

The role of operational interdependence and supervisory experience on management assessments of resource planning systems

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Abstract

Greater interdependence among workers and activities not only increases the need for internal communication, it also imposes complications and barriers to effective information exchange. Intra-organizational communication capabilities of certain information systems can help overcome these barriers. However, the extent to which certain systems are promoted as communication tools depends largely on management's interpretation of their usefulness, which in turn may be largely dependent on operational context and managerial experience. We use a controlled experimental approach to study how these issues interact to impact managerial assessments of resource planning systems. Results show that managers value the communication capabilities of resource planning systems more so in highly task-interdependent contexts, and that these assessments are still more positive among managers with greater supervisory experience. As a result, these findings pose direct implications regarding the management support of technology use.

Key words: *Enterprise Resource Planning Systems, Interdependence, Supervisors, Experience*

1. Introduction

Several contemporary authors have argued that work settings involving high levels of interdependency among resources and activities are likely to show significant performance gains only when matched with mechanisms that facilitate sufficient information sharing (eg. Goodhue et al., 1992; Flynn & Flynn, 1999; Tatikonda and Montoya-Weiss 2001). The reasoning behind this line of logic stems from the idea that settings in which individual business units, sub-units and workers are charged with interrelated tasks are also subject to breakdowns and barriers in information flow between these tasks. Information-sharing mechanisms, technology-driven or otherwise, provide resolutions to these barriers by enabling cross-functional or interpersonal visibility of related and relevant information (Child & McGrath, 2001). Such information can subsequently influence individual unit or worker coordination decisions regarding the specific tasks, may prevent unintended conflicts between the decisions made by the parties sharing information and may open up alternative operational possibilities for which synergies might not have been previously apparent. Various resource planning systems (ERP, MRP II, etc.) represent one potentially under-utilized sources of such communication that may hold a wealth of benefit for firms dealing with increasing levels of operational interdependency.

Modern resource planning systems have popularly been characterized in terms of their transaction processing and data structure capabilities (McAfee 2002; Davenport 2000). However, reviews of research and practitioner articles suggest that regardless of their integrative features few operating managers think of these systems as more than transactional and automated planning mechanisms (Jacobs and Bendoly,

2003). Few provide in-depth considerations or evaluations of these systems as tools for communication and collaboration. This limited perspective may not be a surprising one. Unless managers have experience seeking alternate mechanisms for communication among their co-workers, their views of the availability of such alternate mechanisms tend to remain limited (Trent 1996; Stallworthy and Kharbanda 1987). Based on existing research on supervisory experience we contend that managers with extensive experience in such roles are increasingly likely to recognize the communication capability benefits of resource planning systems, particularly in settings where worker tasks are interdependent. Since the recognition of capability benefits can strongly influence the motivation behind managerial support of technologies, an investigation into this line of logic presents a unique and relevant contribution to the management of technology literature. Furthermore since supervisory experience can be invested in, either through training or more selective hiring and promotion tactics, firms are certainly positioned to adjust such a capability to facilitate technology and organizational objectives. This mirrors the notion of facilitating “awareness” through investments in worker knowledge (Napoleon and Gaimon 2004) and builds on arguments for developing organizational monitoring capabilities (Klassen and Vachon 2003) as discussed in contemporary literature.

Our study takes an experimental approach to investigate managerial assessments of the usefulness of resource planning systems as tools for intra-organizational communication. We specifically consider the role that interdependence among internal operational activities and resources within a work-unit has on these managerial views. In our design and analysis we simultaneously include a range of controls accounting for prior managerial experiences in an attempt to disentangle context-specific effects and the potential moderating role of supervisory experience. The next section will describe the theoretical foundations of our research questions and will be followed by a detailed description of our experiment. We will then describe the analysis and overview of our results, and discuss the implications for both future research and practice.

2. Theoretical foundations

The role of interdependence at the operational level of a firm poses several implications with respect to information needs and means of exchange. To ground these considerations, we adapt a traditional interpretation of interdependence defined as the degree to which two or more activities interact to determine an outcome jointly (Thompson, 1967; McCann & Ferry, 1979; Dean & Snell 1991). Highly interdependent environments thus represent settings in which regular exchange of information is necessary in safeguarding against operational conflicts.

Yet while information sharing between interacting activities can be essential, Sorenson’s (2003) recent study of vertical integration as a proxy for interdependence also suggests that highly interdependent environments create barriers to learning and effective exchange. This phenomenon is attributed largely to increased difficulty in pinpointing sources of error and constraints in these increasingly complex settings (March & Simon, 1958; Simon, 1962; Rivkin, 2000), in contrast to self-contained task contexts (Galbraith 1977). As a result of these two issues acting in tandem (i.e. the greater need for information and greater barriers to exchange), the effectiveness of such complex highly interdependent settings is extremely reliant on the existence of management and organization-wide efforts aimed at facilitating information-sharing (McCann & Ferry, 1979; Child & McGrath, 1991).

Ultimately, one of the principle roles of managers is to “mitigate problems caused by interdependent processes within firms” (King 1999). This mitigation can take the form of direct policy

changes or assistance in the synchronization of delegated worker responsibilities (Macneil 2004; Galbraith 1977). More specifically, Galbraith's information processing theory (IPT) suggests two mechanisms for supporting worker activities in complex highly interdependent settings (1977). One of these mechanisms involves the fostering of lateral relations, such as work teams, to augment interpersonal information exchanges. Alternately, information systems designed to facilitate information-sharing capabilities, in a perhaps more codified form, are thought to enable similar benefits. The view that specific forms of information technology can meet the information processing requirements of particularly interdependent contexts has been reiterated in a number of recent operational studies (Eg. Stock & Tatikonda, 2000; Tatikonda & Rosenthal, 2000; Flynn & Flynn, 1999). In fact Flynn and Flynn (1999) cite the replacement of isolated legacy systems by enterprise-wide, fully integrated transaction-processing systems as a recent instantiation of this need (Morgan, 1998). The findings of Gattiker and Goodhue (2004) further suggest that the greater the extent of interdependence the greater the potential, or at least perceived potential, for resource planning system utility. Yet while the mechanisms (eg. increased communication) available to assist workers in these interdependent tasks have received some consideration in the literature, oddly little attention has been given to the factors motivating managers to champion the use of these mechanisms in specific contexts (King 1999; Therkelson and Freibich 2003).

2.1. Resource planning system capabilities

Viewed as a set, resource planning (RP) systems represent a range of IS architectures specifically geared towards the improved planning and accounts of resources, processes and materials managed by firms (Gumaer 1996; Chase et al. 2001). Though distinctions between specific resource planning system types (eg. ERP and MRPII) are often discussed with respect to system evolution and the state of the art, research has been careful to point out some of the fundamental conceptual differences among these types (Stratman and Roth 2002; Mabert et al. 2001; Sarkis and Gunasekaran 2003). Most notably, research into ERP systems emphasizes the presence of a centralized database and standardized protocols that cross functional boundaries as the key features distinguishing them from MRP II systems (Gatiker and Goodhue 2004; Rabinovich et al. 2003; Austin et al. 2003; Mabert et al. 2001; Davenport 1998). Yet in practice, managers still remain critical of the true distinctions suggested by potentially misleading system 'labels' alone (eg. Robinson 2004; Jacobs and Bendoly 2003). This should not be surprising to academics due to at least two issues: (a) Not all implementations of systems sold by ERP vendors span all business units and functions in practice, (b) Many MRP II systems have undergone enterprise-wide extensions by firms.

Nevertheless, and regardless of labeling, given adequate descriptions of features of any specific information technology a range of potential applied capabilities can be implied. In the existing research, both transactional and non-transactional communicative capabilities have been designated with regards to information system benefits. Weill (1992) specifically delineated informational from transactional benefits, describing informational benefits, and Mirani and Lederer (1998) later validated the proposition that such benefits were distinct, defining informational benefits through such communicative characteristics as "easier access", improved quality for use in operational control, and clearer presentation.

Such characteristics can similarly apply to the more specific information technology case of RP systems. The standardization of data definitions and structures, through the use of a common conceptual schema, represents what several authors refer to as "data-integration" and is typically characteristic of modern resource planning systems (Goodhue et al., 1992; Litwin et al. 1990). The "common language" formalization provided by standardization eliminates the need for additional data translation (Huber, 1982) and thus enables the coordination that Thompson (1967) claims is most critical in highly interdependent

operating environments. At the same time however, although discussion of the transactional capabilities of RP often has an undertone of mandated and unavoidable use, the same cannot be assumed for communicative forms of RP use which in many if not most contexts is better described as discretionary.

To emphasize this point, examples of such communicative non-transactional capabilities discussed in the literature include report-development for performance evaluation (Berk 2001), ad-hoc data access for assisting in problem definition and decision support (Bendoly 2003) and even the availability of codified process maps for use in discussions of redesign all represent valuable uses of ERP systems (Dalal et al. 2004). Since a wide variety of alternative communicative mechanisms exist (eg. phone, e-mail, face-to-face, etc.) and given the potential benefits of discretion afforded to those pursuing such complex tasks (Goodhue and Thompson 1995; Maruping and Agarwal; Staples and Seddon 2004), it would be difficult to argue that the use of these communicative capabilities are anything but discretionary themselves.

If high levels of interdependence are not only descriptive of specific operating settings, but more fundamentally required to support competitive strategies, such intra-organizational communication capabilities may provide critical support mechanisms (Ettlie, 1988; Kern & Schumann, 1990; Dean & Snell, 1991). However, their characterization as discretionary mechanisms implies that perceptions of usefulness will ultimately be critical to ensure that these capabilities are explored, and benefits to performance in complex and even unstructured tasks accrued by firms. While perceptions of usefulness by end users has been widely discussed as impacting such direct use (cf. Harwick and Barki 1994), it would be an oversight to ignore the potential views of managers overseeing such technology use, not to mention the effect of context on these views, since management assessments may ultimately impact norms of use among their subordinates.

2.2. Managerial roles and perceptions

Managerial support has a long history in IS literature as playing a large role in the diffusion of technology changes within firms. While top-management support has often been cited as a key contributor to the successful management of new technology deployment (Leanard-Barton and Deschamps 1988; Purvis et al. 2001), lower level and particularly supervisory managers have been known to play particularly influential role when it comes to the acceptance of change and use among front-line workers (Larkin and Larkin 2000; Therkelsen and Fiebich 2003). Furthermore, supervisors “through their devolved responsibility for people (which, by implication, includes learning and development) have an influence as facilitators promoting knowledge sharing” through communication among their subordinates (MacNeil 2004). Individuals with greater supervisory experience have a stronger impression of the relevance of these roles and the importance of mechanisms that can facilitate these agendas.

This line of thought opens the discussion to the general concepts of information system perceptions, acceptance and support. Aside from the potential capabilities of a system in resolving information-processing requirements, research has established that many measures of information system ‘success’ depend not simply on the presence of a technically functional system but specifically on *perceptions of usefulness* (Jackson et al. 1997; Szajna & Scamell, 1993). Such research discusses how the underutilization of existing system capabilities, due in part to negative perceptual biases, continues to be a problem, limiting appropriate assessments of system value. While perceptions may be justified based on the sheer lack of fit between systems and contexts or tasks (Goodhue, 1995), they may also be simple artifacts of past experiences established in alternate contexts to which managers are exposed.

It is therefore striking that while research into technology adoption by users within firms has acknowledged both the impact of management support (eg. Eder and Igbaria 2001; Rai and Patnayakuni 1996; Libertore and O'Neill 1985; Zmud 1984) and worker perceptions of usefulness (eg. Amoako-Gyampah and Salam 2003; Szajna 1996, Davis 1989), no formal models have taken a serious look at issues that give rise to the perceptions of managers regarding these systems. This is all the more striking given the critical supportive and facilitative roles attributed to managers in driving technology diffusion. The study of contextual effects and prior experiences that influence managerial views of system usefulness therefore remains an important though underexplored topic for technology management research.

Not to confuse the concept of managerial perceptions of technology usefulness with the established construct of *perceived usefulness* as it applies to users in technology adoption models (eg. Davis 1989; Agarwal and Prasad 1999), we instead use the term *management assessed usefulness* to specifically describe managerial perceptions of the usefulness of specific system capabilities in designated contexts. Ultimately, our present interest lays in the management assessed usefulness of RP systems as communication mechanisms (above and beyond their use as transactional systems) in contexts that differ by the level of worker task interdependence.

2.2.1 – Effects of interdependence on assessed usefulness

Recent research by Sharma and Yetton (2003) has suggested a strong relationship between interdependence and management support. Their study focuses on task interdependence, as a general contextual descriptor, and its role in potentially moderating the relationship between management support and IT success. They do not however investigate the direct impact of such interdependence on managerial perceptions of IT (a key motivator of support itself). Since context has a large impact on perceptions, its direct impact on support poses a research question that needs to be addressed if the full impact of operational context on technology management is to be faithfully pursued.

Similar to Gattiker and Goodhue's (2004) interpretation of IPT, the present study in part considers the extent to which interdependency in specific operational contexts relates to perceptions of resource planning system potential. While resource planning systems have traditionally been examined in terms of the efficiency of transaction standards or infrastructural provisions, this study focuses on the potential capability of such systems to serve as alternate media for regular intra-organizational communication (as suggested in Flynn & Flynn 1999). Although prior experience may have a significant effect on subsequent perceptions of usefulness, we posit that the role of interdependence promoted by IPT should be clearly observable if prior experience is adequately accounted for.

Hypothesis 1: Managers are more likely to view the intra-organizational communication capabilities of resource planning systems as "useful" in environments with high levels of operational interdependence than in those with low levels.

2.2.2. – Effects of past supervisory experience

While our first research issue focuses on the primary effect of operational interdependence on system perceptions, our following hypotheses incorporate the role of supervisory experience and the associated awareness of communication requirements in interdependent environments. Contemporary research has already suggested that various forms of foresight, as possibly developed through this experience, may be crucial to managers potentially positioned to impact technology use (cf. Li et al. 2003).

Such an association between supervisory experience and awareness has been suggested by past researchers in passing but not explicitly examined with regards to its role relative to both interdependence and resource planning system usage (Trent 1996; Stallworthy and Kharbanda 1987).

Past research has proposed that supervisory experience exposes managers to “trial and error” learning cycles that inform them as to the imperatives of front-line worker interactions and associated use of communication mechanisms (Karambayya et al. 1992; Bunning 2000; Therkelsen and Fiebich 2003). As a result, experienced supervisors tend to pursue opportunities for communication among subordinates more so than inexperienced supervisors (Magee et al. 1991; Maccoby 2003). Furthermore, those with more supervisory experience should be more attuned to the potential of alternate and perhaps more subtle mechanisms for collaborative communication. Moreover, while certain authors have suggested that oral communications may be most effective in dyadic settings (eg. Daft et al. 1987; Lengel and Daft 1988), increasingly complex interdependent environments call for a “combination of media” (Monge 1989; Volkema and Niederman 1996) including the potential asynchronous use of shared databases. This supervisory-experience bias towards “alternate” mechanisms of communication should therefore tend to be more prominent in increasingly complex interdependent settings. Nevertheless, neither the direct nor moderating effects of supervisory experience on management perceptions of IT communication capabilities has been studied in depth.

Specifically, we consider previously asserted notions that the need for coordination is at the core of high involvement and interdependent operations (eg. Lawler 1988; Tatikonda and Montoya-Weiss 2001; O’Lear-Kelly and Flores 2002) and that a critical role of supervisory managers is to facilitate such coordination (Hirschhorn 1990; Khan & Kram 1994). If resource planning system communicative capabilities can augment such coordination, then managers experienced in supervisory duties should be more aware of the potential of such capabilities to aid in increasingly interdependent settings. We therefore view supervisory experience as playing not only a direct but also a moderating role in the assessments of managers regarding the usefulness of these system capabilities.

Hypothesis 2: The more supervisory experience a manager has had, the more likely he/she is view to the intra-organizational communication capabilities of resource planning systems as “useful”.

Hypothesis 3: The more supervisory experience a manager has had, the stronger the effect of interdependence on his/her assessment of the usefulness of resource planning systems as tools for intra-organizational communication.

2.2.3 – Additional relevant experiential effects

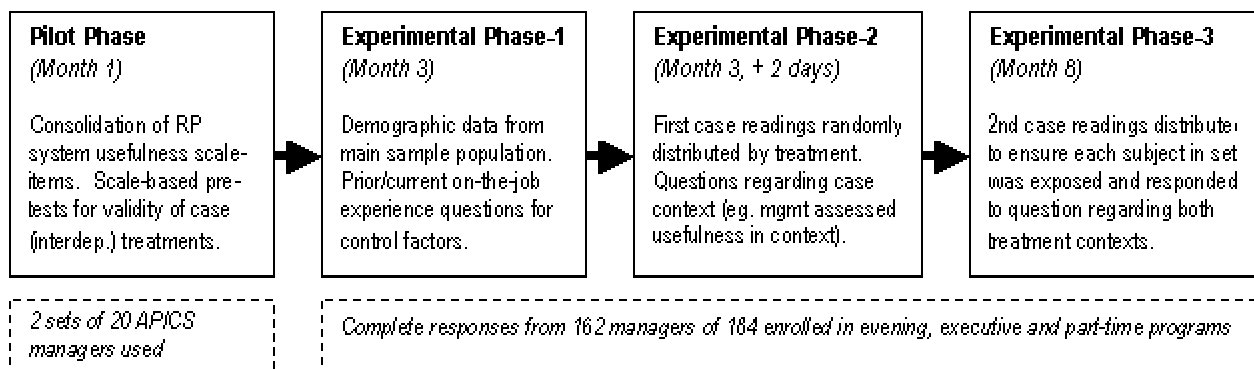
Certainly supervisory experience is not the only managerial experience that can influence their perceptions regarding information technology. Other critical experiences involve both prior use of the IT in general and prior use of the specific capabilities of the technology being studied (Carlson and Zmud 1999; Venkatesh and Davis 1996; Hackbart et al. 2003). For example, managers with strongly negative previous experiences with a system type may carry a negative bias across contextual boundaries (Lyytinen, 1988; Szajna & Scamell, 1993). At the same time however, those with a greater understanding of the needs of specific operational contexts (eg. highly interdependent settings) and capabilities of specific systems have the potential for a more realistic view of the potential usefulness of the technologies in specific contexts (Anderson, 1978; Ginzberg, 1981; Maccoby, 2003). In general the idea that prior experience impacts

perceptions of technology usefulness in other contexts remains compelling as illustrated by the popularity of Expectancy theory and the number of studies involving the focus on such antecedents (see for example Jackson et al. 1997). In examining the effect of context on usefulness of a technology, such prior experiences should be accounted for to help clarify the sources of effects in analysis. For completeness we consider these issues as controls in later analysis, along with a control for prior experience with highly interdependent contexts.

3. Design of experiment

Our interests in this study specifically focus on the extent to which managers view resource planning systems as useful communication tools in increasingly interdependent contexts. Given the strong possibility that prior experience can impact these views, we pursue an experimental approach using a controlled manipulation of context (ie. our experimental treatment: high vs. low interdependence) rather than relying on self-reports of on-the-job contexts. The use of a controlled experimental design (as recommended for example by Cook and Campbell 1979 for studies of work context distinctions), and the associated explicit control of the contextual dependent variable, allows us to mitigate risks of common source biases in our analysis as well as limiting the risks of other unknown exogenous effects in a section of our analysis. To help avoid risks of halo effects and hypothesis guessing on the part of the manager respondents, our experimental design involved the collection of data in three separate phases. While the first was designed to gather preliminary demographic and control data, the latter two phases required subjects to review written case settings (our controlled contexts) and provide their assessments of the relative usefulness of communication capabilities of RP systems specifically in these contexts. A flow chart of our complete procedure is presented in Figure 1.

Figure 1. Flowchart of Experimental Methodology



Each of these phases is described in detail in the following sections.

3.1. Piloting and Development

In order to develop a representative set of questions specifically aimed at a variety of mechanisms by which resource planning systems can be used as mediums for intra-firm data communication/exchange, we first developed a set of fourteen pilot items based on discussions of resource planning systems in an

on-line practitioners' forum (See Appendix A1). This forum consisted of special interest group members of APICS (the American Production and Inventory Control Society). Twenty managers from this group were asked to rate the extent to which the pilot items represented feasible mechanisms for meaningfully communicating information in production settings. They were then asked to rate the percentage of firms that they believe have made use of resource planning systems in such a fashion. The distribution of these responses were then examined in terms of skewness along these pilot scales, as suggested by Converse and Presser (1986), to increase the chances that a more select set of items used in the full study would provide appropriate breadth of scale delineation for statistical purposes. As a result of this procedure, items that did not tend to be viewed as feasible mechanisms were effectively dropped, as were items that were either consistently rated to be nearly in universal use or universally absent from consideration. The remaining five items would be used in both measuring views of system usefulness in prior personal contexts as well as in the subsequent experimental contexts (See Appendices).

To draw controlled comparisons between high and low levels of operational interdependence contexts, we constructed two versions of a case summary intended for distribution to our study sample. One version provided a description of a hypothetical operating environment (a cellular phone assembly), characterized by low levels of interdependence. The other described a variant of that environment intended to represent a significantly higher level of interdependence. Both cases were pre-tested with an alternate group of twenty managers to help ensure they would be interpreted appropriately in our full study. Manipulation checks on interpretability (t-tests, describing level distinctions for subjective measures of these treatments) showed the cases to be adequate in this pilot trial (Cook and Campbell 1979; Purdue and Summers 1987). Such checks would be repeated for the full sample. With the exception of these two case summaries, the remainder of the questions used in the experiment were designed to be identical for all sample subjects.

3.2. Experimental Procedure

The experiment and associated questionnaires including these items were administered in three phases to a set of executive managers enrolled in evening, executive and weekend MBA curricula at two separate institutions. All those in the sample populations had at least two years of work experience as managers at their firms prior to enrollment (and at least 4 years of experience in management roles overall). Early on in the academic semester (1st data collection phase), managerial respondents were instructed to complete a set of questions provided prior to each case, aimed at eliciting standard control data (for example, age, gender, etc.), prior on-the-job experience with the use of intra-organizational communication capabilities of resource planning systems and with such systems in general (See Appendix B). Since ERP and MRPII systems were not a part of the curriculum these managers had been exposed to we provided an explicit definition of our intended interpretation of RP systems in general along with these questionnaires (See Appendix A2). General experience with resource planning systems was measured through the use of three separate items, based on historical perspectives on the distinctions alternate system types (Chase et al. 2001; Mabert et al. 2001; Gumaer 1996). It should be noted that while this general measure of system experience with resource planning systems was collected as a control, it was not anticipated to be a sufficient predictor of management assessed usefulness by itself. This is because general system experience may involve both positive and negative attributions that span multiple system capabilities (Venkatesh and Davis 1996; Szajna 1996) regardless of whether managers have specific experiences with such distinct capabilities. Therefore past experience with such specific capabilities was viewed as a critical additional control. We refer to this more specific control as 'past observed usefulness'

of RP as communication tools in order to distinguish it from our key dependent variable 'management assessed usefulness' (in the experimental contexts).

Also collected in this first phase were proxies for our key uncontrolled independent variable (supervisory experience). These proxies included both the number of workers supervised and the number of months spent in supervisory roles. Since similar measures have been used in past studies (Avery et al. 2003; Tesluk and Jacobs, 1998) and since they could be obtained directly from existing secondary data (company and registration records), they appealed to our use in this study. While either of operationalization of supervisory experience could have been adopted in analysis, the meta-analysis of experience studies conducted by Quinones et al. (1995) demonstrated that "amount" measures of experience (eg. number of workers supervised) consistently account for greater variance in outcome variables than other metric schemes. Specifically, the mean estimated population correlations between these experience metrics and dependent variables in the studies reviewed was 0.43 for "amount measures" as opposed to 0.27 for "time" measures (eg. number of months in a supervisory role). This result corroborates recent and long-existing findings on the inadequacy of time measures of experience as predictive variables (Fiedler 1970; Avery et al. 2003). Hence although "time" measures of supervisory experience remains a popular proxy in research (Borman et al. 1993; Karambayya et al. 1992), we prefer the use of the "amount" measure as our indicator for formal evaluation and testing.

In a second phase, these same managerial respondents were given one of the two case readings (See Appendix C) along with a set of follow-up items related to management assessed usefulness of resource planning technologies specifically in the case settings described. We specify our high interdependence settings as containing both significant reciprocal and sequential task features, as suggested by the characterizations of past research (eg. Sharma and Yetton 2003; Pearce et al. 1992; Thompson 1967), and focus on such interdependence within a given work unit. In this second phase, subjects were also given the opportunity to describe their perceptions of the level of interdependence characterized by the case manipulations. These questions would be used for in-task manipulation checks to validate distinctions between the interpretations of the two contexts were adequate. By structuring the experiment and manipulation in this fashion we retained full control over the primary independent variable of interest to our experiment – interdependence. Furthermore, in arranging our questions in this sequence we avoided the potential that reports of individual prior experiences would be influenced by either the case, the perception of the interdependency represented by the case or the management assessed usefulness of resource planning systems in the specific case context. For completeness and to allow for a stage of analysis free of exogenous effects, a third phase of questioning exposed these managers to the alternate case to that which they had been provided in the 2nd stage. In this third phase, they were asked to provide assessments of RP usefulness in this alternate context and finally to provide an estimate of their experience with highly task interdependent work settings. The later timing of this 3rd phase contextual assessment (5 months following the 2nd phase) also reduced the risk of 'hypothesis guessing' that can lead to unnatural biases in experimental studies. (Cook and Campbell 1979).

Questions describing the extent of perceived interdependence were drawn from Van der Vegt and Janssen's (2003) index and included such items as "Employees in this unit need information and advice from colleagues to perform their jobs well" (see Appendix C). These questions provided a means of later checking the strength and appropriateness of our manipulation. Items used to gauge past management experience with interdependent settings mirrored these questions, while a proxy for RP system familiarity was based on an average of items 13a-15a in the Appendix. Questions regarding the potential usefulness of resource planning technologies mimicked those presented prior to the written cases, but were

specifically aimed at the case context rather than the prior on-the-job experiences of the individual subjects. Although not used in this study, our data collection efforts also provided feedback on a host of items that describe perceptions of the usefulness of interpersonal organizational mechanisms to resolve information requirements in high vs. low interdependency environments. Since our focus is on the usefulness of resource planning systems, we do not report here on these additional items.

4. Data and analysis

Out of the 186 managers solicited to complete the survey experiment, 162 of these (87%) provided complete responses. Of these, 66% were male and 84% were born in the United States. English was the first language of 89%. Additional details describing the professional backgrounds (ie. current or most recent management focus) of the respondents are provided in Table 1.

Table 1. Distribution of professional backgrounds for the study sample

<i>Industry Representation</i>							
Manufacturing (non-Pharma)	Pharma	Energy / Utility	Telecom / IT	Marketing	General Consulting	Banking / Fin / Acctg	Other
19%	10%	7%	15%	9%	15%	19%	6%

<i>Position / Role Representation</i>								
General Manager	Project Manager	Production Manager	Sales Manager	Consulting Manager	Managing Analyst	Engineering Manager	Managing Accountant	Other
26%	9%	10%	7%	15%	14%	6%	6%	7%

4.1. Manipulation Checks and Biases

To ensure that the manipulation provided an appropriate contrast between high interdependence and low interdependence operating environments, we compared the perceived levels of interdependence reported by respondents in each condition. On the whole, the reliability of Van der Vegt and Janssen's scale (2003) was adequate ($\alpha = 0.84$). Results from t-tests indicated that the means of perceived interdependence reported for the high interdependence (5.84, sd = 1.49) and low interdependence (3.97, sd = 1.41) conditions were significantly different, $t(162) = 5.78, p < 0.001$, and fell in the anticipated order. Such manipulation checks supported the adequacy of the experimental treatment (Cook and Campbell 1979; Perdue and Summers 1987).

Additional descriptive statistics of the primary variables of interest to this study, as well as experiential controls included in analysis, are provided in Table 2. As expected, neither the experimental condition nor the perceived level of interdependence associated with the condition were significantly correlated with reports of prior experience, suggesting that these events did not largely influence the interpretation of the level of interdependence associated with the experimental manipulation. As anticipated, for each treatment setting (ie. low and high interdependence), a positive correlation was identified between the interdependence scales and views of the usefulness of intra-organizational communication capabilities of RP systems. However, and also as anticipated, a positive correlation (sig at

p<1%) was detected between prior system use and such views, further suggesting the need to attempt to disentangle prior events from context-specific interpretations.

Table 2. Means, standard deviations, reliabilities, and correlations

	Mean (SD)	1	2	3	4	5	6	7	8
1. Management perceived interdependence (Low Interdep. context) [<i>manip. check</i>]	3.97 (1.49)	(0.86)							
2. Management perceived interdependence (High Interdep. context) [<i>manip. check</i>]	5.84 (1.41)	0.101	(0.83)						
3. Management assessed usefulness of RP systems (Low Interdep. context) [<i>main dependent variable studied</i>]	4.17 (1.50)	0.297**	0.030	(0.82)					
4. Management assessed usefulness of RP systems (High Interdep. context) [<i>main dependent variable studied</i>]	5.89 (1.46)	0.022	0.315**	0.206*	(0.85)				
5. Past supervisory experience [<i>main objective secondary source data</i>]	7.21 (9.41)	0.052	0.067	0.094	0.372**	--			
6. Management past observed usefulness of RP systems (in subject's real-world job) [<i>experiential control</i>]	4.21 (1.32)	0.106	-0.034	0.308**	0.297**	0.091	(0.87)		
7. Management familiarity with resource planning systems [<i>experiential control</i>]	3.37 (1.39)	-0.056	0.011	0.085	0.162*	-0.024	0.187*	(0.78)	
8. Management experience with highly interdependent task settings [<i>experiential control</i>]	3.34 (1.66)	0.091	0.080	0.063	0.190*	0.079	0.164*	0.061	(0.80)

Note: Chronbach (α) reliability estimates appear in parenthesis along the diagonal.

** $p < .01$, one-tailed, * $p < .05$, one-tailed

4.2 Hypothesis Testing

Testing of our first hypothesis required a check for significant differences in management assessed usefulness given contexts of alternate levels of task interdependence. Since each respondent ultimately provided assessments of usefulness for both high and low interdependence treatments, paired comparisons were used. This approach to analysis provided the convenience of avoiding the risk of exogenous effects and thus a cleaner evaluation of results. As anticipated, management assessed usefulness of RP systems as communication tools was significantly greater for the highly interdependent context (5.89, sd=1.46) than for the low context (4.17, sd=1.50). This provided support for H1. Additional ad-hoc tests limiting our sample to the upper quartile of managers based on by experience in interdependent settings (and supposedly more aware of the communicative needs of such contexts) showed still stronger assessment distinctions between high and low contexts.

Our second and third hypotheses were designed to consider in turn the direct and moderating roles of supervisory experience on management assessed usefulness. An evaluation of these effects involved a GLS approach to estimating management assessed usefulness by introducing supervisory experience along with other experimental controls as predictors. Given our matched sample of contextual responses

(ie. assessments of usefulness in both high and low interdependence contexts by each respondent) we ran two separate regressions for comparison purposes. The results of both high and low interdependence contexts are provided in Table 3. The results of Chow Tests for the equality of coefficients (1960) for each independent variable and experiential control are given in Table 3 as well (far right column).

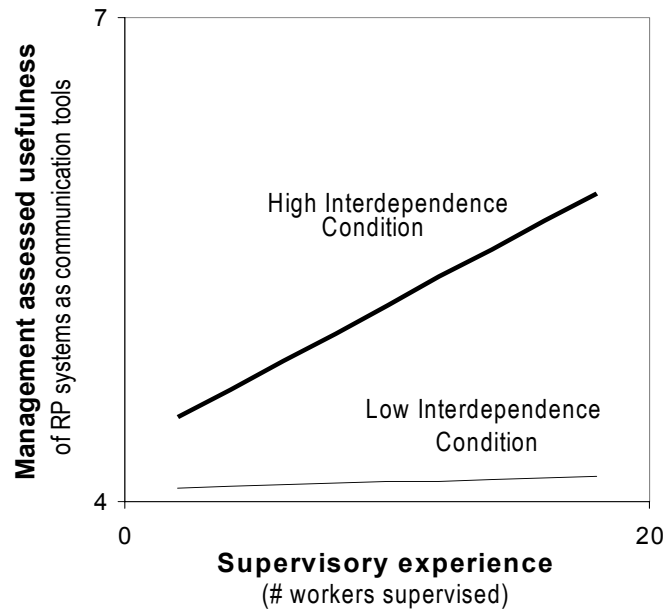
Table 3. Moderation test results for high and low interdependence conditions

Dependent Variable: Management assessed usefulness of RP systems in the Experimental Contexts					
	Low Interdependence Treatment		High Interdependence Treatment		Significance Test for Equality of Coefficients
	Parameter Estimates	Standard Error	Parameter Estimates	Standard Error	
Constant (<i>treatment main effect</i>)	3.181**	(0.422)	3.347**	(0.274)	p < 0.05
Past supervisory experience	0.004	(0.005)	0.087**	(0.007)	p < 0.01
Management past observed usefulness of RP systems (in subject's real-world job)	0.451**	(0.100)	0.384*	(0.059)	n.s.
Management familiarity with RP systems	0.103	(0.162)	0.110*	(0.058)	n.s.
Management experience with highly interdependent task settings	0.153	(0.143)	0.080*	(0.038)	p < 0.05
<i>R² for model excluding controls</i>		0.190		0.344	
<i>R² for model including all above factors</i>		0.261		0.570	
<i>ΔR² on addition of constant to model with only controls</i>		0.183**		0.197**	
<i>ΔR² on addition of 'past supervisory experience' to model with only controls</i>		0.019		0.168**	

*Unstandardized coefficients provided above; **p < .01, one-tailed, *p < .05, one-tailed*

As illustrated by our results, the dynamics associated with low interdependence conditions differ markedly from those of the high operational interdependence condition. A significant main effect for the interdependence level is indicated by Chow tests on the regression constant, demonstrating that such an effect is relevant even in the presence of other factors. Furthermore, while in the high condition, prior supervisory experience provides a significant direct effect on management assessed usefulness, thus lending partial support to H2. Such an effect was not significant in the low interdependence context however. This significant difference in the role of past supervisory experience across the two contexts supports our third hypothesis. A clearer and more direct contextual contrast is provided by a simple graphical effect comparison (Figure 2).

Figure 2. Average Management Assessed Usefulness across main independent variables



Further ad-hoc tests using the number of months of supervisory experience in place of our 'amount' proxy for supervisory experience provided similar though less significant results as anticipated by recent research (Quinones 1995). Sign and significance of effects were also robust to the use of the maximum value across items 13a-15a as an alternate proxy for RP familiarity.

In addition to providing support for H3, and partial support for H2, these results also help emphasize the role of alternate experimental controls (ie. past management observed usefulness, familiarity with RP systems in general and past experience with interdependent contexts). In the high interdependence context these controls contributed 23% of the total variance accounted for. Although incremental ΔR^2 statistics suggest that such controls do not fully mediate the effects of the factors central to this study (ie. interdependence level and supervisory experience), the immediate implication for research is the criticality of accounting for such priors in survey-based assessments. In fact, it is conceivable that neglecting to do so might severely skew alternate contextual effects, thus leading to overstated analytical conclusions in studies. For practitioners, firms hiring outside managers or making major business process changes need to deal with the reality of lingering priors if they actually intend to forge ahead in effecting new operational and strategic developments.

5. Discussion

Researchers studying organizational communications have continued to emphasize the importance of such communication particularly in complex interdependent environments where information processing needs are high. Evidence building on information processing theory and similar foundations such as the contingency perspective can be found in empirical analysis of the role of non-technical based communications (eg. Bensaou and Venkatraman 1995; Tatikonda and Montoya-Weiss 2001; O'Leary-Kelly and Flores 2002). Nevertheless, recent literature on resource planning systems (eg. ERP, MRPII, etc.) has been predominantly limited to discussions of transactional capabilities (McAfee 2002; Davenport 2000),

implying mandated use and roles of supervisors as little more than watchdogs for process quality control regarding system use. In contrast, our results help to emphasize that non-transactional communicative capabilities of RP systems may be viewed as critical by experienced managers in highly interdependent settings.

5.1. Implications

The results show that regardless of prior experience with resource planning systems, interdependent contexts and regardless of pre-existing views of their use, managerial interpretations of these systems as useful communication tools are highly sensitive to the interdependence of their operating contexts. Supervisory experience moderates this effect. Specifically, respondents with more supervisory experience are increasingly more likely to emphasize the usefulness of these systems as communication tools as interdependency increases. In generally low interdependence environments, such supervisory experience has little impact on these management assessments. Yet at very low levels of supervisory experience the practical differences between assessments in these two contexts appear slight. On the whole this suggests that management support and subsequent encouragements of workers in the use of RP systems as communication (as opposed to purely transactional) tools may be difficult to bolster without both evidence for a need of such use (eg. evidence of a highly interdependent setting) and an understanding of the criticality of communication for supporting work dynamics (eg. as developed through past experience).

With reference to the existing research literature, these findings provide a unique contribution to understanding the significance of contextual and experiential influence on the kind of managerial support that is assumed to be so critical in technology adoption and diffusion among workers. It extends existing applications of information processing theory by showing how informational needs posed by such theory in specific (ie. highly task interdependent) contexts (eg. Gattiker and Goodhue 2004) can be used to suggest influences on managerial views. The findings thus provide a potentially powerful link between IPT and alternate theoretical frameworks involving managerial support as antecedents of successful technology application (eg. Eder and Igbaria 2001; Zmud 1984).

From a practitioner's standpoint, our findings are not intended to suggest that interdependence or experience effects on communicative capability assessments drive RP system adoption; Indeed many firms may justify such adoption by virtue of transactional benefits alone. Rather, these findings emphasize that managerial exposures to supervisory roles are increasingly important in increasingly operationally interdependent contexts. Subsequently, since the availability and use of alternate communication mechanisms are particularly critical in such settings (Sorensen, 2003; Flynn and Flynn, 1999), management's awareness of a variety of communication options should be taken into consideration when the value of RP communicative capabilities has the potential of significantly augmenting ROI. This further suggests that firms managing highly interdependent operations should not only ^(a) look for ways to further exploit pre-existing tools for communication, such as in-house resource planning systems, but also ^(b) should ensure that those positioned to champion the use of these tools have sufficient supervisory experience to appreciate the full potential of these tools for communication purposes. Ultimately this translates into a context-specific drive for firms to adjust the roles of certain supervisors from simply quality-usage watchdogs to champions of more diverse technology use with the goal of improving technology management overall. Such a call may require cross-functional supervisory development programs for existing IS staff and system champions. Alternately these efforts may take the form of further information systems training programs for established shop-floor supervisors, operations planners and production team

leaders in general. If further verified by future studies, such prescriptions represent the kind of critical take-aways that are at the heart of applied management of technology research.

Lastly, while not the focus of this paper, it is worth comparing the results specific to the discretionary RP capabilities examined here with results specific to other communication media (eg. e-mail, phone and face-to-face) reviewed in a parallel study conducted. While overall assessments of usefulness of these alternate media along the same usage dimensions were distinct, similar impacts of task interdependence are observed. With overall cost and information-transfer effectiveness differing across these media, it seems that yet another communication option can only assist in easing the burdens of highly interdependent settings. At the same time however, with usage discretionary, it is entirely possible that the benefits of RP communicative capabilities (as well as that of other media) may be largely overlooked if management supervisory experience is underdeveloped. The criticality of firm investments in management experience should thus be viewed as an issue pervasive to the management of discretionary communication technology in general.

5.2. Limitations and Future Work

Regardless of the precautions taken in this study, the results and phenomena suggested should be carefully scrutinized. Although the effectiveness of our experimental manipulation was validated statistically (Cook and Campbell 1979), the contexts considered in these treatments may not provide meaningful comparisons that can be extended to certain alternate manufacturing and service settings. Furthermore, the choice of the manufacturing settings used in our treatment cases may have created unanticipated biases with regards to interpretation by some of our sample respondents. While we believe most managers reacted as anticipated to the intended focus of these case treatments, it is possible that individual differences in interpretation may have influenced our results.

Another possible limitation in our sampling is more general, though likely less of an analytical concern. Convenience sampling has been viewed as an acceptable approach in recent OM studies (see for example Hausman, Montgomery and Roth 2002; Schultz et al. 2003) due in part to the benefits of increased internal validity and control from such selection (Hoyle, Hausman and Judd 2002). These added benefits were particularly relevant to this study since the timing and control of the experimental treatments was necessary to ensure the interpretability of the results. Nevertheless, it should be recognized that such an approach may imply sample biases that limit the robust application of results – ie. much in the same way that the initial selection of many survey target-populations limit interpretation. Future work with alternative samples should be conducted to further validate or refine the results described here. Verification of our findings through field studies (eg. utilizing a case or survey method) represents one possible approach to resolving this issue.

Additional imitations may come from our specific operationalizations of concepts in this study. For example, while we base our measure of interdependence (used in our manipulation checks) on the work of Van de Vegt and Jansen (2003) alternate scales (eg. McCann and Ferry 1979; Wybo and Goodhue 1995) would likely have yielded somewhat modified results. While our results do not suggest that this was an issue in distinguishing our treatment contexts, further studies might be strengthened by the incorporation of multiple views of such widely applied concepts. It should further be stressed that our focus on supervisory experience, though of critical interest to RP settings where users of such systems are often subject to some form of direct supervision, does not imply that such experience is the only (or even the most important) form of experience to consider in studying the link between interdependence and perceptions of system

usefulness. Although we control for several other forms of experience in our study, still others such as experience as technology champions, 'super-users' or technology resource managers may be critical and are certainly worth studying along these lines in future work.

Furthermore, building on the notion that experience as a supervisor is not equivalent to experience as a technology champion, it is worth emphasizing that the positive management assessments of technology usefulness (as focused on here) should not be automatically assumed to predict actions taken by such managers to promote use. Past literature on the linkage between technology promotion and actual use by subordinates remains equivocal (Karahanna et al. 1999; Carlson and Zmud 1999; Agarwal 2000). Therefore, while our study's findings substantiate the importance of considering the role of context and past experience on management assessment of technology, several questions remain to be answered in order to clarify the chain of effects from experience and assessment to promotion and use. For example, do firms faced with certain levels of process complexity and task interdependence currently place greater 'technology champion' responsibilities on supervisory managers? Do they invest more in training to build specific types of experience into such roles? For those that do, are management assessments more directly translated into promotional (eg. champion) actions by such managers, and does such promotion translate into observable changes in technology use by subordinates? For those that do, are operational benefits markedly greater than for those who do not? Only by researching such questions, and applying them jointly with a clear understanding of the role of operational context can prescriptions be developed for improving technology management along these lines.

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Appendix A1: Original 14 “RP Communicative Capability Usefulness” Items Reviewed in Pilot Phase (originated in APICS forum discussions)

For each item: (a) Rate the extent to which it represents a feasible mechanisms for meaningfully communicating information in production settings; (b) Rate the extent to which you believe firms have made use of resource planning systems in such a fashion.

- 1) The communication of production requirements among employees **
- 2) The communication of production contract information among employees
- 3) The communication of production requirements among employees **
- 4) The identification of product-order handling difficulties by employees
- 5) The identification of production problems and issues by employees **
- 6) The identification of production conformance quality levels by employees
- 7) The flagging of production quality control concerns to employees
- 8) The flagging of production inventory account imbalances to employees
- 9) Goal-oriented production-process redesign collaboration among employees
- 10) Goal-oriented production planning and collaboration among employees **
- 11) Production activity coordination and scheduling among employees **
- 12) Production activity critiquing and debate among employees
- 13) The dissemination of forecasted demand reports to production employees
- 14) The dissemination of forecasted maintenance reports to production employees

*[Note that items marked by “**” met the pilot selection criteria and were used in the subsequent experiment]*

Appendix A2: Definition of RP systems accompanying each phase of the study

A resource planning system is one of a set of related information technologies (eg. ERP, MRPII, etc.) that provides standardized interfaces for the entry and retrieval of data relating to both within-day and long-term operating horizons. The associated database contains all information relating to the monitoring of inputs, outputs, resources and process descriptors (eg. status, schedules, pre-requisites, etc.) for a range of activities managed. The system ensures that such information may be visible and available to all workers affiliated with these activities.

Note: This definition was based off of recent personal experience with the implementation of such systems, the past specifications of Davenport (2002), Chase et al. (2001) and Mabert et al. (2003), as well as on direct discussions of such a general definition with several of these authors.

Appendix B: Questions administered prior to case summaries and follow-ups

- 1a. Gender: M / F
 2a. Age: _____
 3a. Years of Education: _____ (e.g., BA, MBA, etc.)
 4a. Country of birth: _____
 5a. First language: _____
 6a. Years of full-time work: _____
 7a. Industry in which you are currently employed: _____
 8a. Years with current organization: _____
 9a. Current job title: _____
 10a. Number of years in current position: _____

{Past supervisory experience}

- 11a. Number of employees for whom you have had supervisory responsibility: *Direct:* _____ *Indirect:* _____
 12a. Number of months that you have spent in a supervisory capacity of some kind: _____

{Management familiarity with RP Systems}

Please rate the extent to which you agree with the following statements about employees in the production unit just described, using the scale below.

1	2	3	4	5	6	7
highly disagree	moderately disagree	slightly disagree	neither agree nor disagree	slightly agree	moderately agree	highly agree
13a. I have extensive on-the-job experience using ERP systems (Enterprise Resource Planning systems such as those developed by SAP, People Soft, etc.; Resource planning systems that provide access to transactional, planning and scheduling data among multiple functional areas including manufacturing, marketing, sales, purchasing, accounting, human resources, etc.).						
14a. I have extensive on-the-job experience using MRPII systems (Manufacturing Resource Planning systems that provide access to planning mechanisms and scheduling data relating to materials and manufacturing capital and resources, but little data regarding other functional area activities).						
15a. I have extensive on-the-job experience using MRP systems (Materials Requirements Planning systems that provide access to planning mechanisms and scheduling data relating to material inputs, but little information regarding equipment, staff schedules or other functional area activities).						

{Management past observed usefulness of RP systems}

Based on your prior work experience, please indicate your agreement with the following statements regarding the extent that resource planning systems are used to facilitate each of the following activities (7 point scale as above)

Based on your prior work experience, planning systems are frequently found to be useful in...

- 16a. The communication of production requirements among employees.
 17a. The communication of production recommendations among employees.
 18a. The identification of production problems and issues by employees.
 19a. Goal-oriented production planning and collaboration among employees.
 20a. Production activity coordination and scheduling among employees.

Appendix C: Experimental cases and questions administered in second phase

Case summary for Low Interdependency conditioned sub-sample:

A production unit in a small factory produces a single cellular phone model for Nokia. Each of the ten members of the production unit is responsible for one of ten sequential operations. Factory policy allows large buffer stocks of work-in-process to be maintained between operations. Although all ten individuals are required to work eight hours each day, they can begin and end their activities according to a flexible work schedule because of the buffer-stock policy. Workers at this factory do not have to communicate information regarding color, stock, or equipment to each other because the phone that they make leaves the factory in only one color, cabinet style, and functionality package. All of the workers at this factory have their own equipment, and so do not have to coordinate their use of production facilities. Over the last several years, neither the product design nor the production process has changed.

Case summary for High Interdependency conditioned sub-sample:

A production unit in a small factory produces several cellular phone models for Nokia. The ten members of the production unit rotate responsibility for each of ten sequential operations. Factory policy allows no buffer stocks of work-in-process to be maintained between operations. Although the unit's members are required to work eight hours each day, they must work together to determine work schedule because of the buffer-stock policy. Workers at this factory have to communicate information regarding color, stock, and equipment to each other because the phone that they make leaves the factory in five colors and cabinet styles with ten functionality packages. Because half of the workers at this factory share equipment, they have to coordinate their use of production facilities. Over the last several years, both the design of the product and the production process have changed extensively.

{Management perceived level of interdependence within experimental context}

Please rate the extent to which you agree with the following statements about employees in the production unit just described, using the scale below.

1	2	3	4	5	6	7
highly disagree	moderately disagree	slightly disagree	neither agree nor disagree	slightly agree	moderately agree	highly agree
1b. Employees in this unit need information and advice from colleagues to perform their jobs well.						
2b. Employees in this unit have a one-person job; it is not necessary for them to coordinate or cooperate with others.						
3b. Employees in this unit need to collaborate with colleagues to perform their jobs well.						
4b. Employees in this unit need information and advice from one another to perform their jobs well.						
5b. Employees in this unit regularly have to communicate with colleagues about work-related issues.						

{Management assessed usefulness of RP systems within experimental context}

Based on the production facility just described, please indicate your agreement with the following statements regarding the potential usefulness of resource planning systems in facilitating the following activities.

In the production facility described above, resource planning systems would be useful in...

- 6b.** The communication of production requirements among employees.
- 7b.** The communication of production recommendations among employees.
- 8b.** The identification of production problems and issues by employees.
- 9b.** Goal-oriented production planning and collaboration among employees.
- 10b.** Production activity coordination and scheduling among employees.