From the Editor ............................................................. G. F. Farris 217

RESEARCH ARTICLES

Toward a Product System Modularity Construct: Literature Review and Reconceptualization ......................... F. Salvador 219
The Influence of New Product Development Competitive Capabilities on Project Performance .......................... J. Jayaram and R. Narasimhan 241
Industry-University IP Relations: Integrating Perspectives and Policy Solutions ........................................ M. Jelinek and S. Markham 257
Exploring Ambidextrous Innovation Tendencies in the Adoption of Telecommunications Technologies ......................... V. Grover, R. L. Purvis, and A. H. Segars 268
Analyzing the Success Drivers of e-Business Companies ................................................................. S. Albers and M. Clement 301
The Influence of Experience and Information Search Styles on Project Risk Identification Performance .................... E. Maytorena, G. M. Winch, J. Freeman, and T. Kiely 315
Managing Competencies in Breakthrough Product Development: A Comparative Study of Two Material Processing Projects ................................................................. C. McDermott and T. Coates 340

FOCUS ON PRACTICE PAPERS

The Complementary Role of Dominant Designs and Industry Standards ..................................................... S. Gallagher 371

RESEARCH NOTES

Integration of Kano’s Model Into QFD for Multiple Product Design ......................................................... Y. Sireli, P. Kauffmann, and E. Ozan 380

BOOK REVIEWS

Kerzner’s Project Management Logic Puzzles by Harold Kerzner .............................................................. J. K. Pinto 391

ANNOUNCEMENTS

Forthcoming Engineering Management Conferences .................................................................................. 393
2007 IEEE EMS International Engineering Management Conference .................................................. 394
Special Interest Groups for the IEEE Engineering Management Society .................................................. 395
Papers to be Published in Future Issues of the IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT .... 396
READERSHIP SURVEY ................................................................................................................. 399
Call for Papers: Special Issue on Managing Innovation in Emerging Economies ........................................... 401
IEEE Engineering Management Society: Call for Case Study Proposals on Managing Engineering, Technology, and Innovation .... 402
IEEE Engineering Management Society: Call for Awards Nominations ................................................... 403
Abstract—Although organizations have applied a variety of practices and tools to address information systems development (ISD) performance problems, most of these approaches have focused on controlling and improving predictability of the development process. There is growing recognition that ISD is a knowledge-intensive process that requires the integration of specialized stakeholder knowledge. We develop the perspective that integration of this specialized knowledge across knowledge boundaries in the ISD process drives ISD performance. We theorize that formal and informal organizational integrative practices influence ISD performance, because they facilitate the development of boundary objects that effectively span knowledge boundaries. Results from a field study of 110 firms provide considerable support for the proposed model. This paper makes three novel contributions to the technology management literature. First, it demonstrates that knowledge integration across knowledge boundaries through boundary objects improves ISD performance. Second, it shows how formal and informal organizational integrative practices enhance the integration of specialized knowledge within and across organizational subunits. Third, it shows that the positive influence of formal and informal organizational integrative practices on ISD performance is partially mediated by knowledge integration. For engineering and technology managers, the results highlight the centrality of knowledge integration for the management of technology development. Collectively, these findings offer a novel knowledge integration-based perspective that complements prior research on systems development and new product development.

Index Terms—Boundary objects, information systems development, knowledge boundaries, knowledge integration, knowledge management, process improvement, project management, software development.

I. INTRODUCTION

Of the $2.5 trillion spent on information technology during 1997–2001, nearly $1 trillion was spent on underperforming information systems projects [11]. A large number of these projects eventually fail, costing US firms more than $78 billion each year [54]. There is, therefore, considerable interest in improving technology development processes in both software and new product development projects. Research on improving information systems development (ISD) processes has primarily focused on mechanisms such as tools, software development methodologies, process capabilities, and technical factors [40]. Although this research has yielded considerable insights into improving the ISD process, but the large majority of ISD projects continue to be over budget, late, and fail to meet intended business objectives [44]. Moreover, IS units in similar organizations, with similar skill sets, comparable practices, capability maturity (CMM) levels, and software development tools seem to have markedly different abilities to develop systems. This suggests that other differences in the intrafirm organization of ISD activities may explain these differences in ISD performance.

The performance challenges described above are not unique to ISD projects [1], [56], [60]; similar challenges are encountered in other complex development projects that must effectively draw on diverse specialized knowledge within and across organizations. Examples include research and development (R&D), development of pharmaceutical drugs and new products, and management of engineering projects. A better understanding of how to address these challenges in the ISD context should provide insights for the management of the development of complex products and technologies.

The ISD process typically involves developing a model of the application domain, translating the model into formalizations that aid construction of the solution, and installing the system in the implementation context. The majority of research on improving ISD has focused on how the process should be engineered to be predictable and repeatable, and from a behavioral standpoint, how conflict among its participants can be minimized. In contrast, an emerging view of organizational subunits as knowledge-utilizing entities recognizes development processes as not only requiring the application of knowledge for specific tasks but requiring that this knowledge be transferred, translated and transformed [13] across participants and stages. We draw on this perspective and focus on how knowledge can be transferred, translated, and transformed across knowledge boundaries of ISD stakeholders by the use of boundary objects, i.e., objects that cross ISD knowledge boundaries seamlessly.

In this paper, we use the term knowledge integration to refer to the extent to which boundary objects characteristics enable integration of knowledge across knowledge boundaries in the development process. From an empirical standpoint, characteristics of boundary objects are more observable than other modalities of knowledge integration, such as transfer of tacit knowledge, which makes this form of knowledge integration more measurable. To understand how knowledge can be integrated in ISD, we focus on two facets of organizational integrative practices: 1) formal practices, specifically job rotation, team-based development, and participative decision-making; 2) informal practices, specifically interaction and communication.
among IS unit staff and with line departments. We choose this focus because of the noted primacy of formal and informal practices for knowledge integration in organizational processes [68], [69], but which have been largely unexamined in the ISD context.

In summary, the purpose of this study is to extend our understanding of how organizational integrative practices facilitate integration of dispersed knowledge held by stakeholders in various organizational subunits and in turn enhance ISD performance. This leads to the following two research questions.

1) How and why do organizational integrative practices in ISD influence ISD performance?
2) What is the role of knowledge integration in this nomology?

The central thesis of this paper is that integration of specialized knowledge needs to occur across knowledge boundaries during the ISD process. Formal and informal organizational integrative practices enable the development of “boundary objects” that support integration of specialized and dispersed knowledge, which, in turn, enhances ISD performance. Results from a field study of 110 firms provide support for the relationships proposed in the research model.

The paper makes four contributions to the IS literature. First, it offers a novel perspective on the role of boundary objects to integrate knowledge across different knowledge boundaries. Second, it demonstrates that formal and informal integrative practices enable the development and use of boundary objects to facilitate knowledge integration. Third, it provides evidence that knowledge integration is positively associated with ISD performance. Finally, it shows that the positive impact of formal integrative practices and informal organizational integrative practices on ISD performance is partially mediated by knowledge integration. Collectively, these findings offer a novel knowledge-based perspective and provide evidence of the importance of knowledge processes in the technology development activities in organizations.

The rest of the paper is organized as follows. In the next section, we develop the conceptual model and hypotheses. In Section Three, we describe the methodology and data collection. In the Fourth Section, we discuss the analyses and results and follow with a discussion of the results in the Fifth Section. We then interpret these results in terms of insights that they offer for managing related knowledge-intensive engineering and technology development projects. We conclude the paper with implications for theory and practice.

II. THEORETICAL DEVELOPMENT

The knowledge-based theory of the firm proposes that performance of organizations depends on the creation, management, and utilization of knowledge from within and outside their boundaries [3], [28], [37], [39], [64], [90]. Building on the resource-based view of organizations [9], [22], this theory is based on the premise that knowledge is a central resource, and the heterogeneous stocks and flows of knowledge in a firm provide it with unique resources for competitive advantage. Two themes dominate this theoretical perspective, one that focuses on knowledge creation [64], [65] and the other that focuses on knowledge application [4], [14]. The latter, which focuses on how organizations integrate and apply dispersed, specialized knowledge to organizational activities through the process of knowledge integration [37], [38], [90], is relevant to our theoretical development. We draw on this theory base to develop the concept of knowledge integration for ISD and to propose a nomological network of its antecedents and performance outcomes. We propose that formal and informal organizational integrative practices influence the extent to which specialized organizational knowledge is integrated in the ISD process through the development and use of boundary objects, and that the application of this integrated knowledge influences the performance of the ISD process.

A. Knowledge in ISD

ISD literature has focused on development tools (such as CASE tools) [40], [70], [76], design paradigms (such as object orientation), risk management approaches [49], [83], [89], coordination strategies [61], methodologies [95], and behavioral factors that can improve the ISD process [51]. These different perspectives and representative studies are summarized in Table I. While these studies have substantially enhanced our understanding on approaches to control ISD through the use of tools, techniques, and methods; problems still abound in completing projects with promised functionality and within anticipated resource constraints. Although the centrality of knowledge in the ISD process is now well recognized, little research has focused on the integration and application of knowledge, or the antecedents of such integration. Therefore,
we adopt a knowledge-based perspective for our investigation, as it represents a valuable complement to past approaches used to address ISD performance problems [24], [31], [93].

From a knowledge-based perspective, a central challenge is that of integrating specialized knowledge necessary to develop the system that is dispersed across stakeholders with business and technical domain knowledge [85]. In addition to being dispersed, some of this knowledge is tacitly held in the minds of individual employees, making its integration and application to the development process challenging [82]. For example, business end-users find it difficult to state a complete and precise set of formal requirements and design specifications or to pre-specify functionality that will render the solution effective. Similarly, IS developers might struggle to explain to business users the technical capabilities and feasibility constraints that have an impact on the functionality that can be delivered. Based on this perspective.

1) Developing systems requires the application of specialized knowledge that is dispersed spatially (e.g., end-users and analysts), temporally (e.g., requirements analysis and programming) and across domains of specialization (e.g., business and technical).

2) Achieving development outcomes effectively requires the exchange and combination of specialized knowledge. Development artifacts, such as requirements specifications, design models, code, and test cases, are routinely used in systems development and may be referred to as “boundary objects,” as they cross specialized knowledge boundaries.

3) Boundary objects that integrate knowledge across knowledge boundaries enable the exchange and combination of specialized knowledge.

4) Organizational integrative practices, formal and informal, should play an important role in the deployment of boundary objects and for knowledge integration.

B. Boundary Objects and Knowledge Integration in ISD

The importance of integrating specialized knowledge in the ISD process is recognized in the IS literature [31], [98]. Recent studies have found that ISD project teams that are better able to integrate specialized knowledge of stakeholders are also more creative [23], [80], [93]. However, prior work has not conceptualized how knowledge should be integrated across different knowledge boundaries. Accordingly, we draw on Carlile’s [13], [14] theorizing of knowledge boundaries and boundary objects in the context of development of complex technologies and product innovation to develop the concept of knowledge integration in the ISD process.

Systems development, like the development of complex technologies and new products, exhibits conditions of: 1) dependence, where spatially and temporally distributed stakeholders are dependent on each others’ specialized knowledge domains; 2) novelty, as most systems projects are by nature, new for either the business domain or require the application of a new technology or both; 3) specialization, where a variety of skill sets are required to take a project from initialization to installation of the system. These similarities between product innovation projects and systems development make the application of Carlile’s conceptualization to the systems development context particularly appropriate.

As per Carlile [13], knowledge integration can be accomplished through the development of boundary objects that are used to transfer, translate, and transform knowledge across boundaries of specialized knowledge. Transfer is concerned with the storage and movement of specialized knowledge; translation is concerned with establishing shared meaning across stakeholders with specialized knowledge; and transformation is concerned with negotiating how specialized knowledge can be combined and used in the ISD process. Drawing on semiotic theory, Carlile [13] identifies syntactic, semantic, and pragmatic knowledge boundaries that require boundary objects for the transfer, translation, and transformation, across domains of specialized knowledge.

At the syntactic boundary, knowledge integration is concerned with common syntaxes or lexicons for transferring, storing, and retrieving knowledge across specialized, albeit related, knowledge domains. In the ISD context, knowledge integration at the syntactic level requires that development-related data is accessible across ISD phases. For instance, data requirements collected by systems analysts in earlier stages of development need to be accessible in later stages. Boundary objects, such as a data dictionary, can facilitate transfer of this specialized knowledge across phases of development. By using codification standards, these objects that are developed in one task/phase can be accessed in subsequent tasks/phases. Similarly, standards for representation, documentation, data elements, and GUI objects enable portability of codified knowledge across phases of development.

At the semantic boundary, knowledge integration is concerned with conveying a consistent and common meaning across stakeholders with specialized knowledge. Such integration is enabled by boundary objects that establish common meanings for identifying novel differences and dependencies across technical and business domains of ISD projects. Knowledge integration at this level implies a shared language for describing the problem domain and shared meaning of the terms used to identify design elements, such as entities/objects (e.g., customer and employee) and processes (e.g., discounting and sales).

At the pragmatic boundary, knowledge integration is concerned with negotiating and establishing shared understanding among stakeholders about how their specialized knowledge can be integrated to develop a solution. This knowledge integration is enabled by boundary objects that can be used to combine specialized knowledge, and represent the negotiated trade-offs, functionality, and service levels of proposed solutions. In the ISD context, logical and physical models (e.g., data models, process models, models of system architecture) represent such boundary objects.

Based on this discussion, we define Knowledge Integration as the establishment of shared syntax, semantics, and understanding in the ISD process, so that specialized knowledge can be exchanged and combined. Table II summarizes the focal characteristics of boundary objects for each of the three knowledge boundaries and provides illustrations of these objects in the ISD context.

III. Research Model

The central premise of the research model is that specific types of organizational integrative practices, formal and in-
formal, influence ISD performance through their effect on knowledge integration. The three central ideas that inform the model development are: 1) integration of specialized knowledge dispersed across subunit boundaries within the firm enhances ISD performance; 2) organizational integrative practices—formal and informal—facilitate the development of boundary objects that support knowledge integration; 3) organizational integrative processes influence ISD outcomes by facilitating knowledge integration. These ideas are developed in subsequent sections and presented in Fig. 1.

### A. Knowledge Integration and ISD Outcomes

Drawing on research on communities of practice, Carlile [14] identifies several challenges faced by organizations in integrating knowledge. For instance, in ISD, members of a project team have knowledge that is specific and localized to the tasks and problems confronted by them. Furthermore, their knowledge is rooted in tools, methods, models, and in tacit knowledge of how to perform tasks corresponding to their roles. Finally, as employees routinely deploy their knowledge to perform their tasks, they demonstrate competence in performing these tasks and reinforce knowledge boundaries. Thus, specialized knowledge required for the ISD process is dispersed among various stakeholders, such as employees in user departments and employees in the IT department with different skill sets.

Successfully integrating knowledge across these stakeholders requires that knowledge boundaries to be bridged.

Knowledge integration at the **pragmatic level** facilitates establishment of development artifacts (e.g., software architectures and high level application design) that represent negotiated tradeoffs and functionality based on the perspectives of various project stakeholders. Boundary objects at this level facilitate joint transformation of knowledge, where “objects, models, and maps are the only category of boundary objects that directly supports transforming knowledge” ([14], pg. 452). By enabling the transformation of knowledge, these boundary objects help to negotiate and establish a shared vision for the system.

At the **semantic level**, knowledge integration establishes common meanings for identifying differences and interdependencies across specialized knowledge domains of the project. In the systems development process, this occurs through the use of accepted and standardized ISD methodologies and development processes. They provide tangible and concrete means for communicating knowledge across boundaries by accurately cascading modifications in requirements to affected phases and tasks. They also allows developers to transform heterogeneous, specialized inputs, such as user needs, business requirements, and technical expertise, into design artifacts for the solution. For instance, techniques such as automated test
case development, prototyping, and agile programming allow developers and end-users to iteratively refine design to improve the match between user needs and solution design [52].

Finally, knowledge integration at the syntactic level facilitates establishment of common syntaxes and lexicons for transferring, storing, and retrieving domain-specific knowledge in the ISD process. This is usually achieved through boundary objects such as event tables, data dictionaries, and code repositories, which facilitate transfer of data across task boundaries. Higher levels of knowledge integration represent the degree to which diverse information such as user requirements and programming knowledge are integrated during the ISD process. Only when the diverse perspectives, viewpoints, and expertise of various stakeholders are brought to bear on the ISD processes, the resulting solution will likely satisfy the end users' intended needs. To the extent that a common base of declarative knowledge has been captured, shared, and formalized, knowledge can be integrated in a consistently and meaningfully across the ISD process. By spanning syntactic, semantic, and pragmatic knowledge boundaries, boundary objects enable artifacts produced at earlier stages of a project (such as requirement analysis) to be appropriately used at later stages (such as coding and testing). Additionally, these boundary objects enable coordination of interdependencies and maintenance of integrity of design information and intermediate ISD artifacts (such as requirements specifications, architectural models, and test plans). Thus, knowledge integration facilitates efficient development of a software solution that is more likely to reflect its intended objectives. Therefore, higher levels of knowledge integration should enhance ISD performance.

\[ H_1: \text{Higher levels of knowledge integration in the ISD process will be associated with higher ISD performance.} \]

B. Role of Organizational Integrative Practices in Facilitating Knowledge Integration

The importance of organizational practices for effective development outcomes is well recognized in prior research [29], [41], [71]. However, this work has not theorized why and how such practices influence ISD performance. We propose that their role in facilitating knowledge integration is the theoretical mechanism that explains the relationship.

The central role of organizational practices for knowledge integration is based on the premise that much useful knowledge is tacitly held by individuals and must be integrated to be effectively applied in organizational processes, such as systems development [68], [92], [96]. Formal and informal integrative practices can facilitate this integration of specialized knowledge that is dispersed across organizational subunits. We focus on both formal and informal organizational practices, as prior research [3], [37], [86] suggests that these practices establish the context for programmatic interactions among individuals across subunit boundaries, which, in turn, influences knowledge integration.

1) Formal Integrative Practices: Formal integrative practices are defined as institutionalized organizational practices that facilitate knowledge integration within and across IS and line departments in the organization. While formal integrative practices are identified as important predictors of ISD outcomes [27], [62], the mechanisms through which they influence ISD outcomes are theoretically underdeveloped. We suggest that formal integrative practices facilitate the integration of knowledge within the IS and between IS and line departments by institutionalizing both mechanisms and routines for interactions. Such practices provide structure to interactions so that individually held knowledge can be surfaced, effectively combined, and integrated to establish shared reference frames [68].

We focus on three formal integrative mechanisms that are identified in the literature as fostering collaboration, mutual understanding, and shared frames of reference, which, in turn, should promote knowledge integration. These mechanisms include: a) the use of teams for ISD activities; b) job rotation among ISD roles and tasks; c) sharing of decision-making authority among IS managers and IS employees. The logic underlying each is next briefly discussed.

First, teams are explicitly recognized as a means to facilitate knowledge integration in organizations [36]. A fundamental activity of teams is to pool the specialized knowledge held by individuals into collective, project-level knowledge [68]. Working in teams provides a platform for individual group member’s knowledge to “spiral up” to a group level [65] of shared understanding. To the extent that the ISD process uses teams, the developed artifacts should bridge knowledge boundaries of stakeholders represented in these teams.

Second, job rotation immerses employees in the routines of co-workers, providing them access to and understanding of the stock of others’ tacit knowledge [16], [30]. It is regarded as a formal mechanism of knowledge transfer that can be effective for the sharing of highly context-specific knowledge [4]. This practice is used to transfer tacit knowledge through observation and demonstration, without having to convert tacit knowledge to explicit knowledge. The complementary perspectives that emerge from job rotation increase the ability of ISD personnel to develop and interpret boundary objects that integrate knowledge across knowledge boundaries.

Finally, participative decision-making provides the organizational context to understand and clarify specialized knowledge of different stakeholders. It enables not only the sharing of information, but also its interpretation from a variety of specialized knowledge domains. This process leads to shared understanding and should enable the development of boundary objects that integrate knowledge across knowledge boundaries.

These three formal integrative practices should collectively increase shared understanding of the objectives, context, and relevance of specialized knowledge among ISD stakeholders. Such understanding should result in the development of boundary objects that integrate knowledge across syntactic, semantic, and pragmatic knowledge boundaries. As not all specialized knowledge can be codified, these integrative organizational practices should enrich the pool of tacit and explicit knowledge that is not captured in boundary objects. Accordingly, in addition to their influence on knowledge integration, formal integrative practices are expected to have a direct effect on ISD performance. This is represented by the direct path labeled Other Organizational Conditions, which captures mechanisms besides knowledge integration such as conflict reduction, pooling of tacit knowledge, and increased awareness of stakeholder needs. This leads to our second set of hypotheses, which propose a partially mediated relationship between formal organizational practices and ISD performance.
H2: Use of formal integrative organizational practices is positively associated with knowledge integration in the ISD process.

H2a: Knowledge integration in the ISD process partially mediates the influence of formal integrative practices on ISD performance.

2) Informal Integrative Practices: Informal integrative practices are defined as the extent of informal interaction among stakeholders associated with the ISD process. In contrast to formal integrative practices that facilitate knowledge integration through institutionalized practices and routines; informal practices enable the spontaneous, unstructured exchange of knowledge [26], [88]. They complement formal practices by building trust and community [12], and, their value lies primarily in promoting knowledge flows that cannot be readily facilitated by formal practices. Knowledge that is either tacit or too contextually embedded to be readily conveyed to or from the IS unit would be more easily integrated through informal practices. For instance, organizational grapevines, casual conversations, and unstructured exchange of ideas and perspectives that occur through informal interactions should help to integrate diverse viewpoints and tacit knowledge from the individual to group level [26], [48], [66].

Informal communication is a dominant type of informal integration practice in organizations. At a fundamental level, informal communication enable learning in employees without converting tacit knowledge to explicit, but by generating tacit knowledge through rich discussions and open-ended conversations [4]. We focus primarily on informal communication practices among developers in the IS unit and between developers and users in line departments. Such informal communication among developers and users in the development process should promote a shared understanding of the contextual knowledge associated with the agendas, objectives, and goals of stakeholders. As in the case of formal practices, informal practices impact the development of boundary objects that integrate knowledge across knowledge boundaries and the integration of relevant tacit and explicit knowledge that is not codified in these objects. Accordingly, in addition to their influence on knowledge integration, informal integrative practices are expected to have a direct effect on ISD performance. Thus, the relationship between informal communication and ISD performance is conceptualized as partially mediated by knowledge integration.

H3: The extent of informal communication among individuals within and across IS and line subunit boundaries will be positively associated with knowledge integration in the ISD process.

H3a: Knowledge integration in the ISD process partially mediates the influence of informal communication on ISD performance.

In summary, the central thesis of the proposed model is that formal and informal organizational integrative practices facilitate the development of boundary objects that integrate knowledge across ISD specialized knowledge boundaries. This integrated knowledge enhances ISD performance and partially mediates the influence of formal and informal integrative practices on ISD performance. This knowledge-integration perspective on ISD complements prior research on ISD process improvement, which has primarily focused on technical and methodological solutions.

C. Controls Variables: Rival Explanations for ISD Performance

To delineate the effects of knowledge integration on ISD performance in the proposed model, we consider two alternative mechanisms that may influence ISD performance. First, organizations with larger IS units typically incur greater coordination costs and are likely to have decreased efficiency in their internal operations. Moreover, larger IS units are likely to be bureaucratic and politically complex, which makes negotiation among stakeholders complex. Therefore, larger IS units are likely to exhibit poorer ISD performance. In addition, the size of the IS department has been used as a control variable in several studies focusing on assimilating software process innovations and IT adoption [32]. We use the number of employees in the IS unit as a measure of ISD size and introduce it as a control variable. Second, organizations with extensive experience in using coordination tools, such as CASE tools, and tools for requirements management, defect tracking, and architecture design, are more likely to exhibit higher ISD performance [74]. Therefore, prior experience of the IS unit with software development tools is likely to be associated with superior ISD performance. We use the age of the development tool portfolio as a proxy for the depth of experience and to control for the potentially confounding effect of the use of such tools across IS units.

The constructs and hypothesized relationships are summarized in Fig. 2.

IV. METHODOLOGY

A. Sample and Data Collection

A field survey of IS departments in manufacturing and service firms was conducted to test the research model. A survey-based approach was appropriate for this investigation because our goal was to test the theoretical model, which was developed based on insights in earlier ISD observational research [72]. The sample was a set of 708 firms randomly selected from the Directory of Computer Executives (Applied Computer Research, Inc., 2001). The key informants were systems development managers as they are most likely to be most informed on knowledge integration in the ISD process and the formal and informal practices used for development. The instrument was pretested with IS managers who closely resembled the profile of potential respondents and also with academic domain experts. After three mailings, responses from a total of 119 firms were received and nine of these were discarded because of missing data. This yielded a response rate of 15.5%, which is comparable to other studies of middle-level managers.

We tested for nonresponse bias by comparing for differences between the first wave of respondents (first quartile) that were received and the last wave of respondents (last quartile) on key demographic and study variables. This comparison is based on the premise that the last wave of respondents are more likely to be similar to nonrespondents and a comparison of the first and last wave of respondents provides a test of response bias in the sample [6]. The comparative assessment revealed no significant
differences across the two groups. Additional follow-ups suggested that nonresponse bias is not a pervasive threat.1

The average revenue of firms in the sample was $1.4 billion (SD = 2.4) with an average IS budget of $9.34 million dollars (SD = 13.74). The average number of full-time employees in the IS department was approximately 60 and, on average, about 50% of them were directly associated with the systems development process. The means and standard deviations for the key constructs in the study are summarized in Table A2 (see the Appendix).

B. Scale Development and Measures

All constructs were operationalized at the IS department level, consistent with the unit of analysis of the proposed model. The measurement items are summarized in Table A1 (see the Appendix). Measures for constructs were developed using a three-stage process. First, we generated a pool of items to tap into the theoretical domain of the construct based on its definition and prior literature. Measures of each of the constructs and subconstructs were grounded in the existing literature as indicated: participative decision making [7], [100], job rotation [16], use of team structures [25], [68], [79], informal communication [25], [63], [100], boundary objects for knowledge integration [13], [14], [59], and ISD performance [10], [33], [79], [97]. The process performance and outcome performance dimensions of ISD performance mirror prior distinctions made in the ISD literature [79], [97]. The two control variables were measured using single-item measures. IS department size was measured by the number of full time equivalent employees in the IS department and prior experience with tools was measured by the number of years the current development tool portfolio was in use. Second, we conducted interviews with six senior IS managers responsible for managing systems development in their respective organizations to refine the preliminary item pool. Finally, the instrument was pilot tested with four senior IS executives in different organizations and six IS academic experts on ISD. Comments on item wording and clarity were incorporated based on their feedback. In this refinement process, we paid close attention to ensure that the items were interpreted unambiguously and had high content validity. Seven-point Likert scales were used to collect responses for each of the measurement items.

V. ANALYSIS AND RESULTS

We used partial least squares (PLS) to evaluate the relationships specified in our research model. The PLS analysis, including significance tests for path coefficients, were performed using PLS-GRAPH version 3.0. Our choice of PLS was guided by two considerations: 1) its ability to model latent constructs as either formative or reflective; 2) its ability to assess the psychometric properties of the constructs (the measurement model) within its theoretical context (the structural model). The analyses were conducted in two stages. The measurement model was first tested to ensure that the constructs had sufficient psychometric validity, followed by an assessment of the structural model in which the hypotheses were tested.

A. Measurement Model Assessment

We assessed the measurement properties of each of the multi-item scales associated with the constructs. These analyses and their results are described in detail in the Appendix. The scale reliability coefficient of 0.7 or higher for all constructs. Evidence of discriminant and convergent validity is obtained from an examination of the diagonal elements of the correlation
matrix (which represent the square root of average variance extracted) in Table A2. All diagonal elements exceed the off-diagonal elements, which indicate acceptable discriminant validity [17]. Additionally, an examination of the item-to-construct correlations shown in Table A3 shows that items demonstrated higher correlations with their corresponding constructs rather than with other constructs. Collectively, the evidence suggests that the constructs demonstrate convergent and discriminant validity.

In developing the structural model, we had to make a decision on whether each of the constructs in our model was reflective or formative. We draw on Jarvis et al.’s [47] review of measurement modeling in marketing and consumer research that suggests that researchers often mis-specify formative constructs as reflective and develop guidelines to avoid such errors. They note that the decision to model a construct as formative or reflective should be based on: 1) direction of causality from construct to indicators; 2) interchangeability of indicators; 3) co-variation among indicators; 4) nomological net of construct indicators [47]. Constructs are modeled as formative if the direction of causality is from indicators to constructs, indicators need not be interchangeable, indicators need not co-vary, and the nomological net of indicators can differ. They are modeled as reflective if the opposite conditions are applicable. Based on these guidelines, each of the two second-order constructs of formal integrative practices and ISD performance are modeled as formative. In the case of ISD performance, outcome performances need not necessarily be accompanied by higher levels of process performance in terms of adherence to budget and schedules. Similarly, for formal integrative practices, the deployment of one organizational practice (such as the use of teams) does not preclude other practices (e.g., job rotation), but there is no theoretical rationale for them to necessarily occur together. Knowledge integration and informal integrative practices constructs are also modeled formatively. For knowledge integration, the five items used for the measure span syntactic, semantic, and pragmatic boundary objects do not necessarily have to covary, even though they could be mutually reinforcing. Similarly, in the case of integrative practices, different channels of communication may be used independently of each other, though they also can reinforce each other. Although the indicators for these constructs met tests of internal consistency and convergent validity in this empirical context, these are not requirements for formative constructs [47]. To derive a measure for each of the formative constructs, a unit mean value of their indicators was computed for reasons elaborated in the Appendix.

For formative indicators, which have a regression-like relationship with the latent constructs, only the weights (and not the loadings) need to be considered in assessing the measurement model [17]. While no minimum threshold values for indicator weights have been established, the statistical significance of the weights can be used to determine the importance of indicators in forming a latent variable. Participative decision-making and use of teams had significant weights of .44 (t = 3.29, p < .001) and .56 (t = 3.50, p < .001) respectively, while the contribution of job rotation to formal integrative practices was not significant. The indicators associated with systems development performance were significant, with weights of .38 (t = 3.28, p < .001) for process performance and .69 (t = 6.77, p < .001) for outcome performance.

B. Hypothesis Tests: The Structural Model

PLS was used to estimate the structural paths and to test the hypotheses. A bootstrapping technique was used to generate 500 subsamples: the path coefficients were re-estimated using each of these sub samples and this vector of parameter estimates was used to compute parameter means, standard errors, path coefficient significance, indicator loadings, and indicator weights. This approach is consistent with recommended practices for estimating significance of path coefficients and indicator loadings [55] and has been used in prior IS studies [19], [21], [46], [79]. The predictive power of the research model is assessed by examining the explained variance (R^2) for the endogenous constructs [8], [18]. In order to assess the extent of mediation in the model, we conducted a three-stage analysis. In the first stage, only control variables were introduced as predictors of systems development performance. The two controls together explained only 9% of the variance in systems development performance. In the second stage, a fully mediated model (i.e., no direct paths from formal integrative practices and informal integrative practices to ISD performance) was evaluated. In other words, knowledge integration is considered to fully mediate the relationship between organizational integrative practices and performance. This model explained about 30% of the variance in ISD performance. In the last stage, direct paths from the two constructs, formal and informal integrative practices, were introduced to examine their direct and mediated effects. The variance explained increased to 58.5%, which is significantly (pseudo F statistic = 72.11, significant at p = .05) higher than the fully mediated model, suggesting that knowledge integration partially mediates the relationship between organizational integrative practices and systems development performance. Table III and Fig. 3 show the results for individual paths.

VI. DISCUSSION

The results support the main premises of the proposed research model: 1) organizational integrative practices have a positive influence on knowledge integration in the ISD process; 2) knowledge integration is positively associated with ISD performance; 3) knowledge integration partially mediates the influence of organizational integrative practices on ISD performance. The results of the structural model are summarized in Table III and discussed next.

A. Influence of Knowledge Integration on ISD Performance

The path coefficient between knowledge integration and ISD performance was positive and significant (β = 0.21, t = 2.25, p < 0.01). This result provides support for Hypothesis 1, which proposed that knowledge integration in the ISD process will play a positive role in performance of the ISD process.

We defined knowledge integration as the application of specialized knowledge across and within the line and IS department of a firm. This study provides one of the first direct tests for the idea that knowledge integration in ISD activities and processes is necessary for deriving benefits from related organizational knowledge. The result further demonstrates that boundary objects that codify and help integrate knowledge across knowledge boundaries can play an important role in ISD performance. This knowledge-based view of organizing ISD complements prior
work on ISD process improvement, which has focused largely on technical factors, coordination tools, methodologies, control of behaviors, and capability maturity.

B. Effect of Formal and Informal Integrative Practices on Knowledge Integration

The effect of formal organizational integrative practices on knowledge integration in the ISD process was positive and statistically significant ($\beta = 0.36; t = 3.97; p < 0.001$). The result supports Hypothesis 2. Participative decision-making and use of teams had significant weights on the construct of formal practices, while job rotation did not. This suggests that participative decision-making and use of teams as formal integrative practices enhance the integration of knowledge in boundary objects. While job rotation may have other positive consequences, it does not appear to influence knowledge integration in ISD. The effect of informal organizational integrative practices on knowledge integration was positive and significant ($\beta = 0.23; t = 1.97; p < 0.05$), supporting Hypothesis 3. Collectively, these practices promote knowledge integration across specialized domains and are positively associated with the development of boundary objects for knowledge integration [14]. The results support the arguments made by other scholars [64], [74], that formal practices establish practiced patterns of interaction that leverage knowledge in collective activities and facilitate integration of knowledge across individual, group, and other organizational levels. A comparison of the standardized path coefficients of formal and informal integrative practices provide an empirical basis to suggest that formal integrative practices are more influential in facilitating knowledge integration in the ISD process.

C. Mediating Role of Knowledge Integration

The results support the idea that formal and informal integrative practices influence ISD performance, in part because they facilitate knowledge integration. As Fig. 3 shows, the relationship between formal and informal integrative practices and ISD performance is partially mediated by knowledge integration. If the direct effects of integrative practices on ISD performance are removed from the model, the $R^2$ drops from 58% to 30%.
This drop in the explanatory power of the model is statistically significant, which suggests that formal and informal integrative practices, in addition to being positively associated with knowledge integration, have a direct and positive association with ISD performance. These findings indicate that formal and informal integrative practices yield performance benefits through two pathways: 1) Through integration of specialized knowledge dispersed across the IS unit and line departments; 2) and through modalities other than knowledge integration with the use of boundary objects. For example, informal integrative practices might facilitate negotiation, enhance agreement among ISD stakeholders on project functionality, and conceivably lower conflict among them, factors that are suggested as important for successful ISD [81]. This result also suggests that not all knowledge resident in individual employees is necessarily manifested in characteristics of boundary objects: organizational integrative practices can facilitate application of knowledge that is not codified in boundary objects but important for ISD performance. Overall, mediation by knowledge integration lends empirical support of the theoretical perspective that the performance of the ISD process relies on the capacity of the IS unit to apply organizational knowledge to the ISD process. The significant direct effects further emphasize that other organizational mechanisms besides knowledge integration explain approximately half of the 58% of the variance explained by our model.

D. Limitations

There are limitations to the present study that reduce its generalizability. First, knowledge management constructs are notoriously difficult to operationalize, largely because of the complexity and nonobservability of knowledge processes [4]. We, therefore, used a three-pronged approach for measuring such constructs, wherein we triangulated the theoretical dimensions that formatively tap into the underlying construct, built on prior qualitative work on knowledge management in ISD, and conducted extensive preliminary interviews with a panel of practitioners and academic experts. For this reason, our investigation was limited to three formal practices and one dominant informal integrative practice. More research on additional indicators of knowledge integration that can be used to complement the existing specification is needed. Second, the phenomenon of knowledge integration can only partially be captured in a cross-sectional study. Notwithstanding the preliminary insights offered by our results, this remains a weakness of the study and the findings must be validated in future longitudinal studies. In addition, the study has been limited to systems development in manufacturing and service industries. This was done to focus on systems development activities in traditional settings, but imposes limitations on how widely the results can be generalized to other industries. Finally, measures of performance are based on the perceptions of a single respondent. We assessed the resulting threat of common methods bias using Harmon’s one-factor test [73]. Following the procedure recommended by Podsakoff and Podsakoff [73], we entered all our independent variables, mediating variables, and dependent variable in an exploratory factor analysis. The dataset would have a common methods bias problem if a single factor emerged that accounted for a large percentage of the variance in the resulting factors. However, in our analyses, a single factor did not emerge and the first factor accounted for 36.9% of the total variance. The seven extracted factors accounted for 67.4% of the total variance. This collectively suggests that our results are not due to common methods variance. Nevertheless, objective performance measures should be used in future work to complement subjective performance measures.

VII. Contributions and Implications

A. Research Contributions

The paper makes three noteworthy contributions to the literature. The overarching contribution of the study lies in theoretically developing the idea of knowledge integration in the ISD process and linking it to both antecedent organizational integrative practices as well as ISD performance. The perspective that ISD can be viewed as a process of embodying specialized knowledge in the process that is distributed across organizational subunit boundaries is a novel complement to prior research on ISD process improvement. The second contribution is that it demonstrates that higher levels of knowledge integration are associated with improved ISD performance. Our conceptualization of knowledge integration as bridging pragmatic, semantic, and syntactic boundaries across specialized ISD knowledge domains is a noteworthy refinement of prior conceptualizations. The perspective that integration of knowledge in ISD processes is one key mechanism through which ISD process improvements can be realized extends research on improving ISD processes in organizations. The results suggest that IS units can exploit specialized knowledge by integrating it in work processes and highlight the centrality of boundary objects their role in ISD processes. The findings suggest that knowledge integration in ISD processes can facilitate the interpretation and use of specialized knowledge by employees who might otherwise lack sufficient expertise to leverage this knowledge. The third contribution is that both formal and informal integrative practices influence the extent to which boundary objects integrate knowledge across knowledge boundaries in the ISD process.

B. Implications for Research

This paper has several important implications for research and practice. First, the key thesis of our theoretical development—that organizational integrative practices improve ISD performance by facilitating integration of specialized organizational knowledge in the systems development process—offers a novel complement to the existing literature by integrating prior engineering-focused work on systems development (e.g., CASE technology, methodologies like information engineering and object-orientation and process improvement techniques.

2The role of organizational practices in facilitating codification and integration of knowledge in the IS development process has not been studied in prior research. The two types of integrative mechanisms play distinct roles and formal practices appear to have a stronger effect on knowledge integration. A noteworthy theoretical implication of this finding is that both formal and informal integrative practices are necessary for effective knowledge integration and excessive emphasis on one over the other can lead to missed opportunities for ISD performance improvements.
like TQM and CMM) and prior work that emphasizes the application of dispersed knowledge to organizational activities [5], [37], [57], [91], including ISD [74], [82], [85], [98]. The theoretical arguments and the observed empirical centralization of knowledge integration suggests that codification and integration of stakeholder knowledge in the ISD process is a key mechanism through which developers and project managers can leverage organizational practices and routines to enhance the ISD process. Our model, therefore, provides the underpinnings of a knowledge-based theory of information systems development. The central premise of this emergent theory is that the performance of the systems development process is influenced by how effectively knowledge is integrated across syntactic, semantic, and pragmatic boundaries in an ISD process. This integration is enabled by the integrative mechanisms, formal and informal, that form the organizational context in which the development process unfolds.

Second, while researchers acknowledge the importance of deploying structures to exploit knowledge assets, the nature of these structures is theoretically underdeveloped [50]. We find that formal integrative practices, specifically participative decision-making, job rotation, and use of team structures, help integrate specialized, distributed knowledge in the development process. Thus, the insight that knowledge integration is a central mechanism through which formal integrative practices enhance ISD performance is novel and noteworthy.

Third, the importance of social interaction for knowledge transfer is extensively discussed in the knowledge management literature [4], [12], [26], [37], [53], [66], [68], [69], [91]. However, this is one of the first studies to demonstrate how informal integrative practices enhance performance. Our results show that informal integrative practices used in the IS organization improve performance by facilitating knowledge integration during ISD processes. The direct effects of such practices on ISD performance suggests that there are other mechanisms in addition to knowledge integration through which this influence occurs.

Fourth, our findings provide insights into the relative importance of formal and informal integrative practices for knowledge integration. There is considerable tension among two schools of thought on knowledge management: One emphasizes the role of knowledge management technologies, tools, and formal top-down approaches [77], [78], [85], the other argues that knowledge management is primarily a grassroots social process in which formal approaches and practices are simply irrelevant [58], [66]. Our results show that—at least in the ISD context—formal practices may potentially play an important role in predicting knowledge integration vis-à-vis informal practices (as suggested by their path coefficients in the results). More importantly, our results suggest that the viewpoints of both schools of thought are complementary.3

Finally, interfirm differences in knowledge integration within the firm and integrative practices that facilitate it might explain why similar firms can exhibit markedly different ISD process capabilities. The results reinforce the basic premise of the knowledge-based framework of organizing internal activities (as well resource based theory on which this perspective is built): the extent to which knowledge resources in the firm are applied to organizational activities—rather than their mere possession—differentiates ISD performance. The model suggests that an organization’s systems development performance is a function of its ability to represent and codify knowledge in the ISD process. Such integration is one mechanism through which IS units can deploy their knowledge assets in ISD activities. Therefore, firms with similar resources, skills, and knowledge might fare differently in similar ISD activities because of differences in knowledge integration for ISD activities.

C. Implications for Practice

The results suggest that ISD managers should complement formal initiatives for software process improvements, such as the introduction of tools, methodologies and formal process frameworks, with day-to-day organizational practices to integrate specialized knowledge in the process of systems development. Technology managers can enhance integration of knowledge in the development process by establishing formal integrative practices and encouraging informal integrative practices. For formal integrative practices, they can use teams and participative decision-making and encourage informal interaction among IS employees and between personnel in IS and line units. These integrative practices and knowledge integration could differentiate ISD performance relative to IS units in similar firms. Finally, the study shows that high performance from development teams cannot be realized by simply introducing formal and informal practices for integration: such practices must enhance knowledge integration for superior development performance.

VIII. Conclusion

Even as the dependence of organizations on their information systems is growing, their ability to develop effective information systems efficiently continues to be chronically disappointing. In the last decade, a large body of research focused on software development tools, capability maturity models, and methodologies for improving ISD performance has emerged. This paper offers a complementary perspective that builds on the emerging knowledge-based theory of organizing activities and focuses on knowledge and its application to the ISD process. The key idea developed in this paper was that formal and informal integrative practices improve ISD performance, to a large extent because they facilitate integration of specialized knowledge for use by the systems development process. Results based on data collected from IS units in 110 organizations provide strong support for the proposed ideas.

The study contributes three novel insights to the engineering management and information systems literature. First, it
demonstrates that knowledge integration in the systems development process enhances development performance. Second, it shows that formal and informal integrative practices used in organizations lead to development performance improvements, because they facilitate such knowledge integration. This contribution is of substantial theoretical significance because it explains how and why organizational integrative practices lead to ISD performance improvements. Third, the study shows that formal and informal integrative practices serve distinct roles and that one cannot readily be substituted for the other. While this research used ISD projects as its empirical context, many of the insights around knowledge integration offered here should generalize to other knowledge-intensive development projects for engineering systems, R&D, and other technological systems that must bring together a diverse array of specialized knowledge. This study provides a starting point and suggests that knowledge-based perspectives for organizing technology development holds much promise for future research.

APPENDIX

MEASUREMENT PROPERTIES OF MULTITEM SCALES

Our analysis indicated that all first-order constructs variables were unidimensional. We then specified a model of all constructs with their respective indicators. The model was analyzed using PLS-Graph using the bootstrap technique for estimating parameters over 500 subsamples. Table A1 shows the item loadings on constructs. As the constructs are unidimensional, Items IC1, PP4, and OP3 are below the 0.707 loading threshold and were dropped.

The mathematical formula for computing Composite Reliability [34], a measure of internal consistency is

\[
\text{Composite Reliability} = \frac{(\sum \lambda_i^2)^2}{\sum \lambda_i^4 + \sum \text{Var}(e_i)}
\]

where \( \text{Var}(e_i) = 1 - \lambda_i^2 \) and \( \lambda \) is the item loading. The interpretation of the measure is similar to that of Cronbach’s alpha. Most constructs had both internal consistency measures well above the 0.70 recommended threshold level [67].

Discriminant validity was assessed by comparing the variance shared with items in the construct with the variance shared between constructs. Fornell and Larcker [35] suggest that average variance extracted can be used to assess the variance shared between the construct and its measures. The formula used to compute average variance extracted is

\[
\text{Average Variance Extracted} = \frac{\sum \lambda_i^2}{\sum \lambda_i^4 + \sum \text{Var}(e_i)}
\]

where \( \text{Var}(e_i) = 1 - \lambda_i^2 \) and \( \lambda \) is the item loading. Table A2 provides descriptive statistics, construct correlations, and the square root of average variance extracted. Since diagonal values are greater than off-diagonal elements, the results suggest that the constructs demonstrate adequate discriminant validity. Additionally, Table A3 shows the item-to-construct correlations: items belonging to a construct share greater variance with the construct than with other constructs.

Finally, linear composites of items belonging to constructs were computed and used in the structural model. Linear composites may be computed either using factor scores or unit means. Unit mean values offer the advantage of replication across studies. It is the recommended approach for new measures and when transferability is desired [42]. Furthermore,
Rozeboom [84] notes that linear composite scores based on different weighting schemes are highly correlated when items exhibit internal consistency. As this is the case for each of the formative measures in this study, we used linear composite scores computed as unit mean values. Given the high correlation among some of the formative indicators for these constructs, this approach effectively avoids multicollinearity problems.

**TABLE A2**

<table>
<thead>
<tr>
<th>Construct</th>
<th>Mean</th>
<th>SD</th>
<th>CR*</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. Participative Decision Making</td>
<td>4.80</td>
<td>1.27</td>
<td>.83</td>
<td>.79**</td>
<td>.55</td>
<td>.66</td>
<td>.67</td>
<td>.64</td>
<td>.54</td>
</tr>
<tr>
<td>2. Job Rotation</td>
<td>4.58</td>
<td>1.44</td>
<td>.82</td>
<td>.60</td>
<td>.54</td>
<td>.52</td>
<td>.59</td>
<td>.42</td>
<td>.86</td>
</tr>
<tr>
<td>3. Use of Teams</td>
<td>4.14</td>
<td>1.35</td>
<td>.86</td>
<td>.67</td>
<td>.66</td>
<td>.62</td>
<td>.64</td>
<td>.52</td>
<td>.57</td>
</tr>
<tr>
<td>4. Informal Communication</td>
<td>5.11</td>
<td>1.14</td>
<td>.89</td>
<td>.47</td>
<td>.49</td>
<td>.46</td>
<td>.82</td>
<td>.54</td>
<td>.38</td>
</tr>
<tr>
<td>5. Knowledge Integration</td>
<td>4.69</td>
<td>1.35</td>
<td>.91</td>
<td>.47</td>
<td>.49</td>
<td>.46</td>
<td>.82</td>
<td>.54</td>
<td>.38</td>
</tr>
<tr>
<td>6. Process Performance</td>
<td>4.35</td>
<td>1.39</td>
<td>.90</td>
<td>.48</td>
<td>.43</td>
<td>.55</td>
<td>.87</td>
<td>.53</td>
<td>.64</td>
</tr>
<tr>
<td>7. Outcome Performance</td>
<td>5.17</td>
<td>1.18</td>
<td>.92</td>
<td>.48</td>
<td>.43</td>
<td>.55</td>
<td>.87</td>
<td>.53</td>
<td>.64</td>
</tr>
</tbody>
</table>

*Composite Reliability

**Values in the bold diagonal are the square root of the Average Variance Extracted from the measurement indicators; the other numbers represent construct correlations.

**TABLE A3**

<table>
<thead>
<tr>
<th>Item</th>
<th>PDM1</th>
<th>PDM2</th>
<th>PDM3</th>
<th>JRR1</th>
<th>JRR2</th>
<th>UT1</th>
<th>UT2</th>
<th>UT3</th>
<th>IC2</th>
<th>IC3</th>
<th>IC4</th>
<th>IC5</th>
<th>IC6</th>
<th>K1</th>
<th>K2</th>
<th>K3</th>
<th>K4</th>
<th>K5</th>
<th>KP1</th>
<th>PP2</th>
<th>PP3</th>
<th>OP1</th>
<th>OP2</th>
<th>OP4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.781</td>
<td>.485</td>
<td>.496</td>
<td>.503</td>
<td>.448</td>
<td>.352</td>
<td>.342</td>
<td>.532</td>
<td>.399</td>
<td>.342</td>
<td>.325</td>
<td>.384</td>
<td>.308</td>
<td>.482</td>
<td>.232</td>
<td>.374</td>
<td>.409</td>
<td>.324</td>
<td>.324</td>
<td>.374</td>
<td>.399</td>
<td>.519</td>
<td>.408</td>
<td></td>
</tr>
</tbody>
</table>

REFERENCES


Ravi Patnayakuni is an Associate Professor of Management Information Systems in the Department of Economics and Information Systems, College of Administrative Sciences, University of Alabama in Huntsville. He has previously held positions at Temple University, Southern Illinois University at Carbondale and The University of Melbourne, Australia. His research focuses on digital supply chains, knowledge management, systems development and the organizational impact of IT. He has published in the Journal of Management Information Systems, MIS Quarterly, Communications of the ACM, the Journal of the AIS, Information Systems Journal, Omega and Communications of the AIS and has presented his work at the International Conference on Information Systems, Americas Conference on Information Systems, and the European Conference on Information Systems.

Arun Rai is Regents’ Professor and Harkins Chair in the Center for Process Innovation and Department of Computer Information Systems at Georgia State University’s Robinson College of Business. His research focuses on business networks and process innovations that are digitally enabled, and the adoption, diffusion, and impacts of information technology. He has published over 55 articles in leading scholarly journals, such as Decision Sciences, European Journal of Operations Research, IEEE Transactions on Engineering Management, Information Systems Research, Journal of Management Information Systems, and MIS Quarterly. He has served, or serves, on the editorial boards for Decision Sciences, IEEE Transactions on Engineering Management, Information Systems Research, Journal of Strategic Information Systems and others. His research has been sponsored by leading corporations and agencies, including A.T. Kearney, Bozell Worldwide, Daimler-Chrysler, Gartner, IBM, Intel, UPS, SAP and the Advanced Practices Council of the Society for Management Information.

Amrit Tiwana is an assistant professor in Iowa State University’s College of Business in Ames, Iowa. His Ph.D. is from Georgia State University’s Robinson College of Business. His work has appeared in journals including the Strategic Management Journal, California Management Review, the Journal of Management Information Systems, Decision Sciences, the IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT, IEEE Software, IEEE Internet Computing, Communications of the ACM, Decision Support Systems, Information Systems Journal, the Journal of Knowledge Management, the Journal of the American Society for Information Science and Technology, and others. His research has been sponsored by the United Parcel Service, IBM Japan, Hitachi, Fujitsu, Toshiba, and Mitsubishi Electric, and other organizations.