How to Improve Interface Management Behaviors in EPC Projects: Roles of Formal Practices and Social Norms

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How to Improve Interface Management Behaviors in EPC Projects: Roles of Formal Practices and Social Norms

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Abstract: Interface management (IM) has emerged as an effective strategy to reduce interface-related issues and risks by facilitating communication and coordination among diverse parties, particularly in engineering, procurement, and construction (EPC) projects. This study developed and tested a theoretical model to investigate how formal IM practices, social norms (i.e., management norms and project norms regarding IM), and personal attitudes interactively affect individuals' IM behaviors. The results show that an individual's IM behaviors are directly driven not only by formal IM practices but also by management and project norms regarding IM. Additionally, formal IM practices have significantly positive effects on management norms, project norms, and personal attitudes toward IM. The findings of this research contribute to the IM body of knowledge by offering insights into the relationships among interface participants' IM behaviors, formal IM practices, social norms, and personal attitudes in EPC projects. Understanding these in-depth underlying relationships can help to develop effective strategies (e.g., developing and maintaining favorable management and project norms) for motivating and supporting IM behaviors.
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Introduction

Engineering, procurement, and construction (EPC) has become a widely adopted project delivery method, especially for large-scale and complex infrastructure projects such as oil and gas production facilities and power plants (Du and El-Gafy 2015). Due to the integration of the design, procurement, and construction processes coordinated by a single entity (e.g., the EPC contractor), EPC delivery methods are more likely to achieve shorter project duration and lower cost (Back and Moreau 2000). Considering that most construction project activities are closely related, integrating and coordinating the diverse functional organizations involved is critical to the successful management of EPC projects (Tang et al. 2008). However, many EPC projects experience difficulties in coordinating diverse project stakeholders (Chinowsky and Rojas 2003; Du and El-Gafy 2015). Particularly, due to the limited available time, EPC contracts are often awarded based on conceptual design without clearly elaborating all the requirements and technical specifications in detail (Öztaş and Ökmen 2004). Under such uncertain circumstances, concurrent engineering (or detailed design), procurement, and construction make it more challenging for EPC contractors to manage numerous interfaces (Shen et al. 2017a, b), such interfaces being the common boundaries between independent but interacting organizations (Morris 1983; Wren 1967). Since the many functions of organizations in a construction project are interdependent, mismanagement of the interfaces can negatively affect subsequent processes, thereby resulting in poor project performances such as delays, cost overruns, low quality, and disputes (Shokri et al. 2016a; Nooteboom 2004).

Recently, interface management (IM) has emerged as an effective approach to enhance coordination among interrelated parties and has received increasing attention in the construction domain (e.g., Shen et al. 2017a; Ahn et al. 2016; Shokri et al. 2016a, b; Chen et al. 2010). According to the Construction Industry Institute (CII), IM is defined as the "management of communications, relationships, and deliverables among two or more interface stakeholders (e.g., contractors, designers, and owners)" (CII 2014, p. 41). For example, in an oil refinery project, changes in tank capacity bring numerous changes in other components, including the structural design for the tank foundation and input pipe sizes. Because the functions of these components are dependent on each other during the design and construction phases, the flow and exchange of information such as technical parameters, resources, and space scheduling information used in the subsequent changes should be well coordinated and integrated among the relevant stakeholders across their interface boundaries (e.g., owner, process engineer, mechanical engineer, structural engineer, contractor). IM plays a significant role in facilitating the efficiency of interactions between an organization and its environment and in mitigating issues that result from incomplete and inaccurate information (Chen et al. 2008; Tang et al. 2006). Given their complexity and uncertainty, EPC projects need extensive collaboration

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among project stakeholders from planning to commissioning; IM can contribute to this collaboration throughout the process and benefit the performance of EPCs (Shokri et al. 2016a; Chen et al. 2010).

Previous research efforts to improve IM mainly focused on organization-level formal IM practices such as specifying IM procedures and developing IM information systems (e.g., Yeh et al. 2017; Shokri et al. 2016b). However, little attention has been paid to the behaviors of interface participants (i.e., project participants who are involved in managing interfaces) in achieving the value of IM. Specifically, the behaviors of interface participants (i.e., IM behavior) refer to the activities aimed at managing interface issues. In this sense, IM behaviors are more related to interactions with others (e.g., communication, coordination) than functional activities. For example, in an EPC refinery project, multiple designs (e.g., structural, piping, electrical, chemical process) and construction activities are carried out in parallel. To accomplish these concurrent design and construction activities and prevent rework, interface participants need to request information and explanations, respond to requests, and exchange information (e.g., technical parameters, drawings) with each other to ensure the consistency and accuracy of interface information to execute their design work. Detecting and resolving interface-related conflicts in technology, time, and space between contractors and designers are also critical activities of interface participants.

Understanding interface participants' IM behaviors is very important because individuals are the engines that drive the interactions between organizations (Jin et al. 1995). Additionally, due to the complexity and dynamism of construction projects, it is almost impractical to establish formal IM practices for every possible situation. In this regard, IM performance may be affected not only by formal IM practices but also by interface participants' discretionary behaviors. Furthermore, in contrast to conventional, permanent organizations, construction projects are inherently temporary organizations, in which participants of different backgrounds, frequently meeting for the first time, work together for a short time and disperse after completing the project. In such a situation, project participants' behaviors when interacting with others, such as coworkers, may not be the same as those in traditional permanent organizations; they may not have sufficient time to fully understand how to work together and manage their common interfaces in a proper way. Therefore, a fundamental understanding of the mechanisms of interface participants' IM behaviors can provide clues to effectively and efficiently motivate interface participants to engage in IM in various situations. With this background, this research aims to investigate the underlying mechanisms of interface participants' IM behaviors.

The structure of this paper is described as follows. In the next section, current IM research efforts are reviewed. Then, a theoretical model of this study and the research hypotheses are presented. In the subsequent section, the research methods used in this study, including the sample, survey measurements, and analytical methods, are described, followed by the analysis results. Finally, theoretical and practical implications of the study are discussed, along with the limitations of this study and the future direction.

Literature Review on Interface Management in Construction and Knowledge Gaps

The current literature on IM mainly focuses on formal IM practices, which refer to a set of formal principles, rules, processes, and tools developed by management and used to govern interfaces. Formal IM practices can be separated into three categories. One category that researchers and practitioners have emphasized is IM procedures, which outline the scopes, methods, and workflows of implementing IM (Yeh et al. 2017; Shokri et al. 2016b; Chua and Godinot 2006). Since IM is a relatively new concept in the construction industry (Chen et al. 2010), each interface participant's understanding and experience of IM implementation (e.g., IM procedures) varies. In such situations, establishing formal IM procedures to provide interface participants with a common understanding of the streamlined means is essential, especially for those who have little experience and knowledge about how to participate in IM. Specifically, formal IM procedures can be summarized by the following five steps: (1) identifying key interfaces at the early stage of the project; (2) documenting interface information (e.g., characteristics, responsibilities of the involved parties, requirements, deadlines); (3) transferring information of the identified interfaces to corresponding parties; (4) communicating with involved parties to execute the interface task; and (5) closing the interface when all involved parties agree on the completion of the interface task (Shokri et al. 2016a; CII 2014; Lin 2013). In addition to the formal IM procedures, existing formal IM practices also include establishing IM-related job positions (e.g., interface managers/coordinators) or allocating specific responsibilities to managers for dealing with interface issues (CII 2014), as well as establishing interface-related information systems for facilitating information exchange and transactions. For instance, Shokri et al. (2016b) and Lin (2013) developed workflow-based processes and developed an interface management system. Chen et al. (2010) provided a systematic interface object model for information technology–oriented interface management. Chua and Godinot (2006) proposed the work breakdown structure matrix system to eliminate unambiguous responsibilities at the interfaces between two parties.

IM formal practices are necessary but may not be sufficient to fully achieve the maximum IM performance. As discussed previously, examining the mechanism of interface participants' behaviors in IM is also critical to improve IM performance because the accomplishment of interface-related tasks requires every interface participant's efforts. Extensive research has confirmed that individuals' behaviors and decision making are influenced by complex factors, including social influences to which they are exposed (e.g., social norms) and personal factors such as attitude toward the behavior of interest (e.g., Tsai and Bagozzi 2014; White et al. 2009; Son and Rojas 2011; Ajzen 1991). Since behaviors pertaining to IM are essentially the coordinative activities between people from different organizations, organizational, social, and personal aspects should be taken into account to fully understand the mechanism of an individual's IM behaviors. However, several research questions have not been explored in the current literature: Which types of social norms are perceived by interface participants? To what extent can these social norms influence their IM behaviors? How do attitudes pertaining to IM influence individuals' IM behaviors, if at all? How do social norms and personal attitudes together with formal IM practices interactively influence individuals' IM behaviors?

Theoretical Model and Hypotheses

To bridge the knowledge gaps, this research aimed to develop and test a theoretical model incorporating social (i.e., social norms) and personal (i.e., personal attitude) factors into organizational controls (i.e., formal IM practices) to examine their collective effects on interface participants' behaviors. The theoretical model and research hypotheses are shown in Fig. 1. The detailed rationales behind the proposed model are discussed in this section.

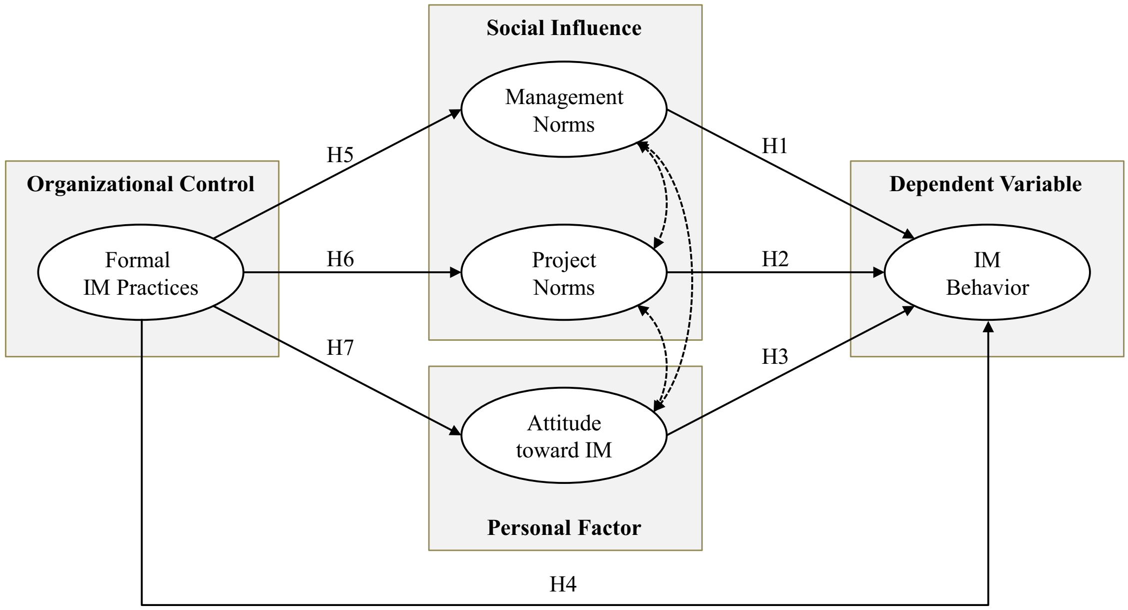

Fig. 1. Theoretical model of the mechanism of IM behavior.

Role of Social Norms in IM Behaviors

Project participants work in a social context in which interactions with others can influence the way they perceive, construe, and behave (Wachtel 1973). A number of empirical studies have revealed the critical role of social norms on organizational behaviors such as collaboration in construction projects (Son and Rojas 2011). Social norms are defined as individuals' shared perception of what behavior is appropriate in a particular group, community, or culture (Elster 1989; Bendor and Swistak 2001). Especially in uncertain situations, people tend to follow what others do to resolve insecurity when making a decision (Smith et al. 2007; Barling and Cooper 2008; Bicchieri 2016). For instance, IM practices of construction companies vary, and many project participants may not have knowledge about or experience with them. If there are no unified or clear rules for IM implementation at the project level, project participants are inclined to behave according to their supervisor's instructions and observations of how others behave. The underlying assumption behind the influence of social norms is that people tend to make their behaviors consistent with the expectations of significant others, which is usually grounded in the need for external validation (Eagly and Chaiken 1993). Compared to a behavioral change under the force of external controls (e.g., formal rules), the behavioral change driven by the internalization of norms has been suggested to be more durable and cost effective (Hogg and Smith 2007). Also, social norms would be more forceful in a situation in which individuals are uncertain about which behaviors are appropriate (Festinger 1954; Barling and Cooper 2008). Considering the large uncertainty regarding IM in construction projects, social norms could be a powerful mechanism to regulate interface participants' behaviors.

Social norms can be categorized into two types: injunctive norms (i.e., the perception that what important others think or approve of, one should do) and descriptive norms (i.e., the perception of whether important others themselves actually perform the behavior) (Cialdini et al. 1990). The important role of the injunctive norm on human behaviors has been widely examined (e.g., Van Breukelen et al. 2004; White et al. 2009; Choi et al. 2017b), especially in the theory of planned behavior (Ajzen 1991). However, many empirical studies showed that injunctive norms often possess relatively weak power in interpreting behaviors due to their failure to clearly define the significant others for a given behavior (White et al. 2009; Terry and Hogg 1996; Sheeran and Orbell 1999; Rivis and Sheeran 2003). Since individuals can interact with diverse groups, treating social norms as a unitary construct can limit the understanding of social influence resources in the context of IM, which has an interactive nature. In the case of IM, the jobs of an interface participant require not only interactions with supervisors (e.g., getting approval) but also interactions with the corresponding interface participants from other organizations in the project (e.g., acquiring information). Therefore, to address this limitation of subjective norms, this study used two distinct types of social norms (i.e., management norms and project norms) to distinguish the significant others for interface participants: supervisors and interface participants from other organizations.

An interface participant acquires the perception of what IM behavior supervisors expect from the participant (i.e., management norms) based on the supervisors' instructions and feedback on specific interorganizational behaviors. If this interface participant recognizes the legitimacy of the supervisors' expectations, the participant would tend to feel an obligation to fulfill them. For example, if an interface participant often completes interface-related tasks late, the participant may receive feedback from managers regarding inappropriate behaviors. The interface participant is more likely to modify those behaviors to conform to the management norms next time. To take another example, when interface participants interact with their counterparts from other organizations and encounter some gray areas in the scope of work, they will be very careful about confirming their respective responsibilities if a manager has taught or reminded them beforehand of the management norms; they can thus avoid some unnecessary disputes. Consequently, the following hypothesized was developed:

Hypothesis 1 (H1): Management norms have a positive influence on IM behaviors.

Since IM behaviors are activities to coordinate and integrate interdependent parties in a project, interface participants' interactions with corresponding interface participants from other organizations would be an important source of social norms. Project norms regarding IM refer to the perceptions of whether the corresponding interface participants from other organizations perform IM behaviors. Project norms are gradually derived from interpersonal interaction and information exchanged with different parties during the project. Interface participants can perceive the appropriateness of their own IM behaviors by observing the actions and responses of other interface participants in the same project during their interaction. For example, in a project, participants from other organizations often arrange face-to-face meetings for decision making or solving interorganizational problems; interface participants who do not prefer meetings may adapt their behavior to prefer meetings because they find that meetings are an effective way to avoid making coordination mistakes. Whereas the management norm is a specific form of injunctive norm (i.e., what significant others think of what one should do), the project norm regarding IM belongs to the descriptive norm category, which refer to what most others do in a given situation (Cialdini et al. 1990). Strong project norms implicitly create a shared understanding among members concerning when and how to participate in project activities (Dholakia et al. 2004). With strong project norms regarding IM, interface participants from multiple parties are more likely to develop a mutual agreement about how to coordinate with each other in a meaningful way. Therefore, it was assumed that:

Hypothesis 2 (H2): Project norms have a positive influence on IM behaviors.

Role of Attitude in IM Behaviors

Attitude is a psychological concept that represents "the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question" (Ajzen 1991, p. 188). Attitude toward a behavior reveals individuals' "overall positive or negative evaluations on the behavior" (White et al. 2009, p. 188) and has been regarded as a significant antecedent to an individual's behaviors (e.g., Ajzen 1991; Tsai and Bagozzi 2014). Specifically, the more favorable one's attitude toward an action, the stronger one's intention to undertake it will be (Ajzen 1991). For instance, IM participants with good attitudes toward IM will often be highly motivated to automatically and successfully perform IM behaviors, as well as to cooperatively assist in others' interface-related works, even when there is a lack of formal practices and social influences. However, if participants hold a negative attitude toward IM, they may choose not to fully follow the rules and social norms pertaining to IM or even to ignore them when supervision is lacking. The attitude–behaviors relation has been empirically supported in various situations, such as contribution behaviors in the community and safety behaviors of construction workers (e.g., Tsai and Bagozzi 2014; Choi et al. 2017b; Armitage and Conner 2001). Therefore, the following hypothesis was proposed:

Hypothesis 3 (H3): Personal attitude has a positive influence on IM behaviors (H3).

An immense number of empirical studies show that attitude and social norms are often correlated from a moderate to a high degree (e.g., Ajzen 1991; Tsai and Bagozzi 2014). There are some overlaps between the concepts of attitude and social norms (Park 2000). Attitude can be classified into two categories: personal attitude and social attitude (i.e., one's belief about behavioral outcomes that affect other people). Both social attitude and social norms involve an individual's behavior in relation to others (Park 2000). That may be why many studies reported the significant correlation between these two variables. Thus, in this model, it was expected that attitude would be correlated with management norms and project norms. It was also assumed that management norms and project norms would be correlated with each other, since they are both related to social expectations toward the same IM activities and often coexist.

Role of Formal IM Practices on IM Behaviors

In practice, actors in construction projects are not working under complete volitional control. They are supposed to comply with the rules in their companies and are often constrained by institutional environment and resources. Formal IM practice is a form of actual organizational control, which provides interface participants with the codified blueprints and requisite resources to implement interfacing tasks. With clearly defined IM procedures, specific job descriptions for IM, and well-established information systems, interface participants should have a shared understanding of their roles and responsibilities in IM and perceive fewer difficulties in performing IM behaviors; therefore, they may be more willing to make extra efforts to carry out IM activities collaboratively. In other words, formal IM practices can contribute to improving individuals' self-efficacy [i.e., individuals' estimation of one's ability to successfully perform target behaviors to produce outcomes (Bandura 1986)] related to IM behaviors and, in turn, improve IM behaviors. From this perspective, it was hypothesized that:

Hypothesis 4 (H4): Formal IM practices have a direct impact on IM behaviors.

Not only should ordinary interface participants' behaviors remain in compliance with organizational regulations in IM, but their supervisors need to follow the companies' IM processes and policies. That is, formal IM practices can affect the supervisors' actions, which in turn influence how they manage their subordinates (i.e., their interface participants). Also, formal IM practices can serve as a reference frame for interface participants to understand the organizational emphasis on IM. In other words, the existence of formal IM practices can explain how much emphasis the organization places on managing interfaces, and it affects interface participants' perceptions of their supervisors' behaviors. For example, interface participants perceive that supervisors give feedback on their inappropriate IM behaviors because those behaviors could impede achieving organizational objectives. Similarly, the formal IM practices they carry out at the project level can be considered a behavioral guideline for all interface participants, whose behaviors would have interaction effects on others. As a consequence, it was hypothesized that:

Hypothesis 5 (H5): Formal IM practices positively influence the development of the perceived management norms.

Hypothesis 6 (H6): Formal IM practices positively influence the development of the perceived project norms.

Although attitudes have been conventionally considered to be a stable assessment of an attitudinal object in long-term memory, many scholars have argued that attitudes can also be considered constructed on the spot [e.g., Tesser 1978]. According to Gawronski and Bodenhausen (2006), the construction process of the implicit attitude depends on two aspects: external input stimuli and the pre-existing structure of associations in memory. In the context of IM, the formal procedures and system are essentially external input stimuli that interface participants have to follow. Moreover, the attitude of a person can be changed "through learning, whereby a person acquires a reaction to an object or action over a period of time or through repeated contact accompanied by reinforcement" (Tsai and Bagozzi 2014, p. 149). By emphasizing the importance of IM and providing the instructions for implementing IM, it is expected that formal IM practices may change interface participants' attitudes toward IM. Following this rationale, it was proposed that:

Hypothesis 7 (H7): Formal IM practices positively influence personal attitude toward IM.

Method

Data Collection

For collecting data to test the model, a questionnaire survey was conducted in 60 international EPC projects that represented a wide range of project characteristics including geographical location, project size, and project type. These EPC projects were located in 32 countries in Asia, Europe, South America, and Africa. The main project types included power generation, such as hydropower stations and thermal power plants (70%), building and infrastructure (15%), and transportation (10%). In terms of project size, the values of seven projects (11.67%) were more than USD 1 billion; 38 projects (63.33%) were valued between USD 10 million and USD 1 billion; and 15 projects (25.00%) were valued at less than USD 10 million.

The managers or staff members whose jobs were related to interface management in EPC projects were chosen as respondents in this study. First, the researchers contacted the headquarters of nine Chinese international EPC contractors that were top 250 international contractors in 2015 Engineering News Record (ENR 2015) and had rich experience with international EPC projects. Then, the administrators of these companies distributed the questionnaires to the potential qualified respondents by email. A total of 200 questionnaires were sent out, and 175 valid responses were received (response rate = 87.50%). The demographic characteristics of the sample are as follows. The respondents' work experience in the construction industry ranged from 1 to 30 years [Mean = 9.13 years, standard deviation (SD) = 6.28]. Of the 175 respondents, 33 respondents (18.86%) had more than 15 years of working experience; 34 respondents (19.40%) had 10–15 years of experience; 66 respondents (37.71%) had 5–10 years of experience; and 42 respondents (24.00%) had less than 5 years of experience. Respondents had, on average, 2.82 years (SD = 1.65) of working experience in the corresponding project. Of the 175 respondents, 83 respondents (47.43%) had more than 3 years of tenure with the project in question; 85 (48.57%) had 1–3 years; and 7 (4.00%) had less than 1 year.

The questionnaire consisted of three sections. The first section included general information on the international EPC project (e.g., location, project type, delivery method) in which the respondents had participated. In the second part, respondents were asked to respond to the items to measure constructs in the model (i.e., formal IM practices, project and management norms, attitude, IM behaviors). To reduce potential social desirability biases and method biases in responses [see Podsakoff et al. (2003)], personal information of the respondent (e.g., job position, working experience) was collected at the end of the questionnaire. The respondents were informed of the confidentiality of their responses and were encouraged to complete the questionnaires honestly, based on their experience in reality.

Measures

Measures for all constructs in the theoretical model are represented in Table 1.

IM Behaviors

Following the definitions of CII (2014) and Lin (2013), IM behaviors in this paper refer to sets of actions that interface participants perform to manage interfaces and are shown in Table 1. Three items—for example, "I have effectively communicated and coordinated with involved parties to request and reply to information and track and monitor interface-related tasks"—were used to measure this construct on a five-point Likert scale (1 = strongly disagree and 5 = strongly agree).

Formal IM Practices

Based on previous research on IM (CII 2014; Shokri et al. 2016a; Ahn et al. 2016), three measures (i.e., formal procedure, IM position, and information system) were used to evaluate the level of formal IM practices on a five-point Likert scale (1 = strongly disagree and 5 = strongly agree). An example is, "There is an information system for our company to use to manage interface-related information."

Management Norms

Management norms were measured by three items representing subjects' perceptions of their supervisors' opinions on the IM behavior measures using a five-point Likert scale (1 = strongly disagree and 5 = strongly agree). An example is, "My supervisor thinks I should effectively communicate with other companies to finish the interface tasks."

Project Norms

Project norms were measured by three items assessing subjects' perceptions of other interface participants' (from other organizations in the same project) behaviors of the same activities that measured IM behaviors and management norms; these items were measured on a five-point Likert scale (1 = strongly disagree and 5 = strongly agree). An example is, "Interface participants from other companies (e.g., designer, owner, consultant) in this project have engaged in identifying and documenting interface information."

Attitude Toward IM

Following Tsai and Bagozzi (2014) and Fishbein and Ajzen (2010), three semantic differential scales (i.e., harmful/beneficial, unenjoyable/enjoyable, and bad/good) on a five-point scale were used to measure attitude toward IM [e.g., "Interface management is always: (1 = harmful to 5 = beneficial)"].

Data Analysis Procedure

To test the research hypotheses, a structural equation model (SEM) was developed using Analysis of Moment Structures. SEM is a statistical technique for measuring and testing substantive and complex interrelationships (Jöreskog and Sörbom 1996). Although many statistical methods can test intermediating relations, SEM can yield benefits not possible with other traditional methods such as multiple regression and correlation analyses. One unique advantage is that SEM is able to model and explicitly estimate both random error and systematic error, which can help to purge systematic bias and certain errors (Fornell and Larcker 1981; Bagozzi and Yi 2012). Other important benefits of SEM over traditional methods include, but are not limited to,

- enabling the simultaneous estimation of multiple dependent variables and the interrelationships among multiple endogenous constructs;
- providing more straightforward and integrative tests of multiple mediations (e.g., to test the model including multiple mediating effects, researchers are required to test and compare at least four regression models; however, in the use of SEM, only one test is needed); and
- taking into account reliability of measures instead of averaging multimeasures of constructs (Bagozzi and Yi 1988).

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Table 1. Summary of measurement items, factor loadings, and reliabilities

Constructs	Items	Factor loading	Cronbach's α
Formal IM practices (F) CR[a] = 0.89 AVE[b] = 0.73	F1: The members of this project can totally understand the interface procedures for carrying out the majority of the interface activities in this project.	0.84	0.89
	F2: There is an information system for our company to use to manage interface-related information.	0.86	
	F3: Our company has job position(s) (e.g., interface coordinator, interface manager) or project manager(s) to deal with IM issues.	0.87	
Management norms (MN) CR[a] = 0.92 AVE[b] = 0.79	MN1: My supervisor thinks I should participate in identifying and documenting interface information with other companies in this project.	0.79	0.92
	MN2: My supervisor thinks I should effectively communicate with other companies to finish the interface tasks.	0.94	
	MN3: My supervisor thinks I should coordinate with other companies to exchange information and track and monitor interface-related tasks.	0.92	
Project norms (PN) CR[a] = 0.91 AVE[b] = 0.77	PN1: Interface participants from other companies (e.g., designer, owner, consultant) in this project have participated in identifying and documenting interface information.	0.95	0.91
	PN2: Interface participants from other companies in this project have effectively communicated with our company in terms of interface-related tasks.	0.91	
	PN3: Interface participants from other companies in this project have effectively coordinated with our company in terms of interface-related tasks.	0.76	
Attitude toward IM (A) CR[a] = 0.90 AVE[b] = 0.76	A1: Interface management is always (1 = harmful to 5 = beneficial).	0.90	0.90
	A2: Interface management is always an experience that is (1 = unenjoyable to 5 = enjoyable).	0.79	
	A3: Interface management is always (1 = bad to 5 = good).	0.92	
IM behaviors (B) CR[a] = 0.91 AVE[b] = 0.84	B1: In this project, I have participated in identifying interfaces and documented interface information (such as responsibilities of the involved parties, requirements, and deadlines), to ensure that they are consistent with all related participants.	0.89	0.91
	B2: I have effectively communicated and coordinated with the involved parties to request and reply to information and track and monitor interface-related tasks.	0.94	
	B3: When an interface task is completed and reconfirmed without further identification, I have informed all corresponding participants that the interface event is finished. (Removed[c])	—	

Note: IM = interface management.
[a]Composite reliability.
[b]Average variance extracted.
[c]This item was removed because its standardized factor loading is lower than 0.7 (Hair et al. 2009).

For these reasons, SEM has been widely applied across many disciplines in the last several decades (e.g., Tsai and Bagozzi 2014; Shen et al. 2017b). Since the theoretical model in this research includes several mediating interrelationships, SEM was used in this research to provide a clear understanding of the mediation process between independent and dependent variables (Bagozzi and Yi 2012). As suggested by Hair et al. (2009) and Anderson and Gerbing (1984), to obtain convergent and appropriate results for a model with six constructs, a sample size of 150 would be sufficient. Therefore, the sample size in this study was adequate for SEM.

Before testing the hypotheses using SEM, adequacy of measures in this study was assessed using a confirmatory factor analysis (CFA). The AMOS 23.0 program was also used for the CFA. The adequacy of measures used in this study was examined based on reliability, convergent validity, and discriminant validity. The following statistics were used to evaluate the goodness of fit (GOF) of the CFA and SEM: chi square/degree of freedom (χ^2/DF), comparative fit index (CFI), Tucker–Lewis index (TLI), the root-mean-square error of approximation index (RMSEA), and the standardized root-mean-squared residual (SRMR; Hu and Bentler 1999; Jöreskog and Sörbom 1996). A satisfactory model fit should meet the following GOF criteria: $1.0 \leq \chi^2/\mathrm{DF} \leq 3.0$; RMSEA ≤ 0.08; SRMR ≤ 0.05; CFI ≥ 0.9; and TLI ≥ 0.9 (Bentler 1990).

Result

Descriptive Statistics and Correlation

Table 2 displays the means, standard deviations, and intercorrelation matrix of the constructs in Fig. 1. As shown in Table 2, formal IM practices, management norms, project norms, and attitude toward IM are significantly correlated with IM behaviors (correlation coefficients ranging from 0.58 to 0.69). Of the five predictors, management norm showed the highest degree of correlation with IM behaviors ($r = 0.69$, $p < 0.01$). As expected, there was a strong correlation between attitude and management norms ($r = 0.82$, $p < 0.01$) as well as attitude and project norms ($r = 0.73$, $p < 0.01$). It was also found that the other predictors correlated with each other (correlation coefficients ranging from 0.61 to 0.73), suggesting that there are positive relationships between these variables.

Measurement Model Evaluation

Reliability reflects the extent to which the assessment is consistent (Bagozzi and Yi 2012). Cronbach's alphas were calculated to assess the scale reliability of the constructs in this study, using Statistical Package for Social Sciences software. Good reliability requires the value of Cronbach's alphas to be greater than 0.7 (Sharma 1996). As shown in Table 1, Cronbach's alphas for all factors ranged from 0.89 to 0.92, indicating that the internal consistency reliability of the proposed model was satisfactory.

Convergent validity, which reflects the degree of homogeneity for a set of items of a latent construct, was evaluated by the following statistics: GOF indices, factor loadings, composite reliability (CR), and average variance extracted (AVE). First, the initial CFA model was built with 6 latent variables and 18 items. Among these items, one was removed (Table 1) because the standardized factor loadings on the constructs were lower than 0.7, which is the threshold value suggested by Hair et al. (2009). The GOF statistics of the model met the recommended criteria mentioned in the "Data Analysis Procedure" section, implying that the data fit it well: χ^2/DF = 1.816; TLI = 0.963; CFI = 0.972; RMSEA = 0.068; and SRMR = 0.036. The factor loadings of all items ranged from 0.76 to 0.95, which is acceptable. As reported in Table 1, the values of CR for six constructs exceeded the recommended threshold of 0.7, and the values of AVE for six constructs were all greater than the acceptable level of 0.50 (Fornell and Larcker 1981), indicating that the convergent validity of all constructs was satisfactory.

Discriminant validity measures how empirically distinct each construct is from the others (Bagozzi and Yi 1988). As the first step, discriminant validity was tested by comparing correlations among all constructs with 1.0 (Bagozzi and Yi 1988). As shown in Table 2, none of the correlation coefficients were significantly close to 1.0.

Table 2. Descriptive data for constructs and intercorrelation matrix

Construct	Mean	SD	1	2	3	4	5
1. Formal IM practices	3.78	0.73	0.85				
2. Attitude toward IM	4.03	0.77	0.61**	0.87			
3. Management norms	3.98	0.76	0.63**	0.82**	0.89		
4. Project norms	3.89	0.75	0.73**	0.73**	0.70**	0.88	
5. IM behaviors	3.67	0.89	0.61**	0.58**	0.69**	0.65**	0.92

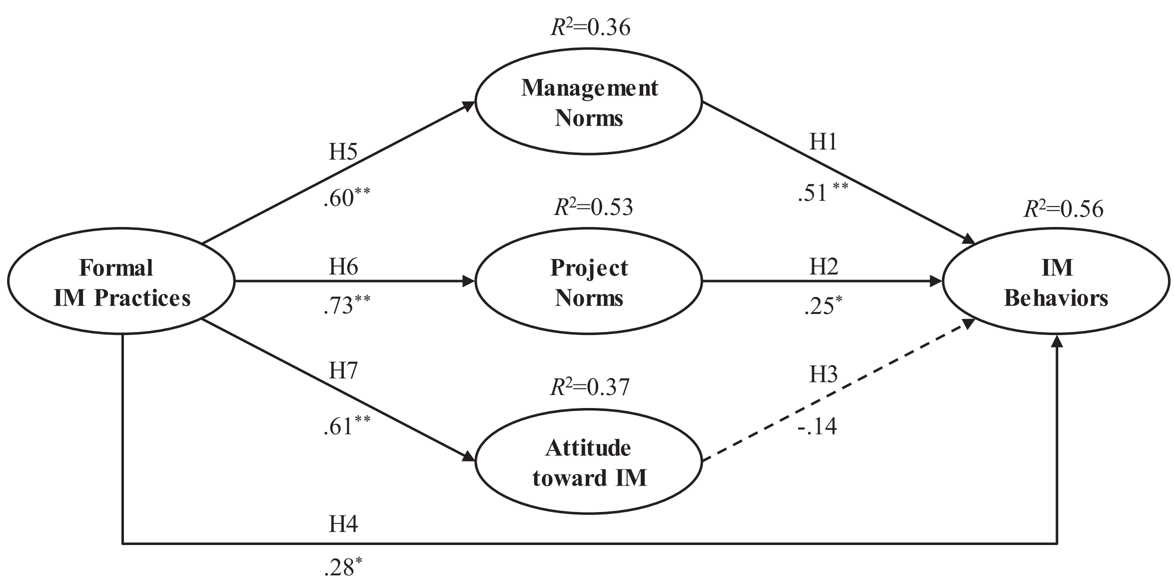
Note: The values in diagonal are the square roots of the average variance extracted (AVEs); nondiagonal values are latent variable correlations. IM = interface management; SD = standard deviation; ** = correlation is significant at the 0.01 level (two-tailed).

Discriminant validity was also tested by examining whether the square roots of AVEs for every construct were greater than the interconstruct correlations (Fornell and Larcker 1981). The square roots of all the constructs' AVEs (i.e., the values represented in the diagonal cells in Table 2) were greater than the interconstruction correlation coefficients. Therefore, all the constructs in this study achieved discriminant validity. With discriminant validity and high reliability of measures confirmed, the probability of inference errors due to multicollinearity was accordingly very low (Grewal et al. 2004; Ramani and Kumar 2008). Also, variance inflation factors (VIFs) were calculated to examine the multicollinearity issue in the model. The values of VIF for all variables ranged from 2.22 to 3.57, far below the threshold of 10.0 (Nunnally and Bernstein 1994). Therefore, the multicollinearity issue was not a major concern in this study.

Structural Model Evaluation

The results of the structural model are shown in Fig. 2. The GOF statistics of the SEM model meet the recommended criteria, indicating that the final model fits well: χ^2/DF = 1.968; TLI = 0.959; CFI = 0.970; RMSEA = 0.075; and SRMR = 0.034.

As hypothesized in H1, management norms had a significantly positive influence on IM behaviors ($\beta = 0.51$, $p < 0.01$). Also, the project norm was a significant predictor of individuals' IM behaviors ($\beta = 0.25$, $p < 0.05$), which is in support of H2. However, the relationship between attitude toward IM and IM behaviors was statistically insignificant, which failed to support H3. There was a positive relationship between formal IM practices and IM behaviors, as proposed in H4 ($\beta = 0.28$, $p < 0.05$). Formal IM practices had significant positive relationships with the management norms (β = 0.60, $p < 0.01$), project norms (β = 0.73, $p < 0.01$), and personal attitude toward IM ($\beta = 0.61$, $p < 0.01$), in support of H5, H6, and H7, respectively. The value of R^2 of IM behaviors was 0.56, indicating that four predictors in the model (formal IM practices, attitude toward IM, management norms, and project norms) collectively explained 56% of the variance in IM behaviors. It is noted that formal IM practices accounted for 53% of the variance in project norms regarding IM, while they accounted for only 36 and 37% of



Note: **= regression coefficient is significant at the 0.01 level (two-tailed); *= regression coefficient is significant at the 0.05 level (two-tailed).

Fig. 2. Final structural equation model.

the variance in management norms and attitude toward IM, respectively. These findings suggest that the effect of formal IM practices on influencing project norms is stronger than their effects on management norms and attitude. Consistent with many previous studies, the standard error of attitude was significantly correlated with those of management norms ($r = 0.72$, $p < 0.01$) and project norms ($r = 0.52$, $p < 0.01$). The standard errors of management norms and project norms were also correlated with each other ($r = 0.48$, $p < 0.01$).

Discussion

Findings

This study developed and tested a theoretical model by examining the mechanisms of interface participants' behaviors in IM. Overall, the results of this study provide evidence that IM behaviors can be directly influenced by management norms, formal IM practices, and project norms. Nevertheless, these factors manifest themselves in different ways.

It was found that management norms can significantly and positively influence actors' IM behaviors ($\beta = 0.51$, $p < 0.01$) and that their direct impact on IM behaviors is much stronger than those of the other three determinants in the model. Project norms were also found to play an important role in positively influencing IM behaviors ($\beta = 0.25$, $p < 0.05$). These findings jointly outline the power of social pressure or expectation in influencing IM behaviors and are in line with findings that individuals' behaviors in the construction projects are under the influence of social control despite the temporary nature of the construction project (Jiang et al. 2010; Lee et al. 2015; Son et al. 2015; Choi and Lee 2017). Because IM is a relatively new strategy in the construction domain, many project participants (including managers) may not have adequate information and experience about what is required to effectively implement IM. In such uncertain situations, people tend to follow their supervisor's instructions and observe how others behave to resolve insecurity about making a decision (Festinger 1954; Hogg and Terry 2000; Smith et al. 2007; Barling and Cooper 2008; Bicchieri 2016). It is noteworthy that the coefficient of management norms is greater than the coefficient of project norms. This result may be explained by differences in the characteristics of the two types of social interactions of interface participants. The intensity of social pressure is determined by the interaction between strength (i.e., power and importance of source to target) and immediacy (i.e., the closeness between the source and target) of the source (Latané 1981). For an interface participant, supervisors in the same organization have formal authority over the participant's IM behaviors, whereas the corresponding interface participants from other organizations usually do not possess enough hierarchical power to affect that participant's IM behaviors. Also, since the supervisors and interface participants belong to the same organization, they share common organizational goals, objectives, and culture. As such, the relationships among them are potentially closer than the relationships between interface participants from different organizations. The strength and immediacy that supervisors have in their relationships with interface participants could result in the stronger coefficient of the management norms.

Contrary to H3, there is no evidence to show that personal attitudes toward IM can significantly affect IM behaviors. The strong norm–behavior links and insignificant attitude–behavior link indicate that institutional and social factors are the primary determinants of IM behaviors, whereas personal factors (i.e., attitude) seem to have somewhat less power. This finding is surprising because attitude–behavior relations are well accepted in numerous studies across various disciplines (e.g., Tsai and Bagozzi 2014; Choi et al. 2017b). However, the result does not necessarily mean that attitude toward IM has nothing to do with IM behaviors. As shown in Table 2, attitude toward IM is significantly correlated with IM behaviors. The relationship becomes insignificant after controlling for the effects of other predictors (i.e., management norms, project norms, formal IM practices). As such, the insignificant coefficient of personal attitude toward IM may be attributed to its strong correlations with other predictors.

This research also reveals the relationships among the four determinants of IM behaviors. Formal IM practices have a positive relationship with the management norms, project norms, and personal attitude toward IM. Combined with the significant paths from management norms and project norms to IM behaviors, it is implied that the formal IM practices have indirect impacts on the IM behaviors through the management norms and project norms. Although the direct link between formal IM practices and IM behaviors is relatively weak ($\beta = 0.28$, $p < 0.05$), the standardized total effect (direct and indirect) of formal IM practices on IM behaviors is 0.60, which is greater than the other three predictors. This finding supports the viewpoint that formal IM practices play a prominent role in improving IM (Yeh et al. 2017; Shokri et al. 2016b; CII 2014).

Understanding the mechanism that relates formal IM practices and IM behaviors can help to explain why project stakeholders sometimes fail to effectively coordinate with each other even if there are formal procedures or managerial tools for managing interfaces. The results show that interface participants' motivations for IM activities are not only determined by the formal control but can also be encouraged or inhibited by the social contexts within which they operate. If positive management and project norms regarding IM are not well developed for various reasons, it is very possible that interface participants do not fully follow, or may even neglect, the formal practices because they may not have sufficient motivations for coordinating with others. In this case, the such formal practices could be much less effective than expected. On the other hand, interface participants who perceive salient social norms regarding IM are more likely to carry out coordinative behaviors because they believe that most significant others conform to and believe they ought to conform to the norms of interest. In the simplest terms, leadership is required to implement IM successfully.

Theoretical Implications

This study has theoretical implications in several research areas. First, the present research supports and advances previous studies on IM by providing a more comprehensive perspective for explaining project participants' actions in the process of IM. A large body of studies on IM focuses on formal mechanisms such as structured procedures and systems (e.g., Yeh et al. 2017; Shokri et al. 2016b; Lin 2013; Pavitt and Gibb 2003). However, the question of whether participants can be effectively motivated by such formal controls and the identification of the underlying mechanisms of their behaviors in IM have been neglected in past research. This empirical research identifies antecedents of IM behaviors and examines how they interactively contribute to the IM behaviors. The results highlight the significance of formal practices and social norms regarding IM, which is consistent with the propositions of institutional theory when making structural and behavioral changes (DiMaggio and Powell 1983). Because IM is not a fully institutionalized practice in the construction industry, interface practitioners working within pluralistic institutional environments must overcome multiple risks and uncertainties to be successful in IM. The work of Scott (2012) on global project organization provides an integrated framework to conceptualize the pillars of institutions: regulative elements (i.e., "rule-setting and sanctioning activities designed to establish and reinforce control") (Scott 2012, p. 29), normative elements (i.e., socially shared expectations of appropriate behavior), and cultural–cognitive elements [i.e., "shared conceptions of social reality" (Scott 2012, p. 27)]. Although the terms are different, the formal IM practice construct in this research is closely associated with the regulative mechanism in Scott's framework, and management norms and project norms are congruent with the normative elements but tailored to fit the nature of IM activities. Except for the institutional and sociological perspectives, the model in this study also takes into account the psychological influence (i.e., attitude) on IM behaviors. By integrating these interdisciplinary perspectives, this study not only outlines their complementarity, which is well developed in project management literature (e.g., Scott 2012; Henisz et al. 2012), but also sheds light on their interactions and reveals which individual elements have stronger impacts. Formal IM practice is found to be the most effective way to improve IM behaviors because it is not only a direct determinant of IM behaviors, but also a strong determinant of management norms, project norms, and attitudes toward IM.

Second, this research extends social influence literature and empirically validates the applicability of social norms in the context of IM by distinguishing injunctive norms (i.e., what significant others think one should do) and descriptive norms (i.e., what significant others do). Although the role of injunctive norms on behaviors has been widely examined (e.g., White et al. 2009; Choi et al. 2017b), many empirical studies showed that it often has relatively weak power in interpreting behaviors due to the failure to clearly define who the significant others are for a given behavior (White et al. 2009; Terry and Hogg 1996). This study further contends that treating social norms as a unitary construct limits the understanding of social influence resources in the context of IM because of the interactive nature of IM: Interface participants not only interact with their supervisor but also with other interface participants from other organizations. Therefore, to address this limitation of subjective norms, this study uses two distinct social norms (i.e., management norms and project norms) to identify the significant others for interface participants and finds that management norms add more value in stimulating IM behaviors than project norms.

Third, the present research also extends previous research on the acceptance or adoption of emerging technologies and practices. The construction industry has long been viewed as conservative in its reticence to embrace new technologies and managerial strategies to facilitate its productivity (Egan 1998). Although previous studies have investigated many factors of acceptance behaviors regarding other emerging technologies or practices in construction projects (e.g., Adriaanse et al. 2010; Park et al. 2012; Son et al. 2012, 2015; Cao et al. 2014; Lee et al. 2015; Choi et al. 2017c), the findings on the impact of social norms seem to be inconsistent. For example, Lee et al. (2015) and Son et al. (2015) reported significant relationships between social norms and building information modeling (BIM) adoption, whereas Cao et al. (2014) found that normative pressures have no statistically significant influence on BIM adoption. In addition, the concepts of social norms in these studies focus more on injunctive norms, which may have limitations in explaining individual behaviors as discussed previously. In the context of IM, this study not only supports the importance of injunctive norms on IM, but also further explores the effect of the descriptive norm, which provides a more specific and comprehensive understanding of the role of social norms in IM.

Practical Implications

Based on the outcomes of this research, several practical implications are discussed. First, management norms regarding IM are found to be an important antecedent of IM behaviors. As such, promoting positive management norms regarding IM behaviors would be an effective strategy to improve IM outcomes. At the individual level, interface behaviors evolve over time, since individuals assess their own behaviors and that of their supervisors against their expectations (Turner 1990). Managers at different levels should offer consistent instruction and feedback to interface participants, since discordant normative expectations could significantly weaken the influence of management norms (Choi et al. 2017a). In this regard, it is crucial that all organization members in management positions recognize the role of IM in project performance. As previously mentioned, since IM has been recently adopted in the construction industry, many managers may not be aware of the importance of IM and may not have enough knowledge and experience to supervise interface participants. Therefore, providing training sessions for management to demonstrate best practices and the benefits of IM could be an effective way to promote management norms and ultimately improve IM behaviors.

Second, it is also found that the project norm is an influential antecedent of IM behaviors. This suggests that management should emphasize developing positive project norms to induce appropriate IM behaviors. Specifically, management should carefully consider how to improve interorganizational communication strategies because project norms generally arise from interactions and information exchanges among different parties. For example, managers are recommended to organize the schedule and nonschedule collective discussions at the project level to encourage interface participants to speak out about their feelings and expectations concerning coordination with each other. A merit of collective discussion is that it can make people more aware of how they themselves, as well as others, think of the ways they work together. If they come to the common conclusion that there is a need for change, they will be more willing to change together because they know that they are not alone in wanting a change.

Third, the results of this research highlight the important role of formal IM practices in promoting IM performance. Fig. 2 illustrates that the formal IM practices are not only direct antecedents of IM behaviors but also can indirectly influence IM behaviors through changing perceived project norms and perceived management norms. This suggests that investing in formal IM practices creates values. Specifically, in order to encourage interface participants' better behaviors in IM, management should develop a codified guideline of action and provide adequate institutional support by enabling key stakeholders to collectively participate in specifying the scope of interdependent works, IM procedures, and rules at the early stage of projects; setting up job positions (such as interface coordinators and interface managers) to be responsible for interorganizational communication and coordination; optimizing organizational structure to allow organizational boundaries to be more permeable; and providing opportunities (e.g., organizing formal and informal meetings among involved organizations) and required resources (e.g., money, technical tools, human resources) for enhancing effectiveness and efficiency of communication and information sharing across boundaries. These organizational supports can enable interface participants to realize the value of effective IM and increase their feelings of control over IM activities, which will, in turn, increase their willingness to spend additional effort to exhibit IM behaviors. It is notable that at the organizational level, interface activities are not static but change over time because different independent tasks are required at different stages. Slight adjustments could be made to the management strategies according to the actual situation.

Limitations and Future Research

Although findings from this study advance the understanding of IM behaviors, several limitations should be acknowledged. First, although samples from diverse project types, sizes, and locations were used (i.e., heterogeneous sampling) to represent the diverse population in this study, all subjects in this study were from contractors. Further research is suggested to validate the model from the perspectives of other parties (e.g., owners, designers, consultants). Second, the findings of this study are based exclusively on data from worldwide EPC projects. However, the insights of the model are developed on a solid theoretical foundation, which appears to be extendable to other project delivery methods in which IM is adopted. Future studies can be conducted to test the validity of the model for related delivery methods. Third, this paper discusses the impact of attitude on IM behaviors and found an insignificant relationship. Other types of attitude besides attitude toward IM behaviors, such as attitude toward professional behaviors, may influence individuals' IM behaviors and are worth investigating in future research. Also, the data collected for this paper were cross sectional, which is common in IM research (e.g., Shokri et al. 2016a, b). However, this method might have limitations in understanding dynamic changes in individuals' attitudes, social norms, and behaviors in the process of interface management. Longitudinal studies are recommended to further study the mechanisms describing how social norms, people's attitudes, and behaviors in IM evolve over time.

Conclusion

Although interface management is a relatively new concept in the construction industry, it holds great promise as a managerial strategy because it facilitates interorganizational communication and coordination and reduces potential risks, especially in EPC projects. Nevertheless, such value can only be achieved when interface participants' behaviors are well stimulated and appropriately supported. This study developed and empirically tested a theoretical model to provide in-depth insights into how organizational controls (i.e., formal IM practices), social influence (i.e., management norms and project norms), and individual attitudes interact in affecting IM behaviors. Based on the data collected from 60 international EPC projects, the main findings are summarized here.

First, in EPC projects, management norms can significantly and positively influence IM participants' behaviors, and their direct impact on shaping IM behaviors is much stronger than that of the other three determinants in the model. Second, project norms are also found to play an important role in positively influencing IM behaviors. Third, the attitude–behavior relationship is not statistically significant. Fourth, formal IM practices have significantly positive effects on not only IM behaviors but also management norms, project norms, and personal attitudes toward IM. In other words, management and project norms partially mediate the relationship between formal IM practices and IM behaviors. The total effect (direct and indirect) of formal IM practices is the greatest among all predictors. The findings indicate that IM is a highly socialized activity that can be driven by not only formal and regulative mechanisms, but also by normative pressures to be consistent within the institutional environment deriving from interpersonal interactions. The findings also provide valuable insights into how different antecedents could be better exercised to improve IM in EPC projects. Understanding the in-depth underlying mechanisms contributes to developing effective strategies for motivating and shaping interface participants' IM behaviors. Future studies are suggested to test the validity of the model for other delivery methods (e.g., design–bid–build) and from the different perspectives of other parties (e.g., owners, designers, consultants). Also, longitudinal studies are recommended in future studies to further study how behaviors in IM evolve over time.

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