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Yuzhu Li
University of Massachusetts at Dartmouth

James Jiang
The Australian National University, James.J.Jiang@anu.edu.au

Gary Klein
The University of Colorado at Colorado Springs

THE IMPACTS OF COMMUNICATION ON IT PROGRAM EXTERNAL ENVIRONMENTS AND IT PRODUCT QUALITY

Yuzhu Li Charlton College of Business, University of Massachusetts at Dartmouth, Dartmouth, MA, USA

James J. Jiang, Research School of Business & School of ABIS, The Australian National University, Canberra, Australia

Gary Klein, College of Business and Administration, The University of Colorado at Colorado Springs, Colorado Springs, USA

Abstract

Multiple software development projects are often managed concurrently to deliver a complex software system. This approach of managing multiple development projects together to deliver an IT product is called program management. How can an IT product development program manage the interfaces with the internal and external environment successful leading to the program's success? This study examined the best communication strategies adopted by an IT product development program for different interdependencies and uncertainty to drive the successful outcomes of product development. The framework provides a useful framework for program managers and researchers to strategically manage communication activities corresponding to different internal constraints and external uncertainties.

Keywords: external communication, program management, product development

1   INTRODUCTION

Rich literature has been developed on the topic of product development. The main claim is that process efficiency and product effectiveness are affected by the behaviour of different agents, including team members, project leaders, senior managers, customers, and suppliers (Brown & Eisenhardt, 1995). However, the literature also suggests that organization capabilities of deploying and coordinating different resources could positively affect the product development outcomes (Grant 1996, Pradhalad and Hamel, 1990). While acknowledging the direct contribution of players to the product development performance, Verona (1999) separated the contribution of participating agents and capabilities and concluded that the final performance of product development can be driven by both the presence of peculiar agents and their leveraging of organizational capabilities.

Few studies have been done to examine how product development programs deal with organizational internal environment characterized by multiple types of interdependencies and external environment with a high degree of uncertainty. The interdependence requires a high degree of information exchange. Team interface management refers to the team-level interdependent management function including the technical definition of system modules, input and output parameters and the coordination of interdependent teams (Hoegl & Weinkauf, 2005). Team interface management has been identified as a critical success factor in the large-scale complex product development programs (Hoegl & Weinkauf, 2005). Given the inherent nature of interdependence between the program and the environment, the program success is dependent upon how well the program's work is integrated with the organizational operational processes, meeting the internal and external needs.

The focus of this study is to examine the communication strategies adopted by the IT product development program to integrate the internal capabilities under different interdependencies and uncertainty to drive the successful outcomes of product development. More specifically, two types of interdependencies -- goal and resource interdependence in the internal environment and market environment uncertainty are examined. Furthermore, two types of communication strategies are also incorporated in this study including team members' ambassador behaviours and task coordination behaviors. Results of a preliminary study indicated that the high level of ambassador communication strategy with a high level of goal interdependence between the program and other business functions in an organization had the highest level of product quality. Comparing to a high level of resource interdependence, a low level of resource interdependence was associated with a higher level of product quality. However, there was no significant difference between the high and low level of resource interdependence when the ambassador behaviours were strongly exhibited by the program development teams. Finally, a larger extent of task coordination with other business functions partially mitigated this negative effective of the market environment uncertainty on product quality. The implications for both practitioners and researchers were then discussed.

The organization of this study is as following: Section II described the literature on two types of interdependencies and environmental uncertainty in product development. It also reviewed the boundary spanning literature to explore the activities that agents perform to interact with the environment. A theoretical framework was proposed based upon the Information Processing Theory. In Section III, effective communication strategies were proposed for each type of interdependence. Hypotheses were developed in this section. Research methodology including constructs, data collection and initial data analysis results were reported in Section VI. Finally, discussions and implications concluded this paper.

2   LITERATURE REVIEW

2.1   Organizational Internal Environment of Product Development

Product development is a process of integrating different functions and required knowledge to deliver a product that satisfies the customers' needs. This integration process involves cross-functional collaborations and needs specialized resources and efforts. Organizations provide a specific internal environment for product development. Product development usually in forms of projects cannot be separated from the internal environment because the projects have to acquire different kinds of resources such as money, time, knowledge, reputation and trust, etc from the internal environment. Since no project is completely self-contained, the key to survival is the ability to acquire sufficient resources (Jensen, Johansson, & Lofstrom, 2006). These multi-project environments are characterized by a high degree of interdependence and uncertainty since the projects have to compete for scarce resources(Jensen et al., 2006). The environmental settings of product development projects are often described as highly political; the diversity of interest and competition give rise to "wheeling and dealing", negotiation and other processes of coalition building (Platje, Seidel, & Wadman, 1994). As a consequence, product managers must use different kinds of strategies to attract attention, to enroll stakeholders, and to mobilize support from more distant but powerful actors.

Table 1 lists the organizational environmental factors including the interdependencies and environmental uncertainty. These interdependencies and environmental uncertainty bring the constraints on the product development process. In order to achieve the final performance including process efficiency and product quality, product managers have to make use of their formal position and personal networks and exercise their powers and influences to reduce the influences from these interdependences and uncertainty and achieve the freedom of action for decision makings. The boundary spanning literature and Information Processing theory were examined to explore the actions of agents to leverage the organizational structures, systems and processes.

Construct	Definition	Studies
Resource Interdependence	It is defined as the extent to which one organizational unit need certain resources that are only available from other unit.	Tushman & Nadler, 1978; Gattiker & Goodhue, 2005; Sharma & Yetton, 2003; Kim, Umanath, & Kim, 2005 Wageman 1995
Goal Interdependence	It is defined as the degree to which programs have clear goals or a clearly defined mission, and the extent to which the goals of the program are linked to other organizational units.	Ortiz et al. 1996; (Campion, Medsker, & Higgs, 1993; Campion, Papper, & Medsker, 1996)
Environmental Uncertainty	The extent to which an individual's perceived inability to understand the direction in which an environment might be changing, the potential impact of those changes on that individuals organization, and whether or not particular responses to the environment might be successful.	(Daft & Lengel, 1986; Karimi, Somers, & Gupta, 2004; Milliken, 1987; Waldman, Ramirez, House, & Puranam, 2001)

Table 1: Internal Organizational Environmental Factors

2.2   Boundary Spanning Literature

Information about environmental contingencies needs to reach organizational decision makers in order that appropriate decisions relevant to the environmental conditions and contingencies may be made (Leifer & Delbecq, 1978). The impetus for boundary spanning activity (BSA) comes from

interdependence with other organizational units and inability to make decisions in a complex environment. Information exchange with local environment is more of interest to the boundary spanning roles (Leifer & Delbecq, 1978).

The agents have to manage the local environment successful to get the resources and supports for the product development. Hoegl and Weinkauf (2005) particularly examine how teams manage the inter-team interdependences through team interface management. The team interface management included more than communication such as clearing the boundary and obtaining the organizational supports. Teams attempt to influence the larger organization by managing their interfaces with the larger organization through various activities and strategies (D. G. Ancona & D. F. Caldwell, 1992). Ancona and Caldwell (Deborah Gladstein. Ancona, 1990; Deborah Gladstein Ancona & Caldwell, 1988; D. G. Ancona & D. F. Caldwell, 1992) classified a group's externally focused activities into two major types including ambassador and task coordination behaviors. Ambassador activities involve frequent communication with managers above the team in the organizational hierarchy because the team lobbies for resources and seeks protection and support. "Task coordinator" activities are carried out to coordinate technical or design issues and are often conducted laterally across the organization. In next section, the organizational internal environment and the external communication purposes are integrated together to develop a theoretical framework.

2.3   Information Processing Theory

The basic assumptions of Information Processing Theory are that organizations are social systems that must process information but have a limited capability to do so (Galbraith, 1973; Malone & Crowston, 1994; Van De Ven, Delbecq, & Koenig, 1976). Organizations must develop information processing mechanisms capable of dealing with both external and internal sources of uncertainty. Interdependence is viewed as a source of uncertainty(Galbraith, 1973). The uncertainty leads to the information processing requirements. Coordination and control mechanism generate the capabilities of information processing. Organizational information processing theory views that tasks can be structured from independence to interdependence. Coordination is viewed as a cost in the process and only needed amount of coordination should be used to match the amount of needs created by interdependence (Victor & Blackburn, 1987).The essence is that effectiveness is a function of matching information processing capabilities with information processing requirements. According to the information processing theory, a match must be achieved between the needs of coordinating created by interdependence and the amount or types of actual coordination mechanisms (Galbraith, 1973; Thompson, 1967; Van De Ven et al., 1976). There is no best way of organizing or coordinating. Any way of organizing is not equally effective.

The extent of coordination mechanisms will be generated to meet the need of information processing. A majority of research of within-team coordination adopts this contingency approach (Andres & Zmud, 2001; Kraut & Streeter, 1995; Nidumolu, 1995) The product development program is interdepent with the organizational internal function units and the external market conditions. The external-oriented communication of the program should meet the needs of communication because of interdependence and uncertainty(D. G. Ancona & D. F. Caldwell, 1992).

3   THEORETICAL FRAMEWORK AND BEST STRATEGIES

According to Organizational Information Processing Theory (Galbraith, 1973), organizational information processing capability must match the information processing needs derived from interdependence and uncertainty. Typically, organizations have two strategies to cope with uncertainty and increased information needs: (1) develop buffers to reduce the effect of uncertainty, and (2) implement structural mechanisms and information processing capability to enhance the information flow and thereby reduce uncertainty. More and more product development processes start to organize multiple related product development projects into one program. Complex IT products consisting of

highly interdependence modules (such as ERP systems) are generally delivered by an IT product development program. This product development program builds a protective layer for projects and represents the related projects as a bigger and more important entity in the organization than individual projects. The program management team has to manage the relationships with the internal organizational environment that are represented by the different type of interdependencies. These interdependencies drive the program's management activities and have impacts on the final performance of the product development. A theoretical framework is proposed in Figure 1.

Focusing on the specific organizational structure, this paper proposes a set of best communication strategies for the product development program (see Table2). These communication strategies can be used to best address the need of communication from the organizational structure and produce the efficient and effective product development process.
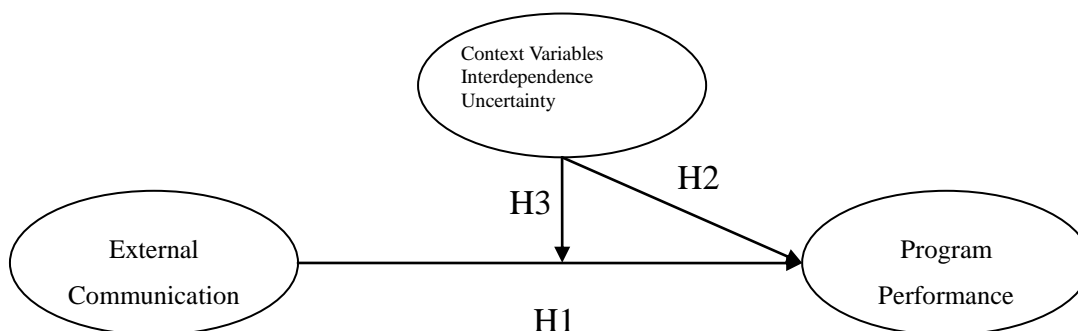

Figure. 1: Theoretical framework

Contextual Factors	External Communication Activities
Resource Interdependence	Ambassador Activities
Goal Interdependence	Ambassador Activities
Environmental Uncertainty	Task Coordinator Activities

Table 2: Best Communication Strategies

According to the small group theory, goal interdependence can enhance the collaboration between team members and positively impact the group's performance (Locke & Latham, 1990). The goal interdependence between the program and the organizational context leads the program to actively seek clarification of its goals, reduce ambiguity and attempt to influence the external environment to suit its agenda by shaping the beliefs and behaviors of outsiders. When the goal interdependence is low, a program manager has to convince other business units that the outcomes of the product development program have essential impacts on the stakeholders in other business units and the whole organization. The program manager has to seek coalition and supports from the senior management. The initiatives supported by the senior management will attract more attention from the other business functions and a positive cooperative relationship is more likely to be created. In essence, these persuading and influencing activities are part of the program's capability to implement the organizational strategy and fill in the gap between the strategic and operational level. Therefore a hypothesis is proposed as follows:

> *H1: The magnitude of the relationship between goal interdependence and program*
>
> *performance is moderated by the extent of ambassador coordination activity.*

Deployment of resources in initial stages of product development is one of the important driver for the product quality (Krishnan, Kriebel, Kekre, & Mukhopadhyay, 2000). In organizations, resource interdependence varies depending on the purpose for which groups are composed. The program has

complimentary access to resources in other business functions since the program experts come from different business functions and they have natural connections with the original department. When the resource interdependence is high, the program team can access to the resources outside of the program easily and a large amount of external communication is not needed. Asking and negotiating for needed resources forces the product program to interact with the organizational environment at a high level. Multiple views are included in the decision makings along the product development process (Fan & Gruenfeld, 1998). When resource interdependence is low, the product development program can accomplish the goals without access to other business functions' resources. The program manager has to actively communicate with the other business functions and senior management so that they can know the product development status and manage to set up appropriate expectations for the products that the program will deliver. Therefore the following hypothesis is proposed.

H2: The magnitude of the relationship between the resource interdependence and program performance is moderated by the extent of ambassador coordination activity.

While environmental uncertainty needs particular attentions and efforts from the program manager and senior managers in the organization (Waldman et al., 2001) , specific task adjustments and design review are needed to be done at the operational level to accommodate the environmental changes. The task coordination activity at the operational level deals with the specific design review, schedule integration and resource exchange. The close interaction between the product development program and other business functions can enable the information sharing regarding to the changes in the market and allow small changes in product specification and other functional areas. However the task coordination activity only has limited effects on the program performance when the environmental uncertainty is high because the high level of environmental uncertainty requires the decision making at the strategic level. Therefore it is proposed that

H3: When the environmental uncertainty is low, the magnitude of the relationship between the environmental uncertainty and program performance is moderated by the extent of the task coordination activity.

4   RESEARCH METHODOLOGY

Initial data collection was done in China in 2006. The data collection unit was a "program". On average each program included 3-5 individual IT projects. The recruiting method for participants was snowballing. Investigators' friends who worked in IT software companies were invited to participate in the survey and asked for introducing more participants. For each program, a program manager was identified and invited to fill in the survey of the program's external communication. All the constructs were adopted from the past studies. The measures of program external activities were adapted from Ancona and Caldwell (1992). Ambassador activity has 12 items. Task coordinator activity has five items. The measure of resource interdependence had six items from Brown et al. (1998). The measure of goal interdependence has three items from Pearce et al. (1992). Program performance was measured by product quality from Nidumolu (1995).

57 surveys were completed and returned for the initial data analysis. Among the 57 respondents, 89.5% is male. 49% of the participants are program managers and other participants have the titles such as product manager, product director, IT director and IS managers, etc. The average work experience is 9.27 years and the average current company experience is 5 years. 47% of respondents work in IT –industry and 57.9% of the companies are medium size organizations. Table 3 listed the descriptive data.

Factor analysis was used to confirm the construct of external communication activities. The measure of ambassadorial activity had 12 items. These 12 items were further divided into three dimensions as protecting, persuasion and vertical involvement, to be consistent with Ancona and Caldwell (Ancona & D. F. Caldwell, 1992) Protecting refers to the activities that will filter the pressure and requests from

organizational environment and isolate the product development from the excessive pressure so that the product can be developed without too much barriers (Ancona & D. F. Caldwell, 1992). Persuasion refers to the activities with the purpose of informing other business functions about the product development status and convincing others that the product development is important for other business functions and can benefit the whole organization (Ancona & D. F. Caldwell, 1992). Vertical Involvement refers to the activities with the purpose of involving the senior managers to make critical decisions and force the business functions to support the product development because of the hierarchical orders (Ancona & D. F. Caldwell, 1992).

The hierarchical moderation test was used to analyze the moderating effect. Following the suggestion from Carte and Russell (2003), moderating effect can be assured by comparing the difference between main effect model and moderating effect model. This hierarchical process was adopted by many IS researchers (e.g. Gefen et al., 2000, Khalifa and Cheng, 2002, Limayem et al., 2001, Mathieson et al., 2001, and Son et al., 2005). Table 3 showed the hierarchical moderation results for Hypothesis 1 which proposes the moderating effect of ambassadorial activity on the relationship between goal interdependence and the program performance. Table 3 indicated that the change of effect size after adding the interaction term was significant for the moderating effect of protecting and persuasion. It meant that the external communication activity with the purpose of protecting and persuasion actually had a significant moderating effect on the relationship between goal interdependence and product quality.

Path Coefficient (Standard error)	Model 0	Model 1	Model 2	Model 3	Model4
Goal Interdependence	0.342* (0.16)	0.325 (0.22)	0.381* (0.20)	0.405* (0.20)	0.357* (0.23)
Ambassador activities					
Protecting activities		0.189 (0.15)	0.142 (0.15)	0.276 (0.16)	0.182 (0.15)
Persuasion activities		0.259 (1.60)	0.317* (0.14)	0.241 (0.16)	0.273 (0.19)
Vertical activities		0.219 (1.75)	0.205 (0.15)	0.121 (0.13)	0.213 (0.19)
Interaction1 (protect x GI)			0.323* (0.24)		
Interaction2 (persuasion x GI)				-0.443* (0.39)	
Interaction3 (vertical x GI)					-0.074 (0.27)
R2	0.117	0.344	0.440	0.508	0.349
R2 Change		0.227*	0.096*	0.164*	0.005

Table 3: Hierarchical moderation results for goal interdependence and product quality

Table 4 showed the hierarchical moderation results for Hypothesis 2 which proposed the moderating effect of ambassadorial activity on the relationship between resource interdependence and the program performance. Table 4 indicated that the change of effect size after adding the interaction term was significant for the moderating effect of persuasion. It meant that external communication activity with the purpose of persuasion actually had a moderating effect on the relationship between resource interdependence and product quality.

Path Coefficient (Standard error)	Model 0	Model 1	Model 2	Model 3	Model4
Resource Interdependence	0.19(0.21)	-0.021 (0.19)	-0.012 (0.05)	0.095 (0.15)	0.047 (0.19)
Ambassador activities					
Protect activities		0.344* (0.33)	0.381* (0.36)	0.371* (0.13)	0.400* (0.13)
Persuasion activities		0.179 (0.19)	0.224 (0.24)	0.148 (0.16)	0.122 (0.17)
Vertical activities		0.164 (0.14)	0.079 (0.05)	0.094 (0.13)	0.154 (0.17)
Interaction1 (protect x RI)			0.224 (0.16)		
Interaction (persuasion x RI)				0.334* (0.22)	
Interaction (vertical x RI)					-0.261 (0.31)
R2	0.036	0.266	0.309	0.359	0.323
R2 Change		0.23*	0.043	0.093*	0.057

Table 4: Hierarchical moderation results for resource interdependence and product quality

Table 5 showed the hierarchical moderation results for Hypothesis 3 which proposed the moderating effect of task coordination activity on the relationship between market environmental uncertainty and the program performance. Table 5 indicated that the change of effect size after adding the interaction term was significant. It meant that task coordination activity actually had a strong effect on the relationship between the market environmental uncertainty and product quality.

Path Coefficient (Standard error)	Model 0	Model 1	Model2
Environmental Uncertainty	0.398* (0.1951)	0.346 (0.1979)	0.442* (0.1319)
Task Coordinator activities		0.170 (0.2333)	0.759 (0.7178)
Interaction (task coordinator x EU)			-0.960* (0.7470)
R2	0.150	0.159	0.258
R2 Change		0.09*	0.076*

Table 5: Hierarchical moderation results for environmental uncertainty and product quality

5   DISCUSSION

The further classification of ambassadorial activity into three categories brought a lot of new insights. Out of expectations protecting was viewed very important by the program manager and it generated critical moderating effects on goal interdependence and resource interdependence. Results indicated that the protecting activity has a slightly stronger impact when goal interdependence is high than when goal interdependence is low. The persuasion activity has a slightly stronger impact on product quality when goal interdependence is high than when goal interdependence is low. The persuasion activity has a strong moderating effect when resource interdependence is low but no effects when resource interdependence is low. Task coordination activity has a moderating effect when the market environmental uncertainty is low.

The inherent interdependence with the organizational environment requires the program manager to scan the environment frequently, analyze the relationship with other business functions and perform ambassador activities in a strategic way. The ambassador activities managed the interfaces with other business functions, leading to success performances (Hoegl & Weinkauf, 2005). This study creates a simple framework to help program manager analyze the external environment. The lens of interdependence and uncertainty can give program manager a good starting point to manage the environment. This study also proposes the best communication strategies for each type of interdependence and uncertainty. The research results indicated that the communication activities with the purposes of protecting the projects in the programs and of persuading others to support the program should be performed more for a high level of goal interdependence than for a low level of goal interdependence. The external communication with the purpose of persuasion significantly impacts the product quality when the resource interdependence is high. Program managers should deploy the external communication strategies to correspond with the interdependence with the program context. The external communication with task coordination as a purpose has more impacts on product quality in the condition of high market uncertainty than low market uncertainty.

While a program manager plays a critical role in the program's external communication and expands the program's boundary, future researcher should explore other forms of boundary spanning mechanisms such as knowledge exchange and the effects of boundary spanning on different types of IT programs.

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