Relationship between the interactive use of control systems and the project performance: The moderating effect of uncertainty and equivocality

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Abstract

Information system development (ISD) projects are knowledge-intensive settings that involve varying levels of uncertainty and equivocality. The objective of the present paper is to better understand how project managers can enhance ISD project performance by adapting their level of interactive use of a project’s control system (PCS) to the project’s uncertainty and equivocality. While interactive use of PCS can enable project managers to personally engage themselves in the project team members’ work by regularly discussing project feedback information in face-to-face meetings, it can also be costly in terms of the time and attention it requires from project participants. These relationships were examined via PLS and Fisher test analyses of survey data collected on 93 ISD projects. The results indicated that PCS interactive use enhanced performance when project uncertainty and equivocality were high, but deteriorated it when they were low.

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1. Introduction

1.1. Background

Information system development (ISD) projects are knowledge-intensive social contexts, which require creativity and where team members need to interact, share information and coordinate tasks. They also often involve representatives of future system users and the organization’s management, as well as internal and external IS professionals, all of whom may have different backgrounds, technical skills and personalities. As such, ISD projects are usually characterized by the existence of divergent perspectives, conflicting expectations and misunderstandings among the participants (Havermans et al., 2015). Moreover, unclear and moving project objectives, unexpected issues that often arise, difficulties in predicting the potential impacts of various decisions and actions render ISD projects even more complex. As such, research on ISD project management has extensively studied the concept of uncertainty and the related concept of risk, with a view to improving IS project management techniques (Nidumolu, 1996; Barki et al., 2001; Tiwana and Keil, 2004; Wallace et al., 2004a, 2004b; Han and Huang, 2007).

Uncertainty is generally defined as the lack of information for managing a given task (Galbraith, 1973). As such, its resolution in ISD contexts requires that project members gather the information needed to answer their questions. However, it may not be possible to resolve some of the issues encountered in a project by simply gathering more information. For
example, if a shared vision of the system to be developed is lacking, the issue is not related to uncertainty (or a lack of information), but rather to equivocality (a lack of understanding). Equivocality is however a concept that has not been closely examined in ISD project contexts (Levander et al., 2011).

1.2. Problem discussion and objectives

According to the information processing literature, organizations can be viewed as information processing systems whose objective is to reduce uncertainty (Galbraith, 1973; Tushman and Nadler, 1978). Given the generally well-accepted definition of uncertainty as the lack of information to achieve a given task (Galbraith, 1973), organizational theorists agree that its resolution requires that managers ask appropriate questions about a task, and answer them by collecting the required information. Based on Weick (1979); Daft and Lengel (1986) argue that, more often than less, organizational participants disagree about the right questions to ask due to differences in their perceptions, backgrounds and interests. As a result, questions that need to be asked regarding a given organizational situation might be unclear and the type of information to be gathered may be unknown. To cater for such situations, Daft and Lengel (1986) have introduced the concept of equivocality as an important factor that relates to a lack of clarity and confusion that can exist in a situation and which can affect information processing in organizations.1

Equivocality in ISD project contexts was conceptually discussed by Kydd (1989), but since then has not been empirically examined, perhaps partly due to a lack of validated measures of equivocality in ISD contexts. As a consequence, project characteristics that can lead to difficulties and a certain lack of clarity in ISD tasks, such as changes in user requirements, large project scopes, lack of expertise, or a challenging technology, have been generally attributed to uncertainty (Nidumolu, 1996; Rai and Al-Hindi, 2000; Lee and Xia, 2005). On the other hand, equivocality has been studied in projects outside the ISD context, including Research & Development projects (Gales et al., 1992; Gales and Mansour-Cole, 1995; Sicotte and Langley, 2000) and construction projects (Chang, 2001; Levander et al., 2011). According to many researchers in the latter two domains, project uncertainty is distinct from equivocality. A similar argument would suggest that a given ISD project can also be characterized by different levels of uncertainty and equivocality. For example, if the organization where the IS will be implemented is new to the ISD team members, they would need to collect information about organizational processes and their interrelationships in order to reduce the project uncertainty. However, if the future users of the new system express different needs or do not share management’s vision of the new system, then the issue would be not only one of uncertainty, but also one of equivocality. That is, in such a situation, ISD team members are likely to encounter different interpretations of the desired system from the parties involved, rendering the ISD task more ambiguous. In this case, while collecting more information about user needs may reduce uncertainty, it will not help address the project’s equivocality. Reducing the latter is likely to require that all participants, including user and management representatives, engage in rich communications in order to collectively define the new system. Such a project can be said to be characterized by high levels of both uncertainty and equivocality. Thus, by itself, the concept of uncertainty is not sufficient to fully capture the challenging and more ambiguous aspects of ISD projects.

As noted by Henry (1995), however, while ISD project participants may realize that they need to discuss their different views to reach a consensus, they might not invest the needed time and effort for doing so, unless they are motivated. This suggests that project managers should play an active role in bringing project participants together, facilitating their discussions and integrating their viewpoints, otherwise, equivocality in a project may remain unresolved. Indeed, Levin et al. (1998) and Tsoukas and Chia (2002) have noted that, as leaders, project managers can influence how team members perceive project issues and respond to them by framing the situation in a specific way (Levin et al., 1998), and are therefore able to influence the sense making processes of their teams. In addition, the management control literature also suggests that how managers use project control systems (PCS) such as project plans, budgets and follow-up reports, reflects the degree of their personal and formal involvement in facilitating the integration of the project participants’ work and perceptions (Davila, 2000). Thus, when project managers establish frequent and personal discussions of the information reported in a PCS, their involvement can be viewed as high, and would correspond to a high level of PCS interactive use. On the other hand, if they were to discuss PCS information only on an exceptional basis, their level of involvement would be more limited, representing a low level of PCS interactive use (Simons, 2000; Ferreira and Otley, 2009; Mundy, 2010).

Given the above ideas, and based on the information processing literature and contingency theory, managers who adapt their level of interactive use of the PCS to the project levels of uncertainty and equivocality can be expected to achieve better results. That is, when project uncertainty and equivocality are both high, a project manager can employ higher levels of interaction with project team members in order to better make sense of the project’s control information and issues, and encourage joint development of solutions. On the other hand, when project uncertainty and equivocality are low, too much interaction to discuss project control information might not be needed, and would result in wasted team time and effort, as well as information overload (Chong, 1996), which in turn can negatively affect project performance.

While past research has examined the composition of formal project control systems (Nidumolu, 1996; Kirsch, 1997; Ditillo, 2004; Mignerat and Rivard, 2012), it has not focused on how project managers deploy such systems in order to influence their teams’ information processing capacity (for exceptions, 1 Equivocality has also been referred to as ambiguity (Daft and Lengel, 1986; Schrader et al., 1993). It is important to note that equivocality is different from complexity, which is generally viewed as a broader concept that incorporates uncertainty and equivocality Bystorm, 2002, as well as other dimensions such as interdependencies within a project (Qureshi and Kang, 2015).
see Davila, 2000 and Sakka et al., 2013). As such, the present paper aims to answer the following research question: to what extent does the fit between the level of PCS interactive use and the levels of project uncertainty and equivocality influence project performance? Providing an answer to this question can be useful because, to the extent that ISD projects can be characterized by varying levels of uncertainty and equivocality, scholars as well as practitioners need to better understand how to best manage different ISD project types.

2. Theoretical background

The present paper integrates research from the fields of information processing, project management, management control and information systems in order to define ISD project performance, uncertainty and equivocality, and PCS interactive use.

2.1. ISD project performance

The IS literature generally defines project performance as the efficiency and effectiveness with which an ISD project is completed (Jun et al., 2011). Efficiency refers to the level of success of the development process, i.e., the extent to which a project has been completed within budget and schedule, while effectiveness can include various aspects of the delivered system, such as its reliability, ease of use, flexibility and efficiency (Rai and Al-Hindi, 2000; Na et al., 2004). It is also possible to assess the success of an ISD project based on other facets, such as user satisfaction, team satisfaction and effectiveness, as well as business success and sustainability (Nidumolu, 1996; Shenhar and Dvir, 2007; Barclay, 2008; Chong and Mahama, 2014; Carvalho et al., 2015).

These performance dimensions cover different aspects of the project success that are not necessarily correlated. As noted by Barki et al. (2001): a project that ends on time and meets initial budget may result in a poor quality system; while a project that results in budget and time overruns may end with a high quality system. Hence, if all the dimensions of the ISD project performance are to be taken in account, a formative conceptualization of ISD project performance will be necessary (Gable et al., 2008; Wong, 2013), and a complete enumeration of all concept characteristics would be required, as the omission of one characteristic leads to misspecification of the concept (Diamantopoulos and Winklhofer, 2001; Wong, 2013). Alternatively, project performance can be seen as a reflective construct that is reflected in its measures. In this case, an overall assessment of the project performance is appropriate and it is not necessary to enumerate the concept individual characteristics (Jarvis et al., 2003; Roy et al., 2012).

This paper focuses on how successfully the project manager dealt with the project uncertainty and equivocality and the overall effect on the project performance. It is therefore reasonable to define project performance as a reflective construct, captured through the project managers’ perception of the overall project success, given their involvement in the project processes and their knowledge of its outcomes (Kirsch, 1997).

2.2. Project management and PCS interactive use

Many project management associations provide systematic project management methods, toolkits and models and emphasize the need to use formal control systems, such as plans, budgets and schedules for project monitoring purposes (Besner and Hobbs, 2012). Such PCS provide control information about the expected versus realized project activities, costs, and schedules (Kirsch, 1997). They also help identify a project’s risks and the strategies to manage them (PMBOK® Guide, 2013). Despite the wide use of these tools, high rates of project failure continue to be reported (Sheffield and Lemétayer, 2013). This may be explained by the fact that managers unquestionably adopt project controls because they confer legitimacy and can be used as defenders in case of project failure, without actually using them in managing the project issues (Mignerat and Rivard, 2012). Therefore, understanding how project managers are using these controls in practice may contribute to explaining why projects, where the same control tools are usually implemented, may show different levels of performance.

Based on the management control literature, we suggest that project managers more or less use the project controls in an interactive manner to personally and actively involve themselves in the project team work and decisions. More specifically, PCS interactive use encompasses the following characteristics:

(1) The PCS is used intensively by the project manager and team members. Intensity of use refers to the extent to which project managers and members devote a significant amount of their limited time to discuss project issues (Bisbe et al., 2007). Intensity is revealed in the regularity and frequency of the discussions of control information (Davila, 2000). Specifically, with interactive use, control information provided by the PCS is discussed even when there are no gaps between project results and plans (Abernethy and Brownell, 1999; Bisbe and Otley, 2004). The more frequent the discussions of control information are among project participants, the more interactive the PCS use is.

(2) Information provided by the PCS is discussed in formal face-to-face meetings with project team members. According to Media Richness Theory, face-to-face debates are a rich medium that is associated with more effective communication about control information (Daft and Lengel, 1986; Daft et al., 1987). The literature suggests that the use of impersonal communication media, such as computer-mediated communication, leads to longer times in making decisions and failures to reach consensus (Siegel et al., 1986; Andres, 2002). Hence, the more face-to-face meetings are used to discuss control information, the more interactive the PCS use is.

(3) The involvement of project managers in discussions is non-invasive, facilitating and inspirational. At one extreme, the regular intervention by the project manager may invade...
the autonomy of team members and limit their decision-making possibilities. At the other extreme, it may be used to orient and empower team members, as well as facilitate their communication and knowledge integration. PCS interactive use is associated with a participative leadership style and aims to clarify a project’s success and risk factors, integrating tasks and decisions and developing a common vision, rather than imposing decisions (Simons, 1995; Lindkvist et al., 1998; Vandenbosch, 1999; Su et al., 2015). The more PCS information is discussed in a way that facilitates and integrates visions and decisions, the more interactive the PCS use will be.

Given the high degrees of personal involvement and attention it requires, the level of PCS interactive use can be expected to greatly vary between different projects (Simons, 1994; Sakka et al., 2013). As it involves structured communication, as well as greater focus on project success factors and more efficient task integration (Chong and Mahama, 2014), PCS interactive use is thought to be a positive factor in projects. However, empirical evidence about its direct effect on performance remains inconclusive. A positive and significant relationship between the level of interactive use of control systems and performance at the team level was reported by Chong and Mahama (2014), a negative relationship was observed by Hofmann et al. (2012), and nonsignificant links between these variables were noted by Bisbe and Otley (2004); Henri (2006) and Sakka et al. (2013). These mixed results suggest that some contextual variables may moderate this relationship (Venkatraman, 1989). Based on the potential differential effects of ISD project uncertainty and equivocality discussed earlier, the present study hypothesized these two constructs as potential moderators of the relationship (Venkatraman, Sakka et al. (2013)). These mixed results suggest that some contextual variables may moderate this relationship (Venkatraman, 1989).

### 2.3. ISD project uncertainty and equivocality

The concepts of uncertainty and equivocality were originally defined in the information processing literature respectively as “the difference between the information an organization has and the information it needs” (Galbraith, 1973, p. 5), and the “ambiguity due to the existence of multiple, conflicting interpretations about a given organizational situation” (Cooper and Wolfe, 2005, p. 32). Task uncertainty and equivocality are expected to require different responses from managers; while uncertainty resolution requires the collection and interpretation of additional data, Daft and Lengel (1986) argue that obtaining more information is not sufficient for resolving equivocality. As it reflects ambiguity and a lack of clarity, resolving equivocality requires building models, defining tasks, making evaluations and reframing, all of which can be attained when managers foster rich communications among all task participants (Bryant et al., 2009).

These two concepts were also defined in other literatures. For example, the project management literature defined uncertainty and equivocality by referring, respectively, to the concepts of variability and unanalyzability of Perrow (1967). While the former represents the number of unrelated tasks or unexpected events associated with the accomplishment of a project (Withney et al., 1983; Daft and Lengel, 1986; Sicotte and Langley, 2000), the latter was defined as the absence of a computational process that can be used to develop solutions to encountered problems (Daft and Lengel, 1986; Gales et al., 1992).

Further, the literature in management control did not consider uncertainty and equivocality as distinct concepts and has combined the variability and unanalyzability dimensions of Perrow (1967) in one concept named “uncertainty”.

In the information systems field, researchers have mainly focused on the concept of uncertainty and defined it in terms of a project’s scope, the changes in the requirements of future system users and technological complexity (Barki et al., 1993; Nidumolu, 1996; Rai and Al-Hindi, 2000).

In addition, some authors have raised the issue of whether uncertainty and equivocality should be considered as objective or perceived task characteristics (Duncan, 1972; Downey and Slocum, 1975; Nöteberg et al., 2003). As such, a lack of consensus appears to exist regarding the definitions of uncertainty and equivocality, which, according to many researchers, is a serious barrier to understanding their impacts (Hartmann and Moers, 1999; Chenhall, 2003; Ditillo, 2004). It is interesting to note that Brownell and Dunk (1991) results show that the effects of uncertainty and equivocality on management control variables are significant when they are considered as distinct constructs, but become insignificant when they are combined into a single construct. Hence, based on the project management literature and Brownell and Dunk’s (1991) findings, the present paper suggests that uncertainty and equivocality represent two distinct concepts that may exist at varying levels in ISD projects (Gales and Mansour-Cole, 1995; Sicotte and Langley, 2000).

Based on an extensive literature review, two types of project uncertainty can be defined in the context of ISD projects:

- **Uncertainty related to project scope** is defined in terms of the number of people involved in the project, its cost, its duration; the number of users affected by the system and the number of systems linked to the new IS (Davila, 2000; Sicotte and Langley, 2000; Barki et al., 2001). Theoretically, uncertainty related to project scope has been linked to organizational structure which can affect the type of controls and coordination that would be appropriate among team members (Ditillo, 2004): the larger a project’s scope, the higher the amount of information needed by its project manager to coordinate different project members, and to monitor the project’s costs and schedules.

- **Uncertainty related to project novelty** is defined as the extent to which the functionalities of the new system and the ISD activities are novel to the members of the project team. The literature suggests that the higher the project’s novelty is for team members, the more they will encounter unpredicted events and issues, and the higher the amount of information they will need to process on the new system’s desired functionalities, as well as the organizational processes and

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2 Other factors that may affect the positive effects of control systems are the level of the team members’ participation in setting the project objectives; the level of difficulty of the objectives and the task interdependence (Hansen and Ven der Stede, 2004).
technical accomplishments required to implement the system (Withey et al., 1983; Keller, 1994). It can be noted that project novelty is similar to the variability dimension of Perrow’s (1967) framework.

The literature also suggests two types of equivocality:

- **Equivocality related to ambiguity of user needs**, defined as the existence of different interpretations among the participants to the project about the system to be developed. User needs are usually defined during the requirements specification phase to determine the kind of system expected by the potential users. The IS literature suggests that several factors can render the definition of these needs particularly challenging, making their revision necessary in later phases of the project. For example, user requirements may change during the course of the project, users may differ among themselves in their requirements, and also developers may have difficulties in understanding the specific jargon of the potential system users and in translating it into technical system specifications (Nidumolu, 1996). While past research has theorized the ambiguity of user requirements as a source of uncertainty (Rai and Al-Hindi, 2000; Mehta et al., 2014), we suggest that it is better viewed as a source of equivocality because it does not stem from a lack of information about user requirements, but rather from a lack of consensus about its interpretation.

- **Equivocality related to technological complexity** is similar to the notion of “task unanalyzability” noted by Perrow (1967), largely due to the complexity of the technology involved (Sicotte and Langley, 2000). When the technology used is innovative and complex, a project team might not have a clear procedure about the appropriate way to implement the project in a given organization. In such a case, a team’s ability to share, integrate and reconfigure their existing competencies in order to build a shared understanding of the company’s context and the way to implement the new system can become critical for project success (Pavlou and El Sawy, 2006; Cheng and Yang, 2014).

Several researchers (e.g. Gales et al., 1992, Gales and Mansour-Cole, 1995, Sicotte and Langley, 2000, Chang and Tien, 2006, Levander et al., 2011) have argued that, while uncertainty and equivocality may be correlated, they can exhibit varying levels. For example, a project may involve a limited number of participants and have a limited expected cost and time of development (low uncertainty related to project scope), but involve high ambiguity about the users’ needs (high equivocality of user needs). As another example, the processes to be supported by a new system may be totally new for the team members, which would imply a strong need for information about organizational processes and their interrelationships (high uncertainty related to project novelty), but the ISD team might be asked to add only a few features to an existing system which would imply a low level of technological complexity (low equivocality related to technological complexity).

### 3. Research model and hypotheses

As can be seen in Fig. 1, the research model hypothesizes that the fit between the level of PCS interactive use and project characteristics (uncertainty and equivocality) will influence ISD project performance. As we expect that the type of PCS use will vary according to the levels of uncertainty and equivocality of a project, the nature of the fit relationship we investigate corresponds to fit as moderation or interaction (Venkatraman, 1989; Luft and Shields, 2003; Gerdin and Greve, 2008).

A more detailed description of the expected association between the level of PCS interactive use and project performance, under different conditions of uncertainty and equivocality is provided in Fig. 2.

#### 3.1. Relationship between project uncertainty, interactive use of PCS and performance

According to research in the information processing field, managers who face uncertainty feel that they know what to do, what information they need, and what results they should expect (Daft and Lengel, 1986). In such cases, an appropriate response would be to gather the information needed to manage the task at hand (Schradler et al., 1993). However, according to Mehta et al. (2014), simply gathering large amounts of information may be insufficient when uncertainty is high. Uncertainty resolution requires that task participants make sense and develop a common interpretation of the information collected in order to be able to use it in decision-making. As interactive use of PCS involves team members throughout a project, it can be viewed as a formal and structured mechanism that allows managers to not only gather large amounts of information, but also to foster the development of a shared understanding of it (Kerzner, 2006; Henry et al., 2007). It is interesting to note that research in the management control field has found that interactive use of control systems tends to be greater in situations of high uncertainty, such as those of strategic change and organizational innovation (Abernethy and Brownell, 1999; Bisbe and Otley, 2004).

In ISD projects, when uncertainty stems from the project’s large scope, using PCS interactively allows project participants to frequently meet and coordinate tasks, as well as avoid redundancies, which in turn is likely to lead to greater project efficiency and effectiveness (Barki et al., 2001). Davila’s (2000) findings confirm that interactive use of project budgets is positively associated to uncertainty related to the scope of new product development projects.

When uncertainty stems for a novel ISD task, team members may be unfamiliar with the organizational context or with the functionalities of the system to be developed. In such cases, researchers suggest that greater collaboration can help build collective competence (Chong and Mahama, 2014; Akgun et al., 2015), defined as “a group’s ability to perform together toward a common goal, which results in the creation of a collective outcome” (Ruuska and Teigland, 2009, p. 324). Formal and structured team communications, specifically planned by the project manager, is thought to facilitate
knowledge integration (as opposed to knowledge generation only), which is necessary to build collective competence (Gibson, 2001; Gibson and Earley, 2007). As managers who make interactive use of PCS are likely to personally be engaged in team discussions, foster collaboration and knowledge integration, they can be expected to actively participate in building the team’s collective competence and addressing the uncertainty that stems from task novelty. This is also supported by Sakka et al. (2013) who found that task novelty positively moderated the relationship between PCS interactive use and ISD project performance.

However, interactive use of control systems also requires regular attention from the project manager and team members, attendance at formal face-to-face meetings, collection and sharing of information, and therefore demands considerable time and effort (Widener, 2007). This suggests that, when uncertainty is low, the costs of this type of use may outweigh its benefits and result in poor performance. Using PCS interactively in low uncertainty contexts means imposing unnecessary interactions to the team members, which may lead to information overload and lack of motivation and result in budget and schedule overruns (Chong, 1996). This is also supported by Sakka et al. (2013) who found that interactive use affected project performance negatively when project novelty was low, and positively when it was high.

Based on the above arguments, it would be reasonable to expect PCS interactive use to improve performance when project uncertainty is high, but to hinder it when deployed in low uncertainty projects. Hence,

**H1a.** Uncertainty related to project scope will positively moderate the relationship between interactive use of PCS and project performance.

**H1b.** Uncertainty related to project novelty will positively moderate the relationship between interactive use of PCS and project performance.

### 3.2. Relationship between project equivocality, interactive use of PCS and performance

According to Koufteros et al. (2002, p. 339), equivocality increases the need for structural mechanisms that “enable debate, clarification, and enactment rather than simply providing large amounts of data”, which suggests that interactive use of PCS is well suited to contexts of high equivocality. However, some studies have also suggested that project managers who face high levels of project equivocality are likely to prefer informal communication, as they may perceive it to be faster and more reliable than the formal communications involved in PCS interactive use (Mintzberg, 1979, 1994). As such, distinguishing between the roles played by informal and formal communications could be useful for investigating this idea. In this regard, Dirschmith and Covaleski (1985, p.152) noted that the use of informal communications is typically not in order to make task-related decisions, but rather to “broadly monitor the environment for problems and opportunities”, whereas the use of formal communication is for “focusing of attention for decision making”.

Hence, compared to those who rely on informal communication channels, managers who use formal face-to-face discussions embedded in PCS interactive use can be viewed as explicitly expressing a desire for structured teamwork and for seeking each team member’s input to the decision making process. This, in turn, is likely to result in higher levels of team collaboration and lower levels of personal conflicts (Jun et al., 2011).

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<th>Uncertainty</th>
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<td>Equivocality</td>
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<td>High</td>
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Fig. 2. Association between PCS Interactive Use and Project Performance depending on the levels of Project Uncertainty and Equivocality.

**Fig. 1.** Research model.
The literature provides further arguments as to why interactive use of PCS is likely to improve performance in high equivocality projects. For example, it is thought that frequent personal meetings can enable team members to better understand each other’s jargon, a factor that is particularly important in ISD projects which often involve participants from different backgrounds (Henry et al., 2007). Media Richness Theory also considers face-to-face interactions to be the richest communication media that managers can use, and hence the most useful medium for managing equivocality (Daft et al., 1987). Moreover, several changes can also occur during the course of an ISD project, such as changes in the organizational environment, business needs, or user requirements, which in turn can lead to differences in the interpretations of the ISD task and of the system that will be implemented. In such contexts, managers who make greater interactive use of PCS would be likely to more quickly detect such changes, and to stimulate the development of new plans that integrate updated information (Lee and Xia, 2005).

As the interactive use of PCS is also not without its costs, it would be reasonable to think that it will be likely to improve performance in high equivocality contexts, but not in low equivocality projects. There is however a lack of empirical research on this specific link. An exception is Sakka et al. (2013) who found that PCS interactive use improved ISD project performance when technological complexity was high, but deteriorated it when it was low.

Some research has examined the management of equivocality related to user needs. For example, Nidumolu (1996) found that the use of output controls in general improved ISD project performance when user needs ambiguity was high. In addition, user participation in the development process was also found to positively influence project performance when ambiguity of user needs was high (Nidumolu, 1995). Given that PCS interactive use involves output controls and requires the participation of all project members, it can be viewed as an effective tool to solve equivocality related to technological complexity and to ambiguity of user needs. Hence,

**H2a.** Equivocality related to technological complexity will positively moderate the relationship between interactive use of PCS and project performance.

**H2b.** Equivocality of user needs will positively moderate the relationship between interactive use of PCS and project performance.

### 3.3. Combined effect of uncertainty and equivocality on the relationship between interactive use of PCS and project performance

As noted by several researchers (Gales et al., 1992; Keller, 1994; Sicotte and Langley, 2000; Chang and Tien, 2006), projects may be characterized by varying levels of uncertainty and equivocality. It is therefore important to study their combined effect on the relationship between PCS interactive use and project performance. Based on the discussion in Sections 3.1. and 3.2., it is reasonable to expect that PCS interactive use would have the strongest effect on performance when project uncertainty and equivocality are both high, the weakest when they are both low, and moderate otherwise. Hence,

**H3.** The effect of PCS interactive use on project performance is strongest when uncertainty and equivocality are both high, and weakest when they are both low.

### 4. Research methodology

#### 4.1. Data collection

As they are generally highly knowledgeable about the ISD projects they manage (Kirsch, 1997), survey data was collected from ISD project managers. We first contacted a random selection of top managers listed in the Directory of Top Computer Executives in Canada to obtain contact information regarding the ISD project managers in their organization. Of the 116 ISD project managers we identified, 36 declined to participate due to time constraints. The remaining 80 were each hand-delivered the study questionnaire and a business reply envelope, and 48 of them completed and returned the questionnaire. The present study’s response rate (41%) and the number of projects in our sample (93) are comparable to the response rates of other studies that surveyed project managers (e.g., Agrawal and Rathold, 2006, Jun et al., 2011) and to the sample size of several published studies on ISD projects (e.g., Keskin, 2009; Liang et al., 2012; Nidumolu, 1996; Rothenberger et al., 2010).

Following Nidumolu (1995, 1996) and Mehta et al. (2014), each respondent was asked to complete the study questionnaire for two different projects they had managed, one successful and one less successful. The objective of this approach was to increase both the number of ISD projects in the study sample, as well as the variance in the study’s dependant variable. Only three respondents failed to respond for two projects, resulting in a final sample of 93 ISD projects in 25 organizations. The respondents were experienced project managers with an average of 13 years of experience. The projects in our sample varied in terms of number of participants (Mean = 18, SD = 19), cost (Mean = $3085 K; SD = $6788 K) and duration (Mean = 15 months, SD = 9 months). They included the development of various types of systems, including ERP, EDI, inventory management and transaction processing systems, cost assessment systems, and life-insurance policy management systems.

Normality of the data was assessed via Kurtosis, Skewness and Kolmogorov–Smirnov statistics, with all study variables having normal distributions, except for uncertainty related to project scope which had a moderately non-normal distribution (Skewness = −1.10; Kurtosis = 1.22; Kolmogorov–Smirnov < 0.01). This finding influenced the choice of the data analysis method that was used, as discussed in section 5.

Given the relatively low number of responses (48) and the risk that our sample would be non-representative of the population, we assessed the potential for organizational bias and for response bias. To assess the potential for organizational bias, we compared the IT department sizes of the 14 organizations that had one
respondent and the 11 that had multiple respondents using t-test and found the difference to be non-significant (t = −0.60; p > ns). This suggests that department size, a key distinguishing characteristic of IT departments, was unlikely to have been a source of bias. Moreover, Chi-square analyses and t-tests showed no significant differences (at p < 0.05) between early and late respondents in terms of experience and educational levels, suggesting that non-response bias was unlikely.

To assess the potential for common method bias, the Harmon one-factor test was applied to the main constructs of the study, and the variance explained by the first extracted factor was found to be 31%. As a second test, we included the first factor that resulted from a Principal Component analysis – considered to be the best approximation of common method variance—in the Partial Least Squares (PLS) models. This factor did not significantly change the variance explained in the dependent variable of the research models, suggesting that common method bias was unlikely to be a serious concern (Podsakoff et al., 2003).

4.2. Construct measurement

The items that were used to measure the study constructs and item weights/loadings are provided in Table 1. We adapted existing measures to the context of our study and pre-tested them with ISD project managers and academics, which led to some minor revisions.

Equivocality related to ambiguity of user needs was measured with items adapted from Daft and Macintosh’s (1981) scale of information equivocality and asked the respondents whether user needs were interpreted differently, were perceived as ambiguous and gave rise to different interpretations among project team members.

PCS interactive use was measured by focusing on the use of project follow-up reports, a type of PCS that is commonly used in ISD projects (Kirsch, 1997; Mignerat and Rivard, 2012). These reports are formal project control systems that provide ongoing feedback about project indicators, such as project costs, schedules, risk management and communications among project participants (PMBOK® Guide, 2013). Based on Bisbe et al. (2007), we used a formative index to measure PCS interactive use defined by three properties:

1- The pervasiveness of face-to-face challenges and debates. One item from Bisbe and Otley (2004) was used to assess the project manager’s and team members’ formal face-to-face discussions of follow-up reports compared to other communication methods such as phone calls or e-mails.

2- The facilitating and inspirational involvement of project managers in discussions of the information provided by project follow-up reports. Five items were adapted from Bisbe and Otley (2004) and Henri (2006) to assess how intensively the respondents used follow-up reports to enable team members to focus on common issues and on the project’s success factors, to foster the development of a common vocabulary and a common vision of the project, and to integrate the various project activities.

3- Intensive use of project follow-up reports. This was assessed with an item from Bisbe and Otley (2004) that asked whether respondents had discussed follow-up reports with team members even when there were no gaps between results and plans.

The above seven items were used as formative indicators of interactive use of follow-up reports by project managers. Following Jarvis et al. (2003) who recommend that reflective items be used to validate a formative scale, two reflective items were added and asked the respondents whether they engaged team members in frequent discussions of project follow-up reports during formal meetings, and took necessary measures to ensure that the entire team gave its constant attention to the reports.

Project performance was assessed via four reflective items borrowed from Na et al. (2004) and Gable et al. (2008) and asked about the extent to which, overall, the project and the development process were considered successful and fulfilled their objectives.

5. Results

In order to test H1a to H2b, we used Partial Least Squares (PLS) regression with SmartPLS (Ringle et al., 2005). PLS was preferred to a moderated regression analysis for two reasons. First, formative constructs, such as interactive use of PCS, can be examined with PLS. Second, the relatively small size of our sample and the moderate non-normality of one of our variables also suggested that PLS would be an appropriate choice (Walczuch et al., 2007; Westner and Strahringer, 2010). PLS is not dependent on data normality because path significance is
Table 1
Item descriptions and loadings/weights.

<table>
<thead>
<tr>
<th>Construct</th>
<th>Item description</th>
<th>Loadings/weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncertainty related to project scope</td>
<td>Please describe the scope of each project in terms of:</td>
<td>0.894</td>
</tr>
<tr>
<td></td>
<td>SCOPE1—approximate number of people on the project team</td>
<td>0.801</td>
</tr>
<tr>
<td></td>
<td>SCOPE2—approximate cost of the project (thousands)</td>
<td>0.888</td>
</tr>
<tr>
<td></td>
<td>SCOPE3—approximate duration of the project (months)</td>
<td>0.311^D</td>
</tr>
<tr>
<td></td>
<td>SCOPE4—approximate number of person-days allocated to the project</td>
<td>0.244^D</td>
</tr>
<tr>
<td></td>
<td>SCOPE5—approximate number of users affected by the new system</td>
<td>0.305^D</td>
</tr>
<tr>
<td></td>
<td>SCOPE6—how many systems were developed concurrently with the new system and then linked to it?</td>
<td></td>
</tr>
<tr>
<td>Uncertainty related to project novelty</td>
<td>To what extent do you agree or disagree with the following statements?: (1 = strongly disagree; 7 = strongly agree)</td>
<td>0.619</td>
</tr>
<tr>
<td></td>
<td>NOV1—many project activities were new to the team</td>
<td>0.690</td>
</tr>
<tr>
<td></td>
<td>NOV2—many system functionalities were new to the team</td>
<td>0.859</td>
</tr>
<tr>
<td>Equivocality related to project technological complexity</td>
<td>To what extent do you agree or disagree with the following statements?: (1 = strongly disagree; 7 = strongly agree)</td>
<td>0.684</td>
</tr>
<tr>
<td></td>
<td>PLEX1—during the project, the team encountered problems that were very difficult to resolve</td>
<td>0.873</td>
</tr>
<tr>
<td></td>
<td>PLEX2—overall, the project was very complex</td>
<td>0.831</td>
</tr>
<tr>
<td>Equivocality related to ambiguity of user needs</td>
<td>To what extent do you agree or disagree with the following statements?: (1 = strongly disagree; 7 = strongly agree)</td>
<td>0.842</td>
</tr>
<tr>
<td></td>
<td>The members of the project team...</td>
<td>0.843</td>
</tr>
<tr>
<td></td>
<td>AMBIG1—interpreted user requirements differently</td>
<td>0.873</td>
</tr>
<tr>
<td></td>
<td>AMBIG2—thought that the user requirements were ambiguous</td>
<td></td>
</tr>
<tr>
<td>Interactive use (formative measure)</td>
<td>To what extent were the following communication methods used to discuss follow-up reports with your team members? (0% to 100%)</td>
<td>0.999***</td>
</tr>
<tr>
<td></td>
<td>INT1—formal face-to-face meetings^a</td>
<td>0.399 ***</td>
</tr>
<tr>
<td></td>
<td>telephone</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e-mail</td>
<td></td>
</tr>
<tr>
<td></td>
<td>other communication methods, please specify.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Please indicate how much you used the project follow-up reports to: (1 = not at all; 7 = very much)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INT2—enable all team members to focus on common issues</td>
<td>0.053</td>
</tr>
<tr>
<td></td>
<td>INT3—foster the development of a common vocabulary for the project</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INT4—provide a common vision of the project</td>
<td>0.234 ***</td>
</tr>
<tr>
<td></td>
<td>INT5—enable all team members to focus on the project’s success factors</td>
<td>0.209^*</td>
</tr>
<tr>
<td></td>
<td>INT6—integrate the project’s various activities</td>
<td>0.709 ***</td>
</tr>
<tr>
<td></td>
<td>To what extent do you agree with the following statements?: (1 = strongly disagree; 7 = strongly agree)</td>
<td>0.167</td>
</tr>
<tr>
<td></td>
<td>INT7—l discussed the follow-up reports with team members even when there were no gaps between the results and the plans</td>
<td>0.186^*</td>
</tr>
<tr>
<td>Interactive use (reflective measure)</td>
<td>To what extent do you agree with the following statements?: (1 = strongly disagree; 7 = strongly agree)</td>
<td>0.824</td>
</tr>
<tr>
<td></td>
<td>INT8—during formal meetings, I engaged team members in frequent discussions about the follow-up reports.</td>
<td>0.959</td>
</tr>
<tr>
<td></td>
<td>INT9—I took the necessary measures to ensure that the entire team would give its constant attention to the follow-up reports.</td>
<td></td>
</tr>
<tr>
<td>Project performance</td>
<td>Please indicate to what extent you agree or disagree with the following statements: (1 = strongly disagree; 7 = strongly agree)</td>
<td>0.910</td>
</tr>
<tr>
<td></td>
<td>Overall, the project...</td>
<td>0.663</td>
</tr>
<tr>
<td></td>
<td>PERF1—was a great success</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PERF2—did not meet its objectives^R</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overall, the development process of this system...</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PERF3—may be considered a great success</td>
<td>0.920</td>
</tr>
<tr>
<td></td>
<td>PERF4—completely fulfilled the objectives</td>
<td>0.876</td>
</tr>
</tbody>
</table>

CR = composite reliability; AVE = average variance extracted; NA = not-applicable.
The weights of the formative indicators are similar to regression coefficients. They are calculated by regressing the latent construct (here Interactive Use) on its formative indicators (with SmartPLS).

^a Only this item was used in measuring the level of interactive use. It was re-coded from 1 to 7.
^R Reversed items.
^D Dropped items (loadings less than 0.4).
^* p < 0.10 (two-tailed).
^*** p < 0.01 (two-tailed).
threshold of 0.7 (Barclay, 2008), suggesting satisfactory reflective constructs were above the minimum recommended (Gerdin and Greve, 2008). Therefore, we complemented PLS relationship, i.e. when it is strongest and when it is weakest
caliber, but no further information is provided regarding this
differ across different levels of project uncertainty and equivocality. The next section describes the PLS results of the
performance under different combinations of uncertainty and differences between the level of PCS interactive use and project
analyses with Fisher-test analyses to examine correlational
style (facilitating, non-invasive involvement), and the intensity of
indicator was also evaluated in relation to the underlying
evident for the formative index. The weight of each formative
significant (ß = 0.82; p
the structural path between the two measures was large and
of the same construct assessed with reflective items and that
formative index of interactive use explained 68% of the variance
use construct was examined via a redundancy model (Mathieson

calculated by bootstrapping and is suitable for relatively small
sample sizes (Chin, 1998; Chin et al., 2003).
The literature suggests that significant interaction terms
indicate that the effects of management control constructs can
ciffer across different levels of project uncertainty and equivocality, but no further information is provided regarding this
relationship, i.e. when it is strongest and when it is weakest
(Gerdin and Greve, 2008). Therefore, we complemented PLS
analyses with Fisher-test analyses to examine correlational
The validity of the formative measure of the PCS interactive
use construct was examined via a redundancy model (Mathieson
et al., 2001). As reported in Table 3, PLS results showed that the
formative index of interactive use explained 68% of the variance
of the same construct assessed with reflective items and that
the structural path between the two measures was large and
significant (ß = 0.82; p < 0.01), providing construct validity
evidence for the formative index. The weight of each formative
indicator was also evaluated in relation to the underlying
construct. Only four items (INT2, INT3, INT4 and INT7) had
significant weights (0.25, 0.20, 0.23 and 0.57, respectively),
indicating that the two properties that contributed the most to PCS
interactive use were related to the project manager’s leadership
style (facilitating, non-invasive involvement), and the intensity of
use of PCS (discussions even when there were no gaps between
results and plans). The extent of face-to-face formal meetings as
measured by INT1 did not significantly contribute to this
construct. Lee et al. (2011) noted that non-significant items may
be retained for content validity reasons. According to Mathieson
et al. (2001, p. 107) non-significant indicators should be deleted
only when their correlations with the other formative items are
high, otherwise they should be used in further analyses because
their weight may change depending on the variables included in
the research model. All correlations between formative indicators
of PCS interactive use were below 0.8 and Variance Inflation
Factor (VIF) values were below 4 (Kennedy, 1997), suggesting
that multi-collinearity between the formative indicators of PCS
interactive use was not an issue. Thus, the analysis was continued
with all seven indicators of interactive use.

5.1. PLS measurement model results

As shown in Table 2, the composite reliabilities of all
reflective constructs were above the minimum recommended
threshold of 0.7 (Barclay, 2008), suggesting satisfactory
reliability. The results of Table 2 also show that all AVEs were
between 0.59 and 0.80, indicating that the latent constructs
accounted for 59% to 81% of the variance in the items measuring
them (Chin, 1998). As can be seen, the square roots of all
diagonal AVEs were greater than their respective inter-construct
correlations, suggesting that each construct shared more variance
with its measures than with other constructs (Gefen and Straub,
2005). Overall, these results indicate that the measurement model
satisfied the generally recommended convergent and discriminant
validity criteria.
The general PLS model was:
Project Performance = \( f(\text{Interactive Use of project follow-up reports; Project Scope; Project Novelty; Technological Complexity; Ambiguity of User Needs; two-way interaction terms}) \)

The research model was analyzed separately both with the
formative and reflective measures of Interactive Use, with
similar results obtained. Interaction terms were calculated by
first standardizing them as recommended by Chin et al. (2003),

<table>
<thead>
<tr>
<th>CR</th>
<th>AVE</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Project scope</td>
<td>0.89</td>
<td>0.74</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Project novelty</td>
<td>0.77</td>
<td>0.59</td>
<td>0.14</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Technological complexity</td>
<td>0.87</td>
<td>0.68</td>
<td>0.42</td>
<td>0.46</td>
<td>0.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Ambiguity of user needs</td>
<td>0.92</td>
<td>0.79</td>
<td>-0.07</td>
<td>0.20</td>
<td>0.07</td>
<td>0.88</td>
<td></td>
</tr>
<tr>
<td>(5) Interactive use</td>
<td>0.80</td>
<td>0.80</td>
<td>0.05</td>
<td>0.10</td>
<td>0.01</td>
<td>0.05</td>
<td>0.90</td>
</tr>
<tr>
<td>(6) Project performance</td>
<td>0.92</td>
<td>0.75</td>
<td>0.08</td>
<td>-0.12</td>
<td>-0.14</td>
<td>-0.35</td>
<td>0.53</td>
</tr>
</tbody>
</table>

CR = composite reliability; AVE = Average variance extracted.
Diagonal elements = square roots of the AVEs; off-diagonal elements = correlations between the latent variables calculated by SmartPLS.

5.2. Structural model results

<table>
<thead>
<tr>
<th>Interactive use formative measure (weights)</th>
<th>Interactive use reflective measure (loadings)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INT1</td>
<td>-0.10</td>
</tr>
<tr>
<td>INT2</td>
<td>0.25 ***</td>
</tr>
<tr>
<td>INT3</td>
<td>0.20 **</td>
</tr>
<tr>
<td>INT4</td>
<td>0.23 **</td>
</tr>
<tr>
<td>INT5</td>
<td>0.04</td>
</tr>
<tr>
<td>INT6</td>
<td>-0.02</td>
</tr>
<tr>
<td>INT7</td>
<td>0.57 ***</td>
</tr>
<tr>
<td>INT8</td>
<td>0.87 ***</td>
</tr>
<tr>
<td>INT9</td>
<td>0.93 ***</td>
</tr>
<tr>
<td>Structural path</td>
<td>0.82 ***</td>
</tr>
</tbody>
</table>

** p < 0.05.
*** p < 0.01.
Table 4

PLS results.

<table>
<thead>
<tr>
<th></th>
<th>PLS paths</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct effects</strong></td>
<td></td>
</tr>
<tr>
<td>Interactive use</td>
<td>0.20*** (6.78)</td>
</tr>
<tr>
<td>Project scope</td>
<td>0.15*** (4.41)</td>
</tr>
<tr>
<td>Project novelty</td>
<td>-0.01 (0.41)</td>
</tr>
<tr>
<td>Ambiguity of user needs</td>
<td>-0.36 *** (13.80)</td>
</tr>
<tr>
<td>Technological complexity</td>
<td>-0.15 ** (2.35)</td>
</tr>
<tr>
<td><strong>Uncertainty interactions</strong></td>
<td></td>
</tr>
<tr>
<td>Project scope × interactive use</td>
<td>0.24 *** (+H1a) (9.42)</td>
</tr>
<tr>
<td>Project novelty × interactive use</td>
<td>0.19 *** (+H1b) (6.05)</td>
</tr>
<tr>
<td><strong>Equivocality interactions</strong></td>
<td></td>
</tr>
<tr>
<td>Tech. complexity × interactive use</td>
<td>0.10 *** (+H2a) (3.58)</td>
</tr>
<tr>
<td>Ambiguity of user needs × interactive use</td>
<td>-0.10 (+H2b) (1.13)</td>
</tr>
<tr>
<td><strong>R²</strong></td>
<td>41.9%</td>
</tr>
</tbody>
</table>

*** p < 0.001.
** p < 0.01.

and by using only the reflective items of Interactive Use. As can be seen from the results reported in Table 4, the model explained 41.9% of the variance in the dependent variable Project Performance, which can be considered satisfactory (Falk and Miller, 1992).

The results of Table 4 strongly support H1a and H1b, indicating that the interaction between Interactive Use of project follow-up reports and uncertainty positively influenced Project Performance for both uncertainty related to Project Scope (β = 0.24; p < 0.01) and uncertainty related to Project Novelty (β = 0.19; p < 0.01).

As expected, the interaction term between Technological Complexity and Interactive Use positively influenced Project Performance (β = 0.10; p < 0.01), supporting H2a. On the other hand, H2b was not supported as the interaction term between Ambiguity of User Needs and Interactive Use was not significant (β = −0.10; ns).

5.3. Results of sub-group analyses

In order to test H3, the sample was first split into two according to the level of uncertainty related to project scope (based on the median value), then each half was further split into two according to the ambiguity of user needs, yielding four sub-samples (Table 5). For each sub-sample, the correlations between the level of interactive use and project performance were calculated, and then compared between the sub-groups via the Fisher test. The same analysis was repeated for the other types of uncertainty and equivocality, yielding three more tables (Tables 6 to 8).

Project managers’ interactive use of project follow-up reports had the strongest correlation with project performance in large projects that had high levels of ambiguity of user needs (cell 4, Table 5), and to some extent in projects characterized by high project novelty and high technological complexity (cell 4, Table 8), interactive use had the weakest correlations with project performance in small projects that had low ambiguity of user needs (cell 1, Table 5), small and low technological complexity projects (cell 1, Table 6) and low novelty and low technological complexity projects (cell 1, Table 8). These results provide support for H3 and show that interactive use of follow-up reports had the strongest correlations with project performance in high uncertainty and high equivocality projects, and the weakest correlations in low uncertainty and equivocality projects. As expected, the interactive use–project performance correlation was negative when uncertainty and equivocality were low (cells 1 in Tables 4 to 8), and positive when they were high (cells 4 in Tables 5 to 8).

6. Discussion and conclusions

The objective of the present study was to examine how project managers can positively influence ISD project performance by adapting their level of PCS interactive use to the project’s levels of uncertainty and equivocality. Building on existing literature, we developed three hypotheses suggesting that the influence of interactive use of PCS on a project’s performance would be strongest in high uncertainty and equivocality projects, and the weakest correlations in low uncertainty and equivocality projects. As expected, the interactive use–project performance correlation was negative when uncertainty and equivocality were low and positive when they were high.

** Table 5 **

<table>
<thead>
<tr>
<th></th>
<th>Small project and low Ambiguity of user needs (N = 20)</th>
<th>Small project and high ambiguity of user needs (N = 27)</th>
<th>Large project and low ambiguity of user needs (N = 28)</th>
<th>Large project and high ambiguity of user needs (N = 18)</th>
<th>Z results and conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>−0.49 ** (1)</td>
<td>0.10 (2)</td>
<td>0.38 ** (3)</td>
<td>0.54 ** (4)</td>
<td>1 &lt; 2; 1 &lt; 3; 1 &lt; 4; 2 &lt; 4</td>
</tr>
</tbody>
</table>

The numbers in parentheses represent cell numbers, which are used in the last column to report Fisher test results.

** p < 0.01.
Small projects and technological complexity

Correlations between PCS interactive use and project performance (subgroups based on “uncertainty related to project scope” and “equivocality related to project technological complexity”).

<table>
<thead>
<tr>
<th></th>
<th>Small projects and low tech. complexity (N = 31)</th>
<th>Small projects and high tech. complexity (N = 16)</th>
<th>Large projects and low tech. complexity (N = 16)</th>
<th>Large projects and high tech. complexity (N = 30)</th>
<th>Z results and conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>−0.48 ** (1)</td>
<td>0.01 (2)</td>
<td>0.58 * (3)</td>
<td>0.45 * (4)</td>
<td>1 &lt; 2; 1 &lt; 3; 1 &lt; 4; 2 &lt; 3; 2 &lt; 4</td>
</tr>
<tr>
<td>Correlation is weakest in cell (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.05.

** p < 0.01.

their freedom and innovation capacity (Amabile, 1998; Hope and Fraser, 2003), our results suggest that formal controls embedded in interactive use of project follow-up reports can be useful in high uncertainty and high equivocality ISD projects and positively affect their performance. The structured personal interactions that are incorporated in interactive use of PCS can foster a team’s innovative capacity by encouraging knowledge integration through the development of a shared understanding of a project’s context, issues and objectives. At the same time, it can enable a project manager to contain the team’s creative capacity by orienting the discussions towards the most important project success factors (Frow et al., 2010).

Contrary to our expectations, we found that equivocality related to ambiguity of user needs did not have a significant moderating effect on the relationship between PCS interactive use and project performance (Table 4).

However, we did find significant differences in the correlations between PCS interactive use and performance when user needs’ ambiguity was simultaneously taken into account with project scope (Table 5). These results suggest that equivocality of user needs might not have a significant moderating effect unless it is combined with a large project scope. This may also be due to the project managers of our sample having dealt with unclear user needs by using tools other than formal controls, such as prototyping, sign-offs or encouraging informal and rapid communications among future users and system designers. Further, ambiguity of user needs may be considered as normal at the beginning of an ISD project, and might become problematic only when it persists during later project phases. Given that we did not specifically asked whether user needs ambiguity existed only at the beginning of a project or at later phases as well, it would be interesting to consider this aspect in future research.

A potential limitation of the present study stems from the non-probabilistic nature of the sample that was used and its relatively small size (93 projects), which may limit the generalizability of our findings, particularly for the Fisher test of correlation differences, where we had to split the sample into four sub-samples. However, it is important to also note that the study sample exhibited considerable variation in terms of its characteristics and had a size that is comparable to those of numerous other studies that have used PLS as an analysis approach (Lee et al., 2011). Still, future research is needed to examine the generalizability of our findings to ISD and to other project contexts.

This study also has several contributions. By focusing on the manner in which formal project control systems are used, the present study contributes to the literature in project management and in information systems. Past research has studied the existence, characteristics and/or relevance of formal controls in ISD contexts (Barki et al., 1993; Kirsch, 1996, 1997; Nidumolu, 1996; Ditillo, 2004), but only limited research has focused on their type of use by managers at the project level (Davila, 2000 and Sakka et al., 2013 are exceptions). The present study’s findings suggest that, to improve ISD project performance, it can be useful for project managers to adjust their level of PCS interactive use according to the uncertainty and equivocality levels of their projects. Some authors suggest that the levels of uncertainty and equivocality of a project can vary between different project phases (Gales et al., 1992; Gales and Mansour-Cole, 1995), which means that project managers do not have to keep the same level of PCS interactive use throughout a project, and could increase or decrease it depending on a project’s requirements. As the present study examined only finished projects, it would be interesting to examine in future research how the level of PCS interactive use may vary during the different project phases.

The present paper also contributes to the literature on information processing where “richness of communications” has been defined by solely referring to the communication medium used by a project team (Gales et al., 1992; Keller, 1994; Gales and Mansour-Cole, 1995). We observed that it is not only the richness of the communications among the participants (i.e. face-to-face discussions) that determines whether or not

Table 6
Correlations between PCS interactive use and project performance (subgroups based on “uncertainty related to project scope” and “equivocality related to project technological complexity”).

<table>
<thead>
<tr>
<th>Low novelty and low ambiguity of user needs (N = 27)</th>
<th>Low novelty and high ambiguity of user needs (N = 22)</th>
<th>High novelty and low ambiguity of user needs (N = 21)</th>
<th>High novelty and high ambiguity of user needs (N = 23)</th>
<th>Z results and conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>0.049 (1)</td>
<td>0.219 (2)</td>
<td>0.223 (3)</td>
<td>0.119 (4)</td>
</tr>
<tr>
<td>Correlation is weakest in cell (1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
uncertainty and equivocality can be successfully addressed, and that the objective of such communications and the manager’s style in leading the discussions are equally important and need to be considered as well. If the project manager does not clearly state that the meetings’ objective is to build consensus and to collectively define solutions to the project issues, communications may waste a team’s time, increase personal conflicts and result in poor project performance (Boerner et al., 2012). In order to ensure that interactive use of PCS can be effective, project managers may wish to consider this aspect and try to make the objectives of their team meetings clear and to actively facilitate the integration of the team’s ideas and points of views.

For practitioners, the results of the present study further suggest that recognizing and distinguishing between a project’s uncertainty and equivocality can be useful for project managers. If all project issues are interpreted as stemming from uncertainty and dealt with by collecting additional information without trying to develop a shared and common perspective, the ensuing information overload might actually lead to increased equivocality (Levander et al., 2011). The main challenge for project managers, however, is likely to be to correctly assess the uncertainty and equivocality levels of their project. They would need to understand the project environment and tasks well enough to be able to effectively assess the need for formal interaction and consensus development, and adapt their interactive use of PCS accordingly (Chang, 2001). It is also important to acknowledge that, while it may not be possible for project managers to completely address a project’s uncertainty and equivocality issues, it is likely to be helpful to work on reducing them to workable levels (Weick, 1979; Chang and Tien, 2006).

Finally, in addition to its theoretical contributions, the present study also makes several methodological contributions. As suggested by Bisbe et al. (2007), we used a formative index to assess the construct of interactive use and followed the recommendations of existing methodological literature to validate it. Conceptually distinguishing between uncertainty and equivocality in the ISD context and operationalizing them with valid measures also provide an important step towards understanding the effects of these concepts on project management and performance. It would be interesting in future research to re-examine the scales used here and validate them in other contexts. A future research avenue would also be to consider other indicators of the project complexity, such as task interdependence and the team human characteristics (Chang and Tien, 2006) and study their moderating effect on the relationship between the use of PCS and project performance.

**References**


**Table 8**

Correlations between PCS interactive use and project performance (subgroups based on “uncertainty related to project novelty” and “equivocality related to technological complexity”).

<table>
<thead>
<tr>
<th>Low novelty and low tech. complexity (N = 30)</th>
<th>Low novelty and high tech. complexity (N = 14)</th>
<th>High novelty and low tech. complexity (N = 17)</th>
<th>High novelty and high tech. complexity (N = 32)</th>
<th>Z results and conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>−0.085 (1)</td>
<td>0.359 (2)</td>
<td>−0.093 (3)</td>
<td>0.331 (4)</td>
<td>1 &lt; 2; 1 &lt; 4; 3 &lt; 4</td>
</tr>
</tbody>
</table>

Some indication that correlation tends to be weakest in cell 1 and strongest is cell 4.