# ONLINE SUPPLEMENT

This online supplement contains the following:

1. Questionnaire items
2. Novelty distributions for the projects in the sample
3. Discussion of the measurement of knowledge integration

## QUESTIONNAIRE ITEMS

The project manager in the vendor organization provided the name of the project and was asked to answer the survey in the specific context of the named project. This project name was provided to the client-side liaison in the client organization, who responded to the client-side questions. The vendor was explicitly defined to include all employees of the vendor organization who worked on this project and the client was defined to include all employees of the client organization with whom the vendor worked with for this project. The responding organization for each scale is underlined.

**Client's Technical Knowledge**[a] (6 items; 7-point Likert scale; $\alpha = 0.91$; respondent: client)
The client organization's knowledge in the following areas of the named project: (a) detailed technical design, (b) technical design constraints, (c) the development methodology, (d) code testing & debugging procedures, (e) development tools & coding environment, (f) the programming language used to write the code.

**Vendor's Business Application Domain Knowledge**[a] (6 items; 7-point Likert scale; $\alpha = 0.81$; respondent: vendor)
The vendor organization's knowledge in the following areas specific to the named project: (a) the client's business processes, (b) the client's business objectives, (c) the client's day-to-day business routines, (d) the business rules implemented in this system, (e) client's overarching business objectives that guide high-level design, (f) interoperability with client's other systems.

**Knowledge Integration**[b] (5 items; 7-point Likert scale; $\alpha = 0.74$; respondent: vendor)
For the specified project, the extent to which the following statements described the vendor's **working relationship with the customer organization**: (a) We [client and vendor] applied our expertise in innovative ways, (b) we carefully made decisions to maximize overall project outcomes, (c) we leveraged the customer's knowledge in many functional areas, (d) many creative ideas came from combining our unique perspectives, (e) we developed a clear understanding of how each business function should be coordinated.

**Conceptual Newness** (4 item Guttmann scale; respondent: vendor)
Vendor assessments of the statement that best describes the project's conceptual newness to the vendor firm: (a) minor modification of a system design already developed by your company, (b) major modification of a system design already developed by your company, (c) completely new design, but based on a concept already demonstrated in another project, (d) technically new to your company and a completely new design.

**Process Newness** (4 item Guttmann scale; respondent: vendor)
Vendor assessments of the statement that best describes the project's process newness to the vendor firm: (a) Existing methodology and development tools used with minor modifications, (b) existing methodology and development tools used with major modifications, (c) either new methodology or development tools, but based on existing ones, (d) entirely new methodology and new development tools.

**Project Performance** was assessed in terms of effectiveness and efficiency. *Effectiveness* (5 items; 7-point Likert scale; $\alpha = 0.91$; respondent: client) was measured using client assessments of (a) system reliability, (b) implementation of functionality, (c) meeting project objectives, (d) meeting functional requirements, and (e) overall fit with client needs. *Efficiency* was measured in terms of the percentage by which each project exceeded its allocated budget. Higher overrun indicates lower efficiency.

## Control variables

**Client-Vendor Interaction** (3 items; 7-point semantic differential scale from Hansen (1999); $\alpha = 0.76$; respondent: vendor)
Vendor's assessments of the following questions: (a) How close was the collaboration between your company and this customer?[c], (b) How close was the working relationship between your company and this customer?[c], (c) How frequently did your company interact with this customer on average, over the life of this project?[d]

**Development Coordination Tools**[e] (6 items identified by Cantor (2002); 7-point Guttmann scale; respondent: vendor)
The extent to which the following tools were used by the vendor during the development process: (a) requirements managers, (b) architectural modelers, (c) test automation tools, (d) test case development tools, (e) configuration managers, (f) defect and change request tracking tools.

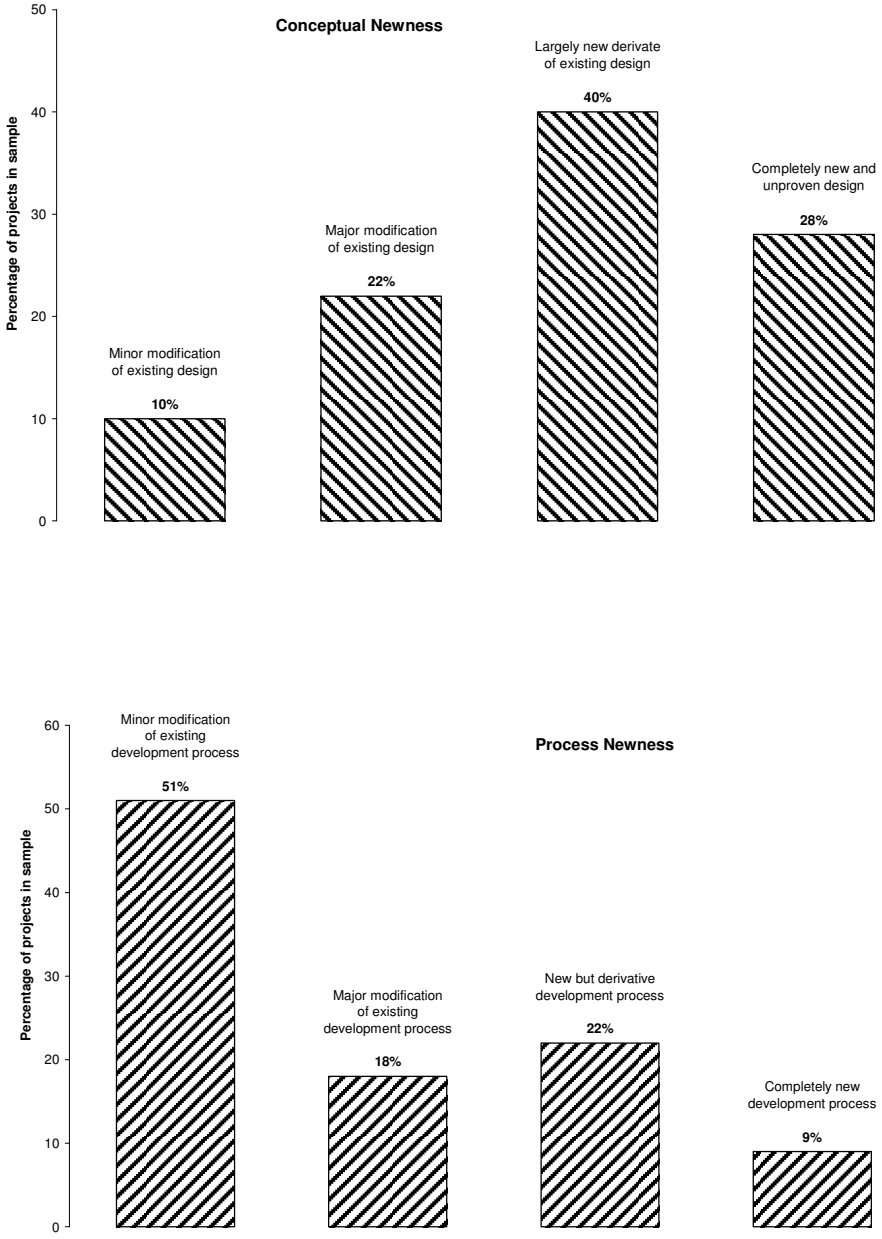
**Architectural Design Effort** (respondent: vendor)
The percentage of the total project hours that were spent on architecture design out of the total project hours spent by the vendor on the following project activities: project management, architecture design, development, and testing.

**Maturity of vendor's software development capabilities** was measured as the vendor's capability maturity (CMM) level.

**Prior collaboration history** was measured as a dummy variable set to 0 if the project was the first project that the vendor had done for the client.

*Scale anchors*

[a]1=very low; 7=very high
[b]1=strongly disagree; 7=strongly agree
[c]bipolar anchors: 1=distant, like an arms-length delivery of the input;
7=very close, practically like being in the same work group
[d]1=every day; 2= twice a week/; 3=once a week/; 4=twice a month; 5=once a month;
6=once every 2nd month; 7=once every 3 months
[e]1=not at all; 4=somewhat; 7=to a great extent




**Supplement Figure 1:** Project novelty distribution.

## SUPPLEMENT TABLE: MEASUREMENT OF KNOWLEDGE INTEGRATION

The knowledge integration construct was measured as a reflective, latent variable measured by five items. I : (a) discuss the underlying logic for this approach, (b) describe the scale development process, and (c) finally discuss each item and how it compares to other similar constructs in the literature.

A. Logic underlying the latent, reflective measurement approach

**Latent:** The objective of the latent measurement approach is to "provide a degree of abstraction that permits us to describe relations among a class of events or variables that share something in common, rather than making highly concrete statements restricted to the relation between more specific, seemingly idiosyncratic variables" (Bollen 2002: page 606). Thus the objective of using five indicators was to tap into the underlying class of events i.e., knowledge integration, that they share in common. Thus the latent measurement approach should be viewed as an attempt to measure the degree to which the knowledge integration process occurred.

**Reflective**: A reflective measure is one in which the measurement items for the unobserved construct are *caused by* the unobserved construct (knowledge integration). To be considered reflective, (a) knowledge integration (the latent variable) must have direct effects on one or more observed variables (measurement items) and (b) the observed variables do not directly affect knowledge integration (Bollen 2002: page 610). Therefore, an increase in the level of knowledge integration should cause an increase in each of the measurement items. Clearly, the items can plausibly be caused by antecedents other than knowledge integration. For this reason, multiple items are used to tap into the construct. Increasing the number of measurement items in this manner helps more reliably tap into the underlying *common* construct (Mulaik and McDonald 1978). This logic is reflected in the knowledge integration scale used in this study. The reflective measurement philosophy is implicitly assumed in most empirical research.

> "Nearly all measurement in psychology and the other social sciences assumes effect indicators (Bollen 2002: page 616)."

B. Scale development process followed for development

The starting point for the scale development process was Faraj and Sproull's (2000) measure for a construct that they labeled "bringing expertise to bear." Their scale was developed in the non-outsourced software development context. This pool was adapted to the specific context of this study through a series of field interviews. To ensure that the Faraj scale was meaningful in the outsourcing context and to ensure reliability and consistency with the construct definition, I expanded the pool of items by drawing on other ISD case studies that used similar concepts (Curtis et al. 1988; Hoopes and Postrel 1999; Walz et al. 1993). With the exception of Faraj and Sproull, most prior studies involving constructs similar to knowledge integration are either case studies or experimental studies such as Okhuysen (2002) that use proxies instead of multi-item scales for knowledge integration. (None of the prior literature on knowledge in software development is in the outsourcing context.) The objective was to identify items that would assume higher values when the level of knowledge integration increases, consistent with the reflective measurement logic described earlier. I did this in conjunction with identification of items for the two key types of knowledge in the ISD process, for which I drew on prior conceptual research on types of knowledge in the software engineering literature (Adelson and Soloway 1985; Ramesh 2002; Robillard 1999; Rus and Lindvall 2002). Following this step, I interviewed 19 software project managers (7 in Russia, 6 in the United States, 2 in Ireland, and 4 in India) to see how they recognized higher levels of knowledge integration in software development projects. I used their feedback to refine and reword specific items to ensure that they were meaningful in their context. Following this, I sought feedback from seven academics with expertise in

software development, IS project management, and knowledge management to refine and narrow the pool of revise items and to ensure psychometric adequacy (e.g., double barreled items, ambiguity, and mapping to the underlying construct definition). I then shared the revised item pool with a subset of these software practioners to further refine the items.

C. Justification for individual scale items

I followed Grant's (1996) conceptualization of knowledge integration as a group-level process. The five items in the scale assume higher values as the level of knowledge integration across the client-vendor boundary during the ISD process increases, following a reflective measurement logic. Thus higher scores on the measurement items *result from* higher levels of knowledge integration. In the survey, the vendor was explicitly defined to include all employees of the vendor organization who worked on the project and the client was defined to include all employees of the client organization with whom the vendor worked with for this project. This is consistent with prior conceptualizations in the literature of knowledge integration as the process of integrating individually-held knowledge to the collective/group/ team level (Alavi and Tiwana 2002; Grant 1996; Okhuysen and Eisenhardt 2002). Note that all items were framed as how well they described the *working relationship between the client and vendor*, thus tapping into the process aspect of the definition. The table on the next page discusses each item in the scale and compares it to other similar scales in the literature.

References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| *Concept measured by scale item* | Reflectiveness (cause→effect) | | *Logic* | *Representative underlying concept identified in the preliminary interviews with software project managers or in prior case studies* |
|---|---|---|---|---|
| | *Cause* | *Effect* | | |
| Extent to which during the development process the vendor organization leveraged the client's expertise in various functional areas | Increase in the extent of integration of technical knowledge and client-specific domain knowledge across the client-vendor organizations during the development process | Increase in the extent to which individuals in the vendor organization utilized specialized knowledge from various functional areas of client organization. | Higher knowledge integration across the client vendor organizations should lead to increased levels to which the vendor staff successfully utilized/tapped into specialized knowledge from individuals in various functional areas and departments of the client organization | Some clients have very bureaucratic arrangements which makes it very difficult to clarify a project requirements directly with a prospective end-user; directly getting ideas from a future user of a system in a client department is sometimes more helpful in defining system functionality and features than a 3-ring binder of project specs. |
| The client and vendor combined their unique perspectives in developing project ideas during the development process | | New project ideas that drew on the unique perspectives of individuals in the client and vendor organizations resulted. | Higher levels of integration of different types of expertise and ideas across the two organization during the development process should lead to higher vendor assessments of the extent to which contributions of unique viewpoints from individuals in the two firms helped develop project-specific ideas. | Software engineers have different ways of looking at client problems and users sometimes bring ideas that might have never occurred to a programmer/developer; clever solutions sometimes develop from combining their ideas. |
| During the development process, the client and vendor developed a shared understanding of how different business functions should be coordinated | | Increase in the level of shared understanding among individuals in the client and vendor organizations. | The process of knowledge integration among individuals in the client and vendor organizations over the course of the project should lead to a higher vendor assessment of how well the vendor staff understood how different business activities in the client organization ought to be coordinated. | (Hoopes and Postrel 1999) |
| The client and vendor collaboratively made decisions on how to maximize project outcomes | | Increase in the level of collaborativeness in making decisions that were intended to improve the resulting system. | The knowledge needed to improve the intended system is often distributed across the two organizations; an increase in the level of knowledge integration across the client-vendor boundary results in more collaborative decision-making on such issues. | Interviewees described some clients with which they felt they had truly collaborative working relationships. |
| The vendor utilized the client's expertise during the development process | | Increase in the extent to which individuals in the vendor were able to draw on and utilize specialized knowledge from individuals in the client organization. | As the extent of knowledge integration among client-vendor staff increases, the extent to which the vendor staff felt that they were able to draw on and use the client staff's knowledge and skills during the development process should increase as well. | (Adelson and Soloway 1985; Curtis et al. 1988; Rus and Lindvall 2002) |