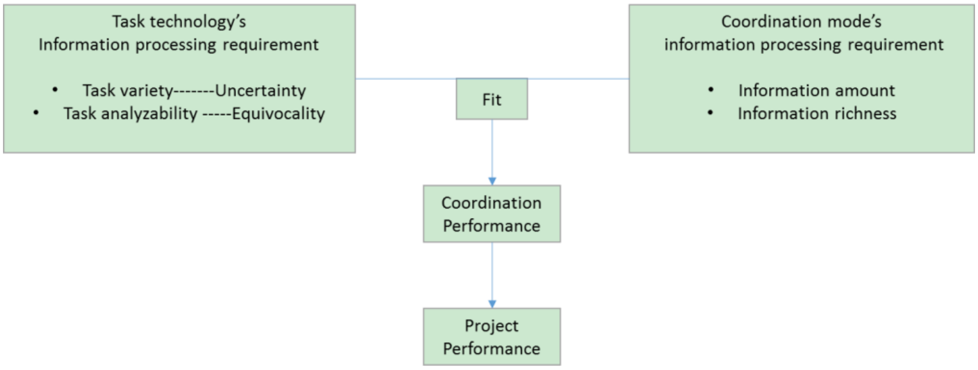

Figure 2 Research model

CONCLUSIONS

Due to multidisciplinary nature and increasing task complexity, how to coordinate multidisciplinary professionals in order to complete a qualified design drawing within time and budget has become challenge for both practitioners and organization design researchers. This paper presented a comprehensive research model applying information processing theory to investigate into multidisciplinary design coordination in the context of building design during detailed design stage. Design coalition which includes a variety of disciplines (e.g. architecture, structure engineering, building service engineering and quantity surveying) is viewed as an information processing system. Coordination mode, as a structure mechanism, facilitates information gathering, processing and distribution by enabling information flow among specific personnel. Uncertainty and equivocality originated from task variety and task analysability require staff in design collation to frequently process information to reduce uncertainty and equivocality. Coordination mode enables information process to reduce uncertainty and equivocality by certain information amount and information richness. Given that task characterises and coordination mode could not be compared directly, by translating task characteristics into information processing requirement and coordination mode to information processing capability, the fit between the two could be tested. Whether the fit is a predictor for coordination performance, and to which extent a better coordination performance lead to better project performance will be tested. In practice aspect, research results will be helpful in establishing proper coordination modes in building design project coalition.

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