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Year: 2018

Version: Final draft (post print, aam)

Please cite the original version:

Patel, P. C., Parida, V., Jayaram, J., & Oghazi, P. (2018). Task equivocality and process modularity in R&D offshore collaboration projects. *Journal of Business Research,* 98(12), 12-22. https://doi.org/10.1016/j.jbusres.2018.08.015

Task Equivocality and Process Modularity in R&D Offshore Collaboration Projects

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Abstract

Extending the literature on the performance of offshore collaboration projects, we explore the how task equivocality is mitigated. We propose that process modularity, the extent to which offshore collaboration tasks can be decoupled and re-sequenced with little loss of functionality in offshore collaboration, has the potential to lower task equivocality. We further propose that knowledge conversion cycles and offshoring collaboration competence (prior experience in offshore collaborations) could strengthen the negative process modularity to task equivocality association. Using data from 86 research and development offshore collaboration projects between two strategic business units (SBUs) of a large European firm with firms in India, we found that process modularity was not negatively associated with task equivocality. However, with increasing process modularity, higher levels of knowledge conversion cycles and offshore collaboration competence were negatively associated with task equivocality. These preliminary findings extend our knowledge of task equivocality in the context of offshore collaboration projects.

Keywords: offshore collaboration; modular processes; task equivocality; knowledge conversion cycles; offshore collaboration competence

1. Introduction

Offshoring refers to a firm's efforts to decompose parts of its value chain and conduct activities overseas. There are two types of offshoring: (1) captive offshoring, where value chain activities are conducted at company-owned subsidiaries and (2) offshore outsourcing, where external offshore partners conduct these activities (Crinò 2009; Schmeisser 2013; Pisani and Ricart 2016). With the globalization of value chains and specialization of knowledge-based activities based on core competencies, offshoring has increasingly become part of a firm's innovation strategy (Nätti et al. 2017). Offshoring can lower costs, improve the competitive positioning of the firm, and provide access to a specialized pool of human capital (Schmeisser 2013). Offshoring also allows firms to develop networks, improve specialization, develop joint capabilities, and develop offshoring competencies (Pagano 2009; Doh et al. 2010; Schmeisser 2013; Fuller et al. 2017).

Based on Lindblom (1959) Martens et al. (2012) highlight that offshoring collaborations require collaborating team members to muddle through. Geographically dispersed participants in offshoring collaborations must develop joint interpretations of environmental and internal challenges and develop collaborative knowledge and routines (Jensen et al. 2013). Unforeseen challenges in knowledge transfer, coordination, and control (Asmussen et al. 2016; Mol and Brandl 2017) could undercut the benefits of offshoring (Larsen 2016), especially for R&D offshoring collaborations where such challenges are more severe (Steinberg et al. 2017). Because discovery, interpretation, and ambiguity in problem-solving are higher in R&D offshoring efforts, task equivocality could be a retardant to such projects.

In the offshoring context, we define task equivocality as the competing interpretations of tasks driven by cultural, institutional, and between firm differences among participating members (cf. Daft and Lengel 1986). Task equivocality in offshoring results from variegated interpretations of requirements and challenges and unanticipated events stemming from less structured innovative processes occur. Task equivocality in offshoring setting is rooted in Leavitt’s (1976) sociotechnical model where the distribution of offshoring tasks (structure), competing interpretations among actors due to differences in their cognitive frames (actors), tools and routines available to solve the problems (technology) and activities that the team must undertake to complete the offshoring task (task) could result in divergent interpretations could result in task equivocality (Sakka et al. 2016). While uncertainty refers to lack of information, equivocality refers to lack of understanding (Levander et al. 2011). Task equivocality presents several specific challenges to the innovation task. First, in offshore projects, there may not be a clear known way to accomplish tasks. Second, the sequence with which the tasks should be approached and tackled may not be clear or known. Third, project personnel does not have access to prior established procedures for guidance owing to the ‘newness’ of the phenomena. Lastly, a defined body of knowledge may not exist to guide the different tasks in the innovation projects. Clearly, task equivocality could be detrimental and identify structures that help mitigate task equivocality could be beneficial.

Rooted in the information processing theory, task equivocality could be lowered by “structurally loose … yet task interdependent approach” (page 501), or as we label it as process modularity. Recently, Nätti et al. (2017) highlighted the value of modularization in professional service context, where “modularity may offer one way to facilitate knowledge sharing related to service offerings, organizational processes, and practices” (page 125), and specifically, in the service context, process modularity “specifies the decomposition of all the service and interaction processes into a set of activity components/chains [and] involves the specification of the interfaces between activity components that define how those will interact” (page 127). As offshoring refers to the service context, the theoretical undergird of process modularity in the offshoring context is in service modularity literature (Iman 2016).

We define process modularity is defined as decomposition of offshore knowledge, tasks, and processes into components to split offshoring activities so that coordination and exchanges can be decoupled and re-sequenced with little loss of functionality in collaboration (Jacobs et al. 2011). Process modularity improves task connectivity by managing processes in modules, lowers the effects of stickiness by improving knowledge management in process modules, and helps dependency in tasks by distributing and connecting tasks (cf. Luo et al. 2012). Based on this collective pattern associated with task equivocality, process modularity offers promise in mitigating the uncertainty and ambiguity with innovative tasks (Vickery et al. 2016). Process modularity entails configuring key tasks and activities that can be conducted in a relatively independent fashion to define, document, standardize, and improve key processes can offer a powerful platform to minimize chances of ambiguity in innovation activities and tasks. Because these platforms of activities take place at the lowest decomposable level of the task, there is a certain independence to accomplishing these tasks, which is the desired end goal. *We ask whether process modularity could be negatively associated with task equivocality in offshore collaboration settings?*

However, process modularity may also create 'hanging' or isolated islands of activities that need to be knit together via integration. Modularity may often come at a cost, which is reduced connectivity across modular units or tasks. This means that cost savings from modularity could dissipate due to missed opportunities stemming from potential resource combinations across modules. To explain mechanisms that could help enhance the influence of process modularity on task equivocality, we draw on knowledge conversion cycles and offshore collaboration competence. Specifically, these qualities can help in further reducing task equivocality under increasing process modularity.

Based on Nonaka and Takeuchi (1995) knowledge conversion cycles aim to convert tacit knowledge into explicit knowledge through socialization (internalizing knowledge by observation), externalization (leveraging dialogues, analogies, and metaphors to convert tacit knowledge into explicit knowledge), combination (using communication mediums explicit knowledge is combined), and internalization (knowledge experiences are internalized). Strengthening the effects of process modularity, the presence of knowledge conversion cycles, help strengthen the effects of modular processes by ensuring socialization, externalization, combination, and internationalization of knowledge. Finally, previously developed offshore collaboration competence could help improve the efficacy of process modularity as offshoring teams can leverage previously developed resources and improve the knowledge management processes. Offshore collaboration competence is related to valuable resources and capabilities associated with completing successful offshore collaborations. *We, therefore, ask whether the negative association between process modularity and task equivocality can be further strengthened at higher levels of knowledge conversion cycles or through higher offshore collaboration competence?*

Our primary contribution of this work is more practical than theoretical. Increasingly, there are calls for responsible offshoring in the practitioner literature (Porter and Rivkin 2012), calls for smarter collaborations within and outside the company (Gardner 2016), and the need for organizing R&D in offshore contexts (Capozzi et al. 2013). Drawing on project-level data, we aim to explore how an R&D offshore collaboration team addresses the early-stage hurdle of task equivocality. Organizing such collaborations in a process modular fashion may not provide higher returns unless knowledge conversion cycles and offshore competence are present. The findings also complement the importance of knowledge conversion cycle in offshoring (Nonaka and Takeuchi 2007) and past offshoring competence (Kumar and Puranam 2011).

The proposed framework makes the following theoretical contributions. First, the extant literature has addressed the roles of several types of modularity on innovation (Frandsen 2017) and specifically explains the design on offshoring efforts (Jensen et al. 2013). Past research has studied the role of modularity through the lens of product (Schilling 2000), supply chain (Ro et al. 2007), and organizational architecture (Sanchez and Mahoney 1996), we extend this line of work by focusing on process modularity, and specifically extend the emerging service modularity literature (Dörbecker and Böhmann 2013). Amongst these types, the focus has been mainly on product and process modularity (Baldwin and Clark 2003; Jacobs et al. 2011). Second, our work sheds light on the offshoring literature. Indeed, it examines offshoring for knowledge motives and proposes a modular approach to integrating knowledge pools across globally dispersed innovation projects. Third, we build on the knowledge-based view of the firm by arguing that a deeper understanding of how knowledge (tacit and explicit bases of knowledge) can be tapped and deployed has the incidental benefit of lowering task equivocality as well.

In the following sections, we develop arguments for the negative association between modular processes and task equivocality, followed by propositions of the moderating effects of knowledge conversion cycles and offshore collaboration competence on this relationship. We then discuss the sample and measures used in the present study and then present the results. We conclude with a discussion of results, limitations, and future research directions.

2. Theory and hypotheses development

Firms are increasingly engaging in offshore collaborations to develop new products and processes. However, offshoring comes with a unique set of challenges. Of particular importance are the communication and coordination challenges that arise in innovation-based collaborations (Manning 2014). Less clearly specified ex-ante conditions, poorly defined expectations during the stages of conceptualization, design, and development increase equivocality. In the first step of complex R&D collaborations, different knowledge types interact from competing for knowledge bases of two or more collaborating firms. Differences in cultural, institutional, and firm-specific interpretation frames result in competing, complementary, or supplementary interpretations that may interfere with decision-making. It is essential to distinguish equivocality from uncertainty. Under uncertainty, or absence of information, probabilities of events cannot be assigned. In contrast, under equivocality, information is present, but participants have multiple or conflicting interpretations. Compared to uncertainty, where more information derived from information processing could help lower uncertainty, more information may not resolve equivocality. As such, exchanging opinions, defining problems, and clarifying ambiguities to reach an agreement are essential for lowering equivocality (Daft and Lengel 1986).

In a related context of Business Process Outsourcing, Luo et al. (2012) propose that overseas collaborations are stifled by task interdependence issues, specifically, task connectivity, stickiness, and dependency. Offshoring tasks require higher task connectivity as they are characterized by a higher need for joint problem solving and divergent information processing. Information integration may be particularly challenging as members from different institutional and cultural backgrounds must integrate variegated firm-specific information and resources. As members increase task connectivity, diverging interpretation frames could result in competing meanings, resulting in higher task equivocality. The offshore collaboration in R&D context is further exacerbated by stickiness “the incremental expenditure required to transfer that unit of information to a specified locus in a form usable by a given information seeker” (Von Hippel 1994, page 430). The stickiness of information among the collaborating organizations may increase the locus of interpretations due to the limited transfer of knowledge across collaborators. The dependency between the collaborators is significant in R&D contexts that require greater coordination and problem-sharing, that in turn, may result in competing sets of goals and priorities (Eng and Ozdemir 2014).

These characteristics of task connectivity, stickiness, and dependency could result in higher equivocality in offshore settings. Equivocality is particularly salient in offshore collaboration processes because partners overseeing different product architecture collaboration platforms could have competing interpretations of new and existing knowledge. Equivocality undergirds ambiguity in collaborations and contracts (Diekmann and Girard 1995), frictions in planning and coordination through meetings (Albino et al. 2002), and mismatch or misunderstanding in expectations (Gerwin 2004).

How can task equivocality be lowered? One plausible approach is in the modularity literature (Frandsen 2017). Srikanth and Puranam (2011) focused on tacit knowledge-based routines and mechanisms that facilitate forming and leveraging shared knowledge. They specifically call for modularized investments in electronic communication channels and developing tacit coordination mechanisms. In contrast, Sidhu and Volberda (2011) proposed standardization, as opposed to tacit mechanisms, to develop a shared identity, which can overcome differences in language, culture, and institutions to help develop unique capabilities. Before collaborators learn to rely on tacit knowledge-based routines or negotiate shared identities, they must resolve task equivocality in the early stages of collaboration to improve coordination and control of knowledge (Hätönen and Eriksson 2009). Based on this discussion we propose that that process modularity could be negatively associated with task equivocality.

2.1. Process modularity.

The literature on modularity has spanned over three decades. Frandsen (2017) provides an extensive review of the modularity literature (1990 to 2015), ranging from product platforms and scheduling systems and from product architecture to research and development outsourcing. The modularity literature is extensive, and through co-citation analysis Frandsen (2017) identified eight emerging areas in the past decade. Relatedly, Nätti et al. (2017) review and discuss the value of modularity in a service context. Combining extant research on modularity with the literature on equivocality, the goal of process modularity strives to develop ‘information that is clear and specific and that generally leads to a single, uniform interpretation by users that are considered [less]equivocal' (Daft and Macintosh 1981, page 211).

Modular processes may facilitate a better fit between information exchange needs under equivocality. Modular processes also allow firms to improve control and anticipate events in order to mitigate against vague and variegated interpretations in innovation settings (Weick 1979). In particular, process modularity has been reported to be useful when managing cooperation with alliance partners during product development (cf. Tiwana and Konsynski 2010) and strengthening governance mechanisms (cf. Gomes and Joglekar 2008). Past heuristics and routines tend to be less reliable in managing offshoring innovation efforts; therefore, process modularity, by defining, documenting, and standardizing can help manage cognitive limits to lower equivocality (Krishnan et al. 2006). Through modular interpretation frames, process modularity helps manage interdependencies among culturally different partners and reduces communication and execution challenges (Lawrence and Lorsch 1967; Daft and Lengel 1986). Also, both equivocality and modular processes are at the *task* level (i.e., the offshore collaboration task), which enables finer-grained analysis of the phenomenon.

Process modularity is salient, because when 'information cue[s] may have several interpretations' (page 211) modularizing the process allows participants to 'reduce equivocality by redefining or creating an answer' (page 211) by better visualizing and combining modularized knowledge management processes. Several scholars proposed that Media Richness Theory lowered equivocality (Daft and Weick 1984; Daft and Lengel 1986). Daft and Macintosh (1981) proposed that the need for analyzability and variety in innovation tasks result not only in equivocality but also in large amounts of information. Media Richness Theory, as a contingency theory, proposes that the fit between the information processing needs of a task and the medium used to exchange information allows for better information processing capacities (Dennis and Kinney 1998).

Process modularity also facilitates structural scaffolding in offshore collaboration efforts that promote knowledge exchange structures that lower task equivocality. In other words, as the knowledge modules could be structured hierarchically, the structure helps collaborators work through the innovation process. Recombining knowledge in modular knowledge networks takes place at a much more rapid pace compared to a firm in a nonmodular knowledge network. Process modularity allows for a hierarchical and less cohesive (da Silva et al. 2008) organization of activities, which lowers complexity and thereby reduces task equivocality. Modularity allows groups and firms to manage complex structures and systems into modules that can be combined and recombined, further allowing for mixing and matching modules (Baldwin and Clark 2000) to manage the knowledge and cues necessary to lower equivocality (Hitt et al. 1998; Worren et al. 2002).

Process modularity promotes cohesion, interdependence, and integration (cf. Jacobs et al. 2011). Process modularity in the R&D context modular processes allows for partition and transfer of tasks in more complex individual, institutional, and cultural contexts such as offshore collaborations (Hoogeweegen et al. 1999; Sanchez and Collins 2001; Worren et al. 2002). In contrast to the integral architecture, modular processes are discrete units that need a higher systems level of aggregation (Fine 1998). Process modularity requires small chunks of tasks and activities to be pursued independently, which is then followed by creating interfaces across modular entities for integration. In the offshoring context, Fine (1998) argued that the intent for offshoring can be used to access extra capacity or access knowledge capital. Given that we are studying innovation offshoring, the motives for modular processes are generally for knowledge management reasons. This means that knowledge tasks need to be made discrete, as manageable chunks, which operate relatively independently. Therefore, process modularity as an approach allows the firm to define, document, standardize, and improve tasks to improve connectivity, increase sensitivity, and strengthen dependency. Continuing from Luo et al. (2012) framework discussed earlier, process modularity facilitates greater connectivity in tasks, helps develop a structure that allows for a better flow of information and knowledge to help conceive and gestate knowledge linkages. Structures that lower stickiness in coordination and knowledge exchange processes could be necessary to ensure adequate transfer of knowledge. Process modularity could promote connectivity through more modular task modules and lower stickiness by distributing knowledge activities and ensuring dependency across the connected and modules with distributed stickiness.

In summary, process modularity in offshore collaboration projects could be useful as collaborators attempt to resolve task equivocality because it allows for a higher level view of the knowledge landscape that the collaborators aim to reconcile, improve connectivity and lower stickiness. Task equivocality could be lowered via process modularity by collating manageable pieces of information, leading to a more efficient path of interconnections among diverse knowledge areas and by reducing the cost of exchanging information (Powell et al. 1996; Owen-Smith and Powell 2004). Process modularity may help develop and maintain knowledge flows and reduce governance problems in offshore innovation collaboration problems marred by cognitive, institutional, and cultural distances. Process modularity allows for better identification and allocation of inventors, employees, and workgroups in innovation efforts due to knowledge specialization (Tiwana and McLean 2003; Pavlou and El Sawy 2006). Because offshore collaboration efforts require recombining existing knowledge pieces to develop new products, processes modularity could help develop, combined, and sustain knowledge repositories. Also, by coordinating across such repositories, collaborators can question, reconcile, and update knowledge frameworks to lower task equivocality.

Based on these overall observations, we propose that:

Hypothesis 1. Process modularity in offshoring collaborations is negatively associated with task equivocality.

2.2. Knowledge conversion cycles

Although process modularity allows for effective organization and flow of knowledge, the ensuing lower cohesiveness across modularized processes must be integrated. Thus, process modularity and lower task equivocality could be enhanced by stronger knowledge conversion cycles. Nonaka and colleagues theorized that knowledge creation occurs through the interaction of tacit and explicit knowledge via what they call the SECI model (Nonaka and Takeuchi 1995). This encompasses Socialization, which refers to knowledge sharing that occurs through social interaction (tacit to tacit); Externalization, which involves codifying tacit knowledge into explicit concepts (tacit to explicit); Combination, which systematically combines explicit knowledge to create new knowledge (explicit to explicit), and Internalization, which transforms explicit knowledge into tacit knowledge (explicit to tacit). Taken together, these four pairs of knowledge constitute knowledge conversion cycles.

The Knowledge-Based View of the firm builds on the Resource-Based View (RBV) of the firm by suggesting that knowledge is the firm's most strategically significant resource. Heterogeneity in firms' capabilities comes from the socially complex and difficult-to-imitate nature of knowledge (Grant 1996; Spender 1996; Phelps et al. 2012). Likewise, the RBV entails a knowledge perspective (Conner and Prahalad 1996; Theriou et al. 2014). For example, Roth and colleagues (1994) used the metaphor of a ‘knowledge factory’ to understand the process of translating knowledge into operational capabilities. Understanding how different knowledge creation mechanisms align with different capabilities may help explain heterogeneity in innovation performance.

Scholars have classified types of knowledge in various ways, including tacit/explicit (Anand et al. 2010), explicit/implicit (Spender 1996), and know-how/know-why (Lapré and Van Wassenhove 2001; Ferdows 2006). Polanyi (1961) formally defined tacit and explicit knowledge as two fundamental types of knowledge. Tacit knowledge cannot be articulated through verbal or linguistic means and has been characterized as intuitive (Polanyi 1961); that is, knowledge of experience, practical intelligence, or difficult-to-codify practical experience (Insch et al. 2008). Tacit knowledge often is connected to action, procedures, and routines (Nonaka 1994). In contrast, explicit knowledge can be articulated and has been described as ‘know-what’ (facts) and ‘know-why’ (science). The literature has also used the terms noncodified/codified knowledge to describe tacit/explicit knowledge. In the operations management domain, Linderman and colleagues (2004) described in detail Nonaka’s knowledge creation process and used it to understand the relationships between knowledge creation and quality management. Anand, Ward, and Tatikonda (2010) further investigated Nonaka’s theory of knowledge creation in the context of Six Sigma lean projects.

Similarly, knowledge conversion cycles could complement modular processes in offshore innovation collaboration projects to lower task equivocality. Process modularity complemented by the SECI cycle (or, knowledge conversion cycles) could further reduce task equivocality. Whereas modularity organizes knowledge into manageable tasks and pieces, the knowledge conversion cycles help integrate these modules, which helps lower task equivocality. Process modularity can lead to decomposing knowledge, which can be further enhanced by the SECI logic by combining, iterating, and honing the needs of the underlying innovation task. Accordingly, we offer that:

Hypothesis 2. Knowledge conversion cycles in offshoring collaboration moderate the association between process modularity and task equivocality, such that more intensive knowledge conversion cycles lower task equivocality and less intensive knowledge conversion cycles increase task equivocality.

2.3. Offshore collaboration competence

In offshoring projects, offshore collaboration competence is salient to knowledge-intensive activities such as R&D and product development (Schubert et al. 2016; Fuller et al. 2017). Such activities provide firm-specific advantages in managing resources, knowledge, and capabilities in globally distributed innovation activities. Offshoring competence in the current context refers to 'repeatable patterns of actions in the use of assets to create, produce, and/or offer new products to a market' (Sanchez 2004, page 519). This allows offshore collaborators to develop collective patterns of resource bundles to manage offshoring activities over time. Offshoring competence is essential, because traditional advantages associated with offshoring (e.g. labor costs) are less viable and tenable, prompting the need to develop the ability to add value in tandem with the ability to modularize knowledge-creating processes (Sako 2006; Lewin et al. 2009; Belderbos et al. 2015; Spithoven and Teirlinck 2015). Building on these works, we posit that offshoring competence further strengthens the negative association between modular processes and task equivocality.

Well-developed offshore collaboration capabilities reduce costs and lower the ambiguity associated with uncertain tasks. Generally, offshoring starts with high fixed costs and lower returns. Units that are able to lower the costs of offshoring over time while improving performance are able to more successfully lower the marginal costs of offshoring in successive projects and develop a more viable resource base. Nieto and Rodríguez (2011) found that offshoring R&D is positively associated with innovation performance, specifically as it relates to product innovation but less so for process innovation. Developing offshore collaboration competence is important because it affords opportunities for strategic learning and systemic organizational transformation (Jensen 2009; Piening et al. 2016) and significantly influences resource stocks (Jensen and Pedersen 2012). Offshore collaboration activities limit erosion of resources and allow resource building (Kotabe and Mudambi 2009), which in turn may become platforms for future growth.

In the context of modular processes, higher offshore collaboration competence is particularly salient in lowering task equivocality. Prior collaboration competence lowers transaction and coordination costs across modular work processes, which reduces knowledge search and combination costs, and helps lower startup costs as collaboration routines become more developed. As collaborators aim to resolve task equivocality, better offshore collaboration competence allows for transactional and transformational knowledge combinations (Vivek et al. 2008; Lacity et al. 2015; Lacity et al. 2017). We, therefore, propose that:

> *Hypothesis 3.* Offshore collaboration competence moderates the association between process modularity and task equivocality, such that higher offshore collaboration competence lowers task equivocality and lower offshore collaboration competence increases task equivocality.

3. Methodology

3.1. Sample context and data collection

R&D offshoring, regarded as the next generation of offshoring, represents coordination challenges for most companies (Manning, Raghavan, and Schutze, 2008). Traditionally, companies have offshored more simple tasks (such as IT functions), whereas the next generation of offshoring includes a wide spectrum of high-value-added activities associated with R&D, such as CAD, modeling and drafting, re-engineering, embedded system development, new technology development, research on new materials and services, prototype design, and product development. According to several industry reports (c.f. Booz and Co., 2007), a trend within R&D offshoring from Western countries includes moving development tasks toward developing or BRIC (Brazil, Russian, India, and China) countries. The increased geographical distance, intercultural issues, difficulties with contracting and predicting what needs to be executed, create coordination and comprehension challenges, leading to different realized R&D benefits than what was actually planned (Manning et al. 2008; Grimpe and Kaiser 2010). This further prompts the critical need to examine issues related to task equivocality and modular processes simultaneously within this context.

The empirical context includes R&D offshoring projects within two large European multinational companies that relocated their in-house R&D activities to external parties located in another country. To obtain an in-depth understanding of the sampling context draws on an explorative pilot study in conjunction with a large-scale survey (Edmondson and McManus 2007).

3.1.1. Sampling context. The multinational company in the current study is based in Sweden, and we used two strategic business units (SBUs) as our focal unit of analysis. The first, SBU A, was established in 1832 and operates in the construction equipment industry. It employs approximately 15,000 employees and had a turnover of €65 billion in 2011. This SBU is considered one of the world's largest manufacturers of construction equipment, including compact wheel loaders, backhoe loaders, haulers, and pavers, among other types of equipment.

The second, SBU B, operates in the aerospace manufacturing industry and was founded in 1930. It manufactures components for both civil and military aero engines, as well as for rocket engines for space applications and gas turbines. They employ approximately 3,500 employees and had a turnover of €216 million in 2011.

These two SBUs were selected for two key reasons. Their early involvement in R&D offshore relationships means that both SBUs have reasonably formalized and stable operational processes. Thus, they fit the present study's focus to examine process modularity and its effects on task equivocality. Second, due to prior relationships within the case SBUs (built through a pilot study), we could access detailed project-level data on module processes, knowledge conversion cycles, and offshore collaboration competence.

3.1.2. Pilot study. We first conducted a pilot study that included 10 explorative interviews with diverse respondents at different locations to build an understanding of the R&D offshoring collaboration experience. We initially interviewed management-level respondents who had taken part in setting up the collaboration. This was followed by interviews of operational-level respondents from both sides (at the SBU and at the offshore location) to gain insights on operational experiences and challenges. Explorative interviews were helpful in several ways. First, they provided fine-grained knowledge about the research context, which helped us identify research issues that were considered critical for reducing task equivocality. Second, the interviews helped us operationalize the key variables, particularly choosing among items and competing scales (Edmondson and McManus 2007). Finally, the interviews helped us build trust and secure commitment from the survey sites.

3.1.3. Data collection. Survey data collection was conducted over a period of several months, with multiple researchers actively involved in the process. First, by collaborating with key contacts at the case companies, we identified R&D offshore projects that had high strategic value and were considered the R&D units' top priorities. These projects were mainly innovation related, cross-border projects between the two SBUs and their R&D offshore suppliers (i.e. located in India). The second step involved gathering background information about the identified projects and contact information of key respondents (usually project leaders or managers and a project coordinator). These respondents had a holistic overview of the project's goals, and the project coordinator organized offshore activities on a day-to-day basis with the offshore suppliers. Because these respondents were responsible mainly for ensuring the success of the R&D offshore operation, detailed insights into strategic and operational challenges and their knowledge of offshoring collaboration activities were important in examining issues related to our research. The third step included constructing an online survey instrument on the intranet of the two case companies. After receiving approval from top management, we were given permission to contact approximately 150 respondents from case companies. Background information, the motivation for the survey, a paragraph on confidentiality assurance, and an online link to the survey portal were mailed to the project leader and project coordinator of each offshoring collaboration. Participating in the present study was strictly voluntary and no internal pressure was imposed to enhance the response rate. Several phone calls and emails were sent as reminders to complete the survey. Ultimately, we received complete responses from the leaders of 86 projects. Table 1 lists the details of the projects included in the study.

[Insert Table 1 about here]

3.2. Measures

The appendix includes a detailed description of all measurement items used in operationalizing our dependent, independent, and some of the control variables. We took the mean of responses from two respondents on each scale item to operationalize our measures.

Our dependent variable is task equivocality, which is a 4-item scale from Abernethy and Brownell (1997). We reverse coded the items to focus on how well tasks were defined in an offshore collaboration; in other words, the extent to which managers must clarify ambiguity in tasks. The Cronbach's alpha is listed in Appendix.

Our independent variable, process modularity, is a 4-item measure. Higher values indicate more modular processes in innovation efforts (Worren et al. 2002).

Our two moderators are knowledge conversion cycle and offshore collaboration competence. The knowledge conversion cycle scale is based on Lee and Choi (2003) scale with sub-dimensions of knowledge articulation and coding (6 items) and knowledge sharing and internalization (10 items). The offshore collaboration competence was measured using a 5-item scale, developed based on discussions with practitioners in a similar industry (Kogut and Zander 1993; Parida et al. 2013). The scale captures a company's ability to coordinate and benefit from R&D activities across globally dispersed units, which leads to a competitive advantage in a global business setting (Kogut and Zander 1993; Parida et al. 2013).

3.2.1. Controls. As controls, we included trust (5-item scale), culture (2-item scale), a combined team size of offshore collaborators, years of off-shore experience, and level of task uncertainty (4-item scale by Abernethy and Brownell (1997).

3.3. Common method variance

We took precautionary steps to minimize common method variance in the data collection stage (Podsakoff et al. 2003). First, we assured respondent confidentiality to reduce potential social desirability issues and to increase respondent candidness. Second, we minimize respondents' evaluation apprehension by explaining there were no right/wrong answers to the survey questions. Third, we carefully constructed the items to minimize item ambiguity and complexity (Podsakoff et al. 2003). Harman's factor test resulted in 11 factors, with the first factor explaining 45.99% of the variance, suggesting that common method variance bias may be lower.

3.4. Results

Table 2 displays the descriptive statistics. The variance inflation factors ranged from 1.05 to 1.14; therefore, multicollinearity was not a significant concern.

Due to smaller sample size, we used robust regression (*rreg* routine in Stata 15). The results are presented in Table 3.

Hypothesis 1 proposed that process modularity in offshoring tasks is associated with lowering task equivocality. Although the correlation for this association was negative ($r = –0.125$), the direct effect was not significant (Model 2: $\beta = –0.060$, $p > 0.10$).

Hypothesis 2 proposed that intensive knowledge conversion cycles moderate the relationship between process modularity and task equivocality (Model 3: $\beta = –0.667$, $p < 0.10$; Model 5: $\beta = –0.603$, $p < 0.10$). The interaction plot based on *margins* command in Stata 14.2 in Figure 1(a) shows that with more intensive knowledge cycles, a higher level of modularity lowers task equivocality.

Hypothesis 3 proposed that intensive knowledge conversion cycles moderate the relationship between process modularity and task equivocality (Model 4: $\beta = –0.505$, $p < 0.05$; Model 5: $\beta = –0.499$, $p < 0.05$). The interaction plot based on *margins* command in Figure 1(b) shows that with offshore collaboration competence, a higher level of modularity lowers task equivocality.

[Insert Table 2 and 3 about here. Insert Figure 1 about here.]

4. Discussion

In the current sample, by drawing on a sample of product innovation activities that were offshored, our objective via our research framework was to establish a deeper understanding of the factors that influence a critical early stage challenge of task equivocality.

The key finding of our paper is that process modularity is not *directly* associated with lower task equivocality. However, knowledge conversion cycles and offshore collaboration capabilities are present, process modularity could be negatively associated with task equivocality. Our proposed research framework contributes to the literature of offshoring, the knowledge-based view, and modularity in offshoring settings. In the offshoring literature, the often overlooked aspect of activities is task equivocality. Although proposed by Daft and colleagues three decades ago, it has received limited attention in the offshoring literature, where equivocality in tasks and activities are pervasive. By drawing on cross-border collaboration projects, we add a global context to the task equivocality literature. The contingent effects of knowledge conversion cycles and offshore collaboration competence add further to our understanding of task equivocality. The findings also contribute to the international business domain by demonstrating the relevance of equivocality in international collaboration efforts, where knowledge exchange processes could be affected by equivocality and, more importantly, could be strengthened by working in tandem with knowledge conversion cycles and offshore collaboration competence.

4.1. Theoretical implications

Iman (2016) reviews the literature on service modularity. In a recent work by Nätti et al. (2017) and related work on service modularization (Bask et al. 2010; Dörbecker and Böhmann 2013; De Blok et al. 2014). Complementing and extending case-study and descriptive approaches in service modularity literature, in a quantitative study we find that process modularity does not directly impact task equivocality, plausibly a proximal and an important outcome of organizing process modularity. We find that knowledge conversion cycles and offshore competence provide the necessary scaffolds to improve the role of process modularity in lowering task equivocality. Our main implications are for modularity in collaboration in service contexts. Through the task equivocality lens applied to modularization in offshoring tasks, we also extend the work of Luo et al. (2009), which relied on information processing theory and found that task complexity and task security, as well as the associated task interdependence (connectivity and stickiness), increase the degree of business integration.

The lack of significance for the process modularity effects, call for greater focus on how firms can develop knowledge conversion cycles. Development of such cycles involve extensive documentation and project management milestones, developing and maintaining ‘routines’, and laying down checklists or roadmap guidelines. The collection of these tools, templates, and frameworks can constitute a user manual, which preserves knowledge, as well as augments knowledge via updating. Collectively, our results show that these mechanisms of knowledge coding and articulation levied against modular processes can lower task equivocality. Another platform in the knowledge conversion cycle is sharing and internalization across functional, organizational, and divisional groups. This may involve formal structures such as committees, task forces, and training programs that promote knowledge sharing. Also, through the processes of executive exchange, rotating employees, and ‘strategy camps’, an informal mode of knowledge sharing and internalization can take place. Employees working on innovation projects should specifically be steered toward tapping and accessing documented and codified knowledge. Similar to how knowledge coding and articulation accelerated the effects of process modularity in lowering task equivocality, our research found that knowledge sharing and internalization against the backdrop of modular processes also accelerated its impact on lowering task equivocality. Thus, knowledge conversion cycles via knowledge coding and articulation and leading to knowledge sharing and internalization had a moderating influence on the relationship of process modularity to task equivocality. Specifically, they lowered task equivocality in offshore innovation projects.

Our research points to the value of fundamental levels of discrete knowledge tasks followed by integration under more intensive knowledge conversion cycles. This development at the lowest level followed by integration at a higher (say platform) level combines modular and integral product architectures (see Fine 1998). Leveraging multiple 'soft' and 'hard' skills and competencies enhance offshore collaboration competencies. At the technical level, this leads to debates on the product, part, and process commonality. Other areas of technical capabilities that can be developed include considering the ease of assembly and manufacturing at the design stage. Taken together, this rich contextual variance in culture, contexts, and geography coupled with technology platforms of learning is what enables offshore collaboration competence to lower task equivocality in modular processes. Such an experience can be enjoyed entirely within one's domestic domain; however, our research shows that geographically dispersed innovation activities accelerate this pattern significantly.

4.2. Managerial relevance

The present study provides practical guidance to participants in offshoring activities. Understanding the nature of task equivocality under competing goals and information could smooth collaboration efforts. As parties work across borders under different assumptions and knowledge bases and with access to different resources, managing challenges related to task equivocality could improve clarity and provide direction. Knowledge articulation and coding activities and knowledge sharing and internalization such as face-to-face meetings, verbal communication, and personal memos could be important to managing the efficacy of modular processes in overseas collaboration. Exchange visits among the collaborators can also increase their comfort zone and promote trust.

Lastly, our research points to the unique challenges of offshoring innovation projects where there is considerable diversity in culture, skillsets, and motivational levels across firms in geographically distant country settings. Our research specifically dealt with knowledge suppliers located in India for a Western client. Naturally, what is presumed to be modus operandi in the West is seldom the case with respect to the Indian offshore supplier. Over years, the knowledge and experience of diverse partners help promote collaboration competence capital. Beyond the cultural- and country level understanding, there is domain-specific knowledge relating to product, design, and technology that needs to be managed. Again, a modular process helps as such cross-fertilization of competencies can be better managed by discretization.

4.3. Limitations and future research avenues

The present study's findings are not without limitations. First, while drawing on real-world offshoring projects with significant monetary and strategic scopes, the findings cannot be generalized beyond the two SBUs of a large European firm. Future studies could further assess the role of differences in cultures, resources, and capabilities among collaborating partners.

Second, although we collected data from multiple respondents to provide a diverse but triangulating perspective, the present study lacks the micro-dynamics of offshore collaborations. Future studies, possibly through qualitative analysis, could create a temporal assessment of stocks and flows of resources and knowledge in innovation activities. Third, although we control for the effects of culture, trust, and performance, future studies could specifically examine the relationships among these factors.

Related to some avenues for future research, uncertainty and equivocality are interconnected, and future research could focus on the synchronous coordination in resolving both uncertainty and equivocality. Higher equivocality can reduce uncertainty and vice versa. Second, although we used the full construct of the SECI scale, future studies could focus on how subcomponents of this scale could have contingent effects on the proposed relationships. Finally, examining the influence of cultural differences among collaborators could further add to our understanding of how knowledge exchanges could be influenced by both organizational and national culture.

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TABLE 1
Description of projects

SBU #1		SBU #2	
Project type (N=47)	**Average Duration**	**Project type (N=40)**	**Average Duration**
Prototype development (*n*=8)	3 months – 1 year	Hard and soft forming modeling (*n*=10)	1 month – 6 months
Modeling (*n*=10)	25 days – 4 months	System design (*n*=4)	7 months – 2 years
Simulation (*n*=6)	2 months – 6 months	Simulation (*n*=10)	1 month – 6 months
CAD drawing (*n*=12)	20 days – 4 months	CAD drawing (*n*=9)	15 days – 4 months
Code development (*n*=6)	1 month – 1 year	Code development (*n*=4)	3 month – 4 months
Product and technology development (*n*=5)	6 months – 1 year	Application development (*n*=3)	5 months – 2 years

TABLE 2

Mean, SD, Correlations

		VIF	mean	sd	Min	Max	1	2	3	4	5	6	7	8	9	10
1	Task Equivocality		3.18	0.63	1.50	4.50	1									
2	Modular Process	1.06	2.83	0.65	1.67	4.67	-0.1252	1								
3	Knowledge conversion cycle	1.09	3.10	0.37	2.13	4.02	-0.13	0.0159	1							
4	Offshore collaboration competence	1.06	2.86	0.38	2.00	3.80	0.0097	0.1078	0.0599	1						
5	Modular process × Knowledge conversion cycle		8.78	2.37	5.00	15.47	-0.1838	0.8951*	0.4521*	0.1276	1					
6	Modular process × Offshore collaboration competence		8.11	2.37	4.33	17.73	-0.1305	0.8786*	0.0491	0.5558*	0.8049*	1				
7	Trust	1.10	3.13	0.59	1.80	5.00	0.0775	-0.0711	-0.0728	0.1005	-0.0955	-0.0132	1			
8	Culture	1.14	3.03	0.73	1.00	5.00	0.0969	-0.0131	0.1605	0.0079	0.0669	-0.0103	0.1685	1		
9	Team Size	1.09	5.01	7.17	0.00	50.00	0.1134	0.0667	-0.156	-0.1645	-0.0194	-0.0232	-0.1479	0.009	1	
10	offshore experience	1.05	3.09	2.92	0.00	20.00	-0.0126	-0.0686	0.1253	-0.0927	-0.0141	-0.0954	0.0781	0.1108	0.0239	1
11	Offshore Task Uncertainty	1.11	3.05	0.51	2.00	4.00	0.3436*	-0.1661	0.0545	0.0091	-0.1295	-0.1437	-0.0369	0.2384*	0.0142	0.0748

Note.

N=86 (casewise deletion); *$p < 0.05$ (two-tailed); VIF = Variance inflation factor; VIFs obtained from running Ordinary Least Square Regressions without the interaction terms; Mean VIF = 1.09

TABLE 3
Robust Regression Estimates

VARIABLES	Hypothesis	Supported	(1) Task Equivocality	(2) Task Equivocality	(3) Task Equivocality	(4) Task Equivocality	(5) Task Equivocality
Modular process	**[H1]** – negative association	No		–0.0600	2.119+	1.454+	3.392**
				(0.107)	(1.093)	(0.752)	(1.253)
Knowledge conversion cycle			–0.133	–0.121	1.776+	–0.0968	1.599+
			(0.189)	(0.192)	(0.965)	(0.189)	(0.939)
Modular process × Knowledge conversion cycle	**[H2]** – mitigates the negative association in H1	Yes			–0.667+		–0.603+
					(0.338)		(0.329)
Offshore collaboration competence			–0.0175	–0.0176	–0.0289	1.452+	1.446*
			(0.179)	(0.183)	(0.179)	(0.744)	(0.716)
Modular process × Offshore collaboration competence	**[H3]** – mitigates the negative association in H1	Yes				–0.505*	–0.499*
						(0.248)	(0.239)
Trust			0.100	0.0962	0.0677	0.0882	0.0705
			(0.118)	(0.120)	(0.117)	(0.118)	(0.114)
Culture			0.0250	0.0263	0.0687	0.0261	0.0561
			(0.0977)	(0.0991)	(0.0974)	(0.0975)	(0.0948)
Team Size			0.00839	0.00864	0.00568	0.00834	0.00623
			(0.00966)	(0.00981)	(0.00963)	(0.00965)	(0.00936)
Offshore experience			0.000850	0.00164	–0.000639	0.00411	–0.000312
			(0.0234)	(0.0237)	(0.0232)	(0.0233)	(0.0226)
Offshore Task Uncertainty			0.471***	0.466**	0.475***	0.453**	0.439**
			(0.134)	(0.138)	(0.135)	(0.136)	(0.132)
Constant			1.774+	1.928+	–4.281	–2.475	–7.929*
			(0.932)	(0.995)	(3.194)	(2.368)	(3.656)
Observations			86	86	86	86	86
R-squared			0.167	0.172	0.227	0.221	0.266
F			2.229	1.994	2.480	2.394	2.719

Standard errors in parentheses
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$

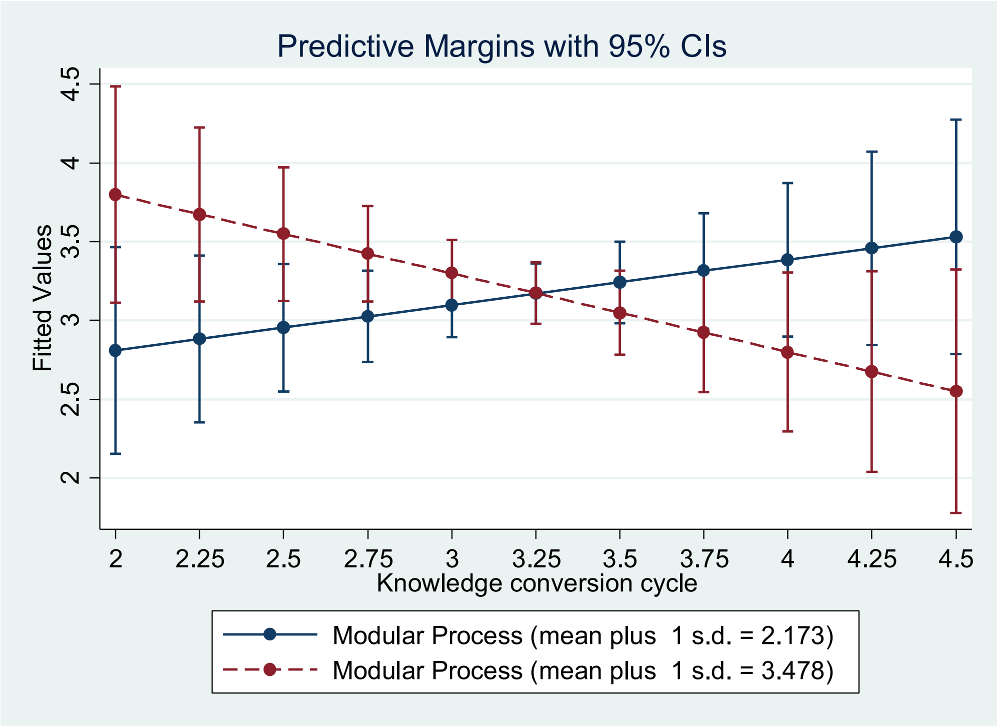

Figure 1
Knowledge conversion cycle and modular process

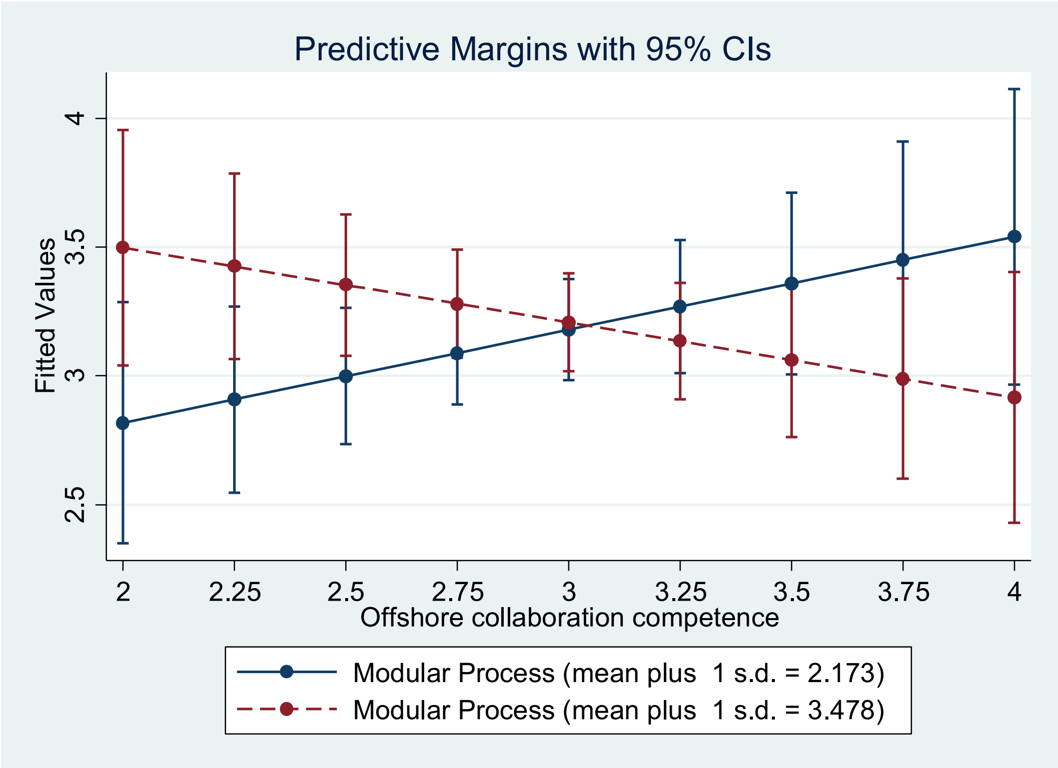

Figure 2
Offshore collaboration competence and modular process

APPENDIX

Scale items (5-point scale anchored by 1 = not at all to 5 = to a large extent)

Task equivocality (Cronbach's alpha = 0.76)

1. To what extent is there a clearly known way to accomplish the major types of R&D offshore tasks? (Reverse coded)
2. To what extent can personnel actually rely on established procedures and practices for performing R&D offshore tasks? (Reverse coded)
3. To what extent is there an understandable sequence of steps that can be followed in doing the tasks in your unit? (Reverse coded)
4. To what extent is there a clearly defined body of knowledge of subject matter that can guide the tasks done in your unit? (Reverse coded)

Modular process (Cronbach's alpha = 0.51)

1. Improving work processes has become a key part of our R&D offshoring efforts.
2. We have documented the steps involved in our key work processes for R&D offshore tasks.
3. We have defined business processes for R&D offshoring that cut across functional boundaries.
4. We have standardized work processes for R&D offshoring across departments and business units.

Knowledge articulation and coding (Cronbach's alpha = 0.60)

1. We maintain a record (in the form of a memo, note, report, or presentation) of all major incidents, decisions, or actions associated with the R&D offshoring.
2. We regularly report on the progress and performance of the collaboration to management.
3. We follow a specific 'process or routine' to manage the R&D offshore tasks effectively.
4. Resources such as checklists or guidelines are developed and used to assist with actions for an effective R&D offshoring.
5. Resources such as offshoring manuals (containing tools, templates, or frameworks) are developed and used to assist with decision making or actions for an effective R&D offshoring.
6. The company updates the R&D offshoring checklists, guidelines, or manuals that have been developed and are in use.

Knowledge sharing and internalization

1. We regularly discuss and share our prior and current R&D offshore experiences internally with other employees.
2. The company maintains a 'repository' or database containing factual information regarding each of its R&D offshoring tasks (e.g., date and purpose of the collaboration formation, the name of the collaboration partner, names of managers/executives who manage that collaboration, etc.).
3. We participate in forums such as committees or task forces to share our R&D offshoring experiences and practices.
4. We engage in informal sharing and exchange of R&D offshoring-related information and know-how with peers or colleagues within the organization.
5. We rotate those employees that have substantial prior experience in R&D offshoring.
6. Company management conducts a 'collective review' to assess the progress and performance of R&D offshoring tasks.
7. We attend in-house training programs for managing R&D offshoring tasks effectively.
8. We provide the opportunities for on-the-job R&D offshoring task training to individuals who are relatively new to the offshoring activities.
9. Employees can access documented and codified information and know-how on prior and ongoing R&D offshoring task experiences.

10. Company managers attend externally conducted training programs on R&D offshoring task management whenever they are assigned to manage or work with any alliance.

Collaboration competence (Cronbach's alpha = 0.60)

1. To what extent is it challenging to perform the R&D offshoring tasks, due to a low level of knowledge and experience at the partner unit regarding the product, process, and tools?
2. To what extent are you able to leverage the multiple skills and competencies of the R&D offshoring resources?
3. To what extent are you able to effectively realize design to cost and commonality in the R&D offshoring tasks?
4. To what extent are you able to effectively realize design for manufacturing and assembling in the R&D offshoring tasks?
5. To what extent is the R&D offshoring tasks challenging due to a lack of adequate experience among in-house employees working in a globally distributed setting?

Trust (Cronbach's alpha = 0.53)

1. To what extent are you concerned about issues related to confidentiality (i.e., data privacy and data transfer) during the R&D offshoring?
2. To what extent do you feel that the data and information exchange is secure in the R&D offshoring?
3. To what extent do you feel that the R&D offshoring engineers are part of your extended team?
4. To what extent is the R&D offshoring team managed through control rather than trust?
5. To what extent are you concerned about in-house job losses due to the R&D offshoring?

Culture

1. To what extent does the R&D offshore collaboration suffer from the differences related to organizational culture (e.g. behavior, norms, work approach and etc)?
2. The what extent is R&D offshore collaboration challenging because of the difficulty to change the mindset and motivate in-house employees to support and adapt offshore collaboration?

Offshore task uncertainty (Cronbach's alpha = 0.56)

1. To what extent is the R&D offshoring tasks are repetitive in nature? (Reverse coded)
2. To what extent do you perform similar R&D offshoring task in a similar way most of the time? (Reverse coded)
3. To what extent would you say that the R&D offshoring task of your unit is formally routinized? (Reverse coded)
4. To what extent are the jobs in your unit same from day to day in R&D offshoring tasks? (Reverse coded)