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LEVERAGING CUSTOMER INVOLVEMENT FOR FUELING INNOVATION: THE ROLE OF RELATIONAL AND ANALYTICAL INFORMATION PROCESSING CAPABILITIES[1]

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How do IT-enabled capabilities influence firms' ability to leverage customer involvement and shape the amount of firm innovation? This study theorizes that effective processing and management of customer information flows requires organizations to possess "relational information processing capability" (RIPC) and "analytical information processing capability" (AIPC). Drawing on and extending the theories of absorptive capacity and complementarities in the context of innovation, we posit that RIPC and AIPC complement product-focused customer involvement (PCI) and information-intensive customer involvement (ICI) practices, respectively, to enhance the amount of firm innovation. To test our hypotheses, we collected archival data from more than 300 large U.S. manufacturing firms and mapped their RIPC and AIPC to specific IT applications.

Consistent with our theorizing, we find that RIPC positively moderates the relationship between PCI and amount of firm innovation and that AIPC positively moderates the relationship between ICI and amount of firm innovation. In further exploratory analysis, we find a positive three-way interaction between AIPC, RIPC, and PCI. Taken together, the results suggest that configurations of IT-enabled capabilities alone are not enough for innovation; instead, firms benefit more when specific configurations of IT-enabled capabilities are leveraged in unison with specific types of customer involvement. The study contributes to theory and practice by shedding light on important complementarities between specific types of customer involvement (PCI and ICI) and specific IT-enabled capabilities (RIPC and AIPC).

Keywords: Digital innovation, customer involvement, information technology, relational information processing capability, analytical information processing capability, business value of IT

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The appendices for this paper are located in the "Online Supplements" section of the *MIS Quarterly*'s website (http://www.misq.org).

Introduction

In recent years, there has been a paradigm shift in how companies innovate. The traditional heavy focus on a firm's own resources has given way to a model in which firms innovate by tapping into external sources, such as customers and partners (Majchrzak and Malhotra 2013). Customers are pivotal sources of knowledge, and involving customers in innovation processes helps translate their needs into new products (Nambisan 2002; Prahalad and Ramaswamy 2000). For example, the Lego Group involves customers in innovation processes, and Sony developed its PlayStation 2 in collaboration with customers (El Sawy et al. 2016; Li and Calantone 1998). The importance of customer involvement in innovation processes is recognized in marketing research and contemporary management practices such as design thinking and agile methodologies (Hult et al. 2017; Ramasubbu et al. 2015; Rigby et al. 2016; Rose 2013). Although some studies provide useful conjectures on the importance of customer involvement for firm innovation, others suggest that customer involvement may not be as beneficial and can even hinder innovation.[2] For example, Ittner and Larcker (1997, p. 21) conclude that their statistically insignificant or negative results for customer involvement imply that an

> overemphasis on customer feedback in the design process can make a firm reactive rather than proactive and can push the organization to exceed its capabilities in an attempt to provide products that respond to every customer demand.

Some researchers suggest that other factors may affect the relationship between customer involvement and innovation. For example, Campbell and Cooper (1999, p. 513) note,

> Given the surprising lack of impact of [customer] partnering on new product performance results, an obvious question becomes: are there other factors not accounted for which may explain the insignificant results?

We argue that information technology (IT) capabilities may be among the important factors that affect the relationship between customer involvement and amount of innovation, which we define as innovations developed by the firm as measured by number of patents (Schilling and Phelps 2007). Firms such as Adidas and Procter & Gamble use IT platforms to imbibe customer insights into their product development. Advances in Internet technologies have magnified opportunities for firms to interact with customers and to link technology and customer competences (Varadarajan and Yadav 2009). Our efforts are motivated by calls to understand and test specific mechanisms that explain how IT enables customer-focused innovation (Majchrzak and Malhotra 2013).

Our core thesis is that specific IT-enabled capabilities complement the relationships between specific kinds of customer involvement and innovation. We ground our study in the theories of absorptive capacity and complementarities in the context of innovation, and we draw on arguments in innovation research suggesting that although customers are sources of knowledge for innovation, whether and how well knowledge from customers is leveraged for innovation depends on the firm's capabilities that enhance its absorptive capacity to leverage external information from customers and other partners (Cohen and Levinthal 1990; Foss et al. 2011). We argue that the use of relevant IT, not just more IT, helps assimilate external knowledge from customers, which in turn influences the amount of innovation. Our theorizing and findings provide potential explanations for divergent findings in prior research related to customer involvement and help managers understand the types of IT-enabled capabilities that facilitate a customer-oriented model of innovation. Our results suggest that IT can play a role in facilitating digital innovation in collaboration with customers (and, in general, the broader ecosystem of partners) by enhancing the absorptive capacity of the firm via relevant digital infrastructure and IT-enabled capabilities.

Background, Theory, and Hypotheses

Prior Literature

We draw on three streams of literature: customer involvement, innovation, and information systems (IS).[3] Prior research on customer involvement points to benefits and risks of customer involvement (see Table A1 in Appendix A). On the one hand, involving customers can improve outcomes such as innovation speed (Carbonell et al. 2009) and customer satisfaction (Bendapudi and Leone 2003). On the other hand, involving customers can cause challenges such as lower product innovativeness (Lawton and Parasuraman 1980), information overload from customer opinions (Hoyer et al. 2010), and process delays (Subramanyam et al. 2010). This literature suggests that the overall effect of customer involvement may well be contingent on other factors, and how these factors moderate the relationship between customer involvement and innovation is ultimately an empirical question.

[2]See Table A1 in Appendix A for a review of prior studies related to customer involvement.

[3]Figure A1 (Appendix A) depicts where our study fits relative to illustrative studies in the three literature streams.

Our review of the innovation literature and the IS literature points to IT as one such factor. For example, prior work suggests that IT can enhance innovation through improved knowledge management (Joshi et al. 2010; Song et al. 2007), product development management (Pavlou and El Sawy 2006), new product performance (Barczak et al. 2007), and innovation process efficiency (Durmusoglu et al. 2006). Prior research at the nexus of IT, customer involvement, and innovation suggests that firms can use IT-enabled platforms to execute collaborative innovation models with customers (Nambisan and Baron 2009). To the extent that innovation originates from ideas and decisions made during idea development (Kornish and Ulrich 2014), IT capabilities that promote imbibing ideas and improved decisions during idea development may increase innovation. Nevertheless, there is limited research linking IT to innovation, barring some notable exceptions (e.g., Banker, Bardhan and Asdemir 2006; Di Benedetto et al. 2008; Kleis et al. 2012; Nambisan 2003, 2013; Ravichandran et al. 2017). Regarding the IT capabilities we study (which we discuss in greater detail subsequently), although the literature argues that customer relationship management (CRM) systems improve customer satisfaction and thereby firm performance (Mithas et al. 2005, 2016; Reinartz et al. 2004), it also reports mixed results (see Table A2 in Appendix A). Likewise, although research suggests that business analytics systems can help firms "sense" the market and enhance their decision-making abilities (Chen et al. 2012; Sharma et al. 2014), few quantitative empirical studies link business analytics to innovation. To the best of our knowledge, there are no studies that specifically and empirically examine the role of IT capabilities in facilitating customer involvement for innovation. Our study addresses this gap in the literature.

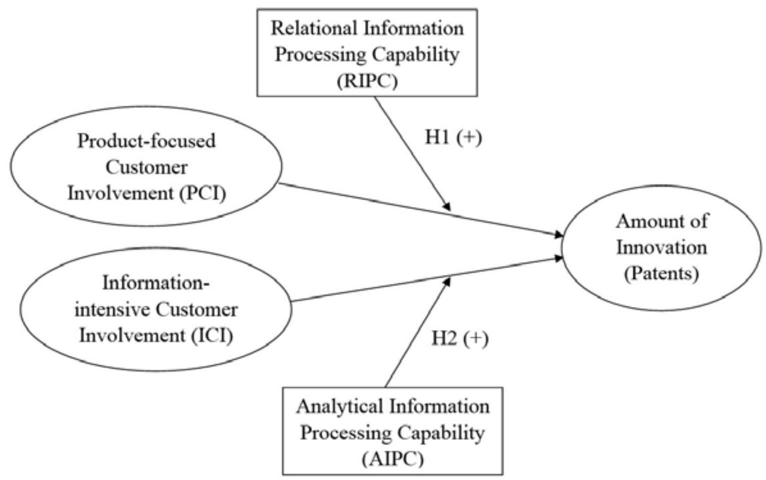
Theory Development

We draw on absorptive capacity theory, which argues that the ability to exploit, assimilate, and apply external knowledge contributes to firms' absorptive capacity, which in turn may contribute to innovation (Cohen and Levinthal 1990). Prior research in innovation and marketing emphasizes that although customer involvement is a mechanism for incorporating external input and knowledge from customers in innovation, whether and how well knowledge and input from customers are utilized and leveraged depend on the firm's capabilities related to its absorptive capacity to leverage information from customers and translate it into innovation (Foss et al. 2011; Jayachandran et al. 2005). Consistent with the view that IS can shape innovation (Majchrzak and Malhotra 2013), we argue that the differential ability of firms to transform information, knowledge, and inputs from customer involvement into innovation lies in their differential IT-enabled capabilities. These arguments are also consistent with those in the theory of complementarities, which suggest that the role of IT in innovation can be complemented by organizational processes such as involving customers in product development (Fichman and Nambisan 2009).

Recognizing that complementarities theory needs to be specified with more granularity to understand the precise role of IT capabilities and customer involvement in jointly influencing the amount of innovation, we articulate specific mechanisms and IT capabilities that apply in this context. We define *customer involvement* as the extent to which a firm interacts with representatives of one or more customers in developing products (Carbonell et al. 2009). Prior research has identified several roles of customers in product development: resource, coproducer, buyer, user, and product; of these, the first two are more significant in innovation because they reflect the upstream or input side of innovation activity (Nambisan 2002, p. 394). Drawing on this literature, we make a distinction between what we call *information-intensive customer involvement* (ICI) and *product-focused customer involvement* (PCI). We define ICI as a type of involvement focused on gathering information from customers via customer opinions and feedback and structured inquiry mechanisms such as focus groups (Nambisan 2002). In this type of involvement, the firm involves customers as a resource to source information, opinions, and feedback (Nambisan 2002). We define PCI as the type of involvement in which the firm engages customers in a participative role in codeveloping products, and it manifests in key customers driving product development or doing custom configuration of products (Nambisan 2002). Thus, in contrast to ICI, PCI represents more active involvement of customers as codevelopers of products (Fang 2008; Nambisan 2002).

We view ICI and PCI as management interventions that are complemented by IT-enabled capabilities to influence the amount of firm innovation. Prior research suggests that to effectively leverage ICI for innovation, firms need to have the ability to derive insights from complex signals obtained from ICI (Hoyer et al. 2010). Likewise, for effective PCI, firms must forge meaningful relationships with customers (Garcia-Murillo and Annabi 2002).

We define specific IT-enabled capabilities that are pertinent to providing these complementary abilities. First, we define *analytical information processing capability* (AIPC) as the extent to which a firm uses business analytics technologies or applications that analyze critical business data to better understand its business and market and make timely business decisions (Chen et al. 2012). Business analytics technologies such as data warehousing and data mining enable firms to generate insights from information obtained from customers.



Note: Control variables are omitted for clarity.

Figure 1. Research Model

Such technologies facilitate storage and retrieval of the history of events related to interactions with customers and can be used to leverage previously stored information to create new innovations (Malhotra et al. 2005). Thus, we theorize that AIPC complements the relationship between ICI and amount of firm innovation. Second, we define *relational information processing capability* (RIPC) as the extent to which a firm uses CRM-related IT applications to support organizational work processes pertaining to managing relationships with customers (Zablah et al. 2012). RIPC helps firms develop and manage customer relationships by effectively utilizing IT to acquire and manage customer knowledge bases (Reinartz et al. 2004). We theorize that RIPC enhances the firm's ability to develop relationships with customers and identify appropriate customers for PCI, thus facilitating more innovation from PCI.

In summary, building on prior literature, our core theory (Figure 1) is that the links between specific types of customer involvement (PCI and ICI) and amount of firm innovation are moderated by specific IT-enabled capabilities (RIPC and AIPC). Although we expect baseline positive relationships between customer involvement (PCI and ICI) and amount of innovation, we focus here on the moderating effects of RIPC and AIPC.

Hypotheses

Our first hypothesis pertains to the complementarity of RIPC and PCI. First, because PCI refers to active involvement of customers in codeveloping products, it involves developing a relationship type of exchange with customers (Etgar 2008). Such involvement, along the principles of relationship marketing, "upholds the active and participative interaction between the parties of the relation as the most important source of market knowledge" (Lagrosen 2005, p. 425). Because PCI takes on features of a collaborative relationship between a firm and customers and because ineffective management of customer relationships in product codevelopment is a key impediment to innovation (Athaide and Stump 1999), firms need relational capabilities for developing long-term and close relationships with key customers that drive product development. RIPC enabled by CRM systems helps discern customer behavior and facilitate effective relationship building with customers (Jayachandran et al. 2005). For example, using CRM for tracking customer loyalty, satisfaction, personalized marketing, and customer support yields RIPC that firms can use to develop and sustain customer relationships (Reinartz et al. 2004).

Second, involving customers in product codevelopment via product configuration and having customers drive product development helps firms identify options that will optimize product configurations (Nijssen and Lieshout 1995). However, the efficacy of such optimization is increased when the firm also has the capacity to effectively process information related to its customer relationships, so that customer inputs can be appropriately weighted. Prior research argues that for effective customer involvement in codeveloping products, firms need to segment various types of customers (Desouza et al. 2008). For example, customers who are innovators can help drive innovation (Leiponen 2000), whereas other types of customers may be less useful for this purpose. Segmenting customers is an important step toward developing an absorptive capacity for recognizing customer knowledge and incorporating it into a firm's strategy (Sawhney and Prandelli 2000). Strong RIPC can help a firm segment its customers into relevant categories (e.g., innovators versus emergent consumers) based on their interactions with the firm. Because different categories of customers have different motivations to participate in product codevelopment and because different skills are required to provide inputs as part of codeveloping products (Etgar 2008), RIPC can enhance the conversion of such inputs into more innovation by facilitating segmentation and identification of appropriate customers for product codevelopment (Chen and Ching 2004).

Furthermore, RIPC, via the development of personalized customer profiles and a better understanding of personalized market preferences, can equip firms with individualized customer knowledge that is critical for leveraging PCI for innovation (Liang and Tanniru 2007). By using CRM systems to track customer loyalty and satisfaction, firms can develop their RIPC, which in turn helps them prioritize customers on the basis of their unique value potential and better respond to personalized customer needs for products identified via PCI (Zablah et al. 2012).

In summary, RIPC enhances the firm's ability to develop and manage customer relationships, identify appropriate customers for PCI, and identify customers' personalized needs for products. Together, these improve the firm's absorptive capacity to benefit from PCI in terms of more innovation. Formally, we offer the following hypothesis:

> **Hypothesis H1**: *Relational information processing capability (RIPC) positively moderates the relationship between product-focused customer involvement (PCI) and the amount of firm innovation.*

Next, we posit that AIPC positively moderates the relationship between ICI and amount of innovation, for three reasons. First, research suggests that ICI can yield large volumes of customer input that can lead to information overload (Hoyer et al. 2010). AIPC helps firms overcome information overload by deriving insights from large volumes of data, uncovering patterns among seemingly unrelated pieces of information, and distributing information from customers across the firm. This improved information management enhances the firm's ability to analyze customer-sourced information and identify feasible avenues for innovation (Song et al. 2007). For example, Best Buy used a business analytics approach to leverage input from its customers for competitive advantage (SAS 2011). Conversely, manufacturers in Europe and North America have recognized that the lack of tools to analyze customer inputs has been a key restraint to leveraging customer insights (Iyer et al. 2014).

Second, to effectively leverage ICI for innovation, firms need to weigh market trends against individual customer suggestions to better understand the potential for product overlap and market interest in new products (Ottum and Moore 1997). With AIPC, firms can model such factors and adjust product designs accordingly. AIPC provides a firm with an external market-sensing capability to identify industry trends and customer interests that align with its product development strategy (Joshi et al. 2010). AIPC helps firms integrate market information, customer-sourced information, and internal factors such as skills and product positioning (Ottum and Moore 1997). For example, data mining facilitates the discovery of new information about markets and customers, providing more avenues for innovation (Chen and Ching 2004).

Third, AIPC improves information access for decision makers (Sharma et al. 2014), providing the ability to analyze and repurpose data, which in turn can lead to actionable insights and contexts for information about customers. Firms with AIPC are better equipped with insights that enable them to imbibe customer opinions more effectively into their development processes (Ramamurthy et al. 2008). Data mining and data warehousing help firms make better decisions and select the most effective solutions among a multitude of options. AIPC facilitates the storage and retrieval of a history of events related to customer interactions and enhances organizational memory to leverage previously stored information to create new innovations (Malhotra et al. 2005).

In summary, we argue that AIPC helps firms manage information overload, combine external information with internal factors, and provide improved information access to decision makers. In turn, this capability improves the firm's absorptive capacity to leverage information from ICI for innovation. Formally, we offer the following hypothesis:

> **Hypothesis H2**: *Analytical information processing capability (AIPC) positively moderates the relationship between information-intensive customer involvement (ICI) and the amount of firm innovation.*

Research Design and Methodology

Data and Sources

We collected data from several sources. First, we obtained IT-related data from *InformationWeek*, a leading IT publication in the United States, which collected survey data in 2002 from senior IT managers and chief information officers (CIOs). In line with prior research, data collection from CIOs and senior IT managers is important because they are in a good position as key respondents to be knowledgeable of the firm's IT practices (Aral and Weill 2007). *InformationWeek* surveys are reliable data sources and have been used in prior research (e.g. Bharadwaj et al. 1999). The survey also captured the extent to which firms involved their customers in product development. Second, for amount of firm innovation, we collected firm-level patent data from the U.S. Patent and Trademark Office. Third, we collected firm-level control variables from Standard & Poor's Compustat database and U.S. Securities and Exchange Commission (SEC) filings. Finally, we collected industry data from the U.S. Census Bureau. After we matched firms across the various data sets, dropped incomplete observations and outliers based on recommended procedures (Greene 2003), and dropped firms in service industries because they do not have a common patenting practice (Joshi et al. 2010), the final sample comprised 310 firms in manufacturing industries, including industries such as electrical and electronics, pharmaceuticals, home appliances, telecommunications equipment and appliances, and metals.[4]

Variables

Amount of Innovation (Innovation). Patenting activity is widely recognized as a reliable measure of amount of innovation (Ahuja et al. 2008; Joshi et al. 2010; Schilling and Phelps 2007) that can be externally validated through the patent examination process (Griliches 1990). Consistent with prior research, we use patent application data for the firm one year subsequent to the year of the IT data, to incorporate a lag from inputs to outputs (Sampson 2007; Wadhwa and Kotha 2006). Using the patent application date rather than the issue date is common practice in the literature because it is the earliest point at which we can identify new firm capabilities, and it represents the best measure of the time when patentable work was actually completed and avoids methodological issues caused by lags between patent filing and issue (Sampson 2007; Wadhwa and Kotha 2006).[5] For robustness, following prior research (Wadhwa and Kotha 2006), we repeated the analyses using patents that had application dates two years subsequent to the IT data and found substantively similar results.

RIPC and AIPC. We measure RIPC as a summative index that captures deployment of CRM systems for (1) customer service and support, (2) tracking customer loyalty or satisfaction, (3) product marketing and information, and (4) personalized marketing. This measurement is consistent with how other studies measure technology use (see Table A2 in Appendix A). For example, Jayachandran et al. (2005) use an aggregate measure of CRM related to functions such as sales support, marketing support, and service support. Likewise, Zablah et al. (2012) use summative indices of CRM interaction support tools and CRM prioritization tools. We measure AIPC as a summative index of the deployment of (1) data mining and (2) data warehousing in the firm. These technologies have been identified in prior research as critical for business analytics (Chen et al. 2012).[6]

ICI. We measure ICI as a summative index of (1) customer participation in focus groups or formal user feedback and (2) the extent to which customer opinion is solicited and analyzed. This operationalization is consistent with and similar to items used in prior research. For example, prior research has measured customer involvement using items such as the extent to which firms screen customer opinions (Chien and Chen 2010), consult with customers via means such as focus groups, and analyze customer opinions (Carbonell et al. 2009; Chien and Chen 2010; Lawton and Parasuraman 1980), and clarify user needs (Gupta and Souder 1998).

PCI. We measure PCI as a summative index of the extent to which (1) customers custom-configure products and (2) key customers drive product development. This operationalization is consistent with the definition of customer involvement as the extent to which the firm involves customers in producing products (Dabholkar 1990) through, for example, custom configuration and driving product development. It is also in line with the definition of coproduction as the engagement of "customers as active participants in the organization's

[4]Because we use patents as the dependent variable, it is important to select industries that use patents. There is evidence that firms in these industries actively patent their innovations (Levin et al. 1987). Furthermore, the industries in our study are similar to those in prior empirical studies related to innovation, new product development, and customer linking capabilities (e.g., Patel and Pavitt 1997; Schilling and Phelps 2007; Song et al. 2005; Wagner 2007).

[5]Modeling patents in this way also limits the possibility of reverse causality. Nonetheless, our regression estimations using two-stage empirical models (discussed in the following subsection and in Appendix B) account for potential endogeneity.

[6]Our approach of operationalizing RIPC and AIPC as the IT applications that enable these capabilities is consistent with prior IS studies that use secondary data on IT applications to assess IT-enabled organizational capabilities (Joshi et al. 2010; Sabherwal and Sabherwal 2007). For example, Joshi et al. (2010) operationalize IT-enabled absorptive capacities by counts of IT applications that provide those capabilities. Our use of summative indexes is similar to studies that use summative indices of binary measures to capture IT use (Banker, Bardhan, Chang and Lin 2006; Saldanha et al. 2013).

Table 1. Variables

Variable	Description	Source
Amount of innovation (Innovation)	The number of the firm's patents that had an application date one year subsequent to the IT data. We also repeated the analysis using a two-year lag and found substantively similar results.	U.S. Patent and Trademark Office
Relational information processing capability (RIPC)	Summative index that captures deployment of CRM systems to support business processes for (1) customer service and support, (2) tracking customer loyalty or satisfaction, (3) product marketing and information, (4) personalized marketing.	*InformationWeek*
Analytical information processing capability (AIPC)	Summative index of the wide deployment of the following business analytics technologies in the firm: (1) data mining and (2) data warehousing.	*InformationWeek*
Product-focused customer Involvement (PCI)	We measure PCI with a composite measure created by summing the following two indicators: (1) customers can custom configure products and (2) key customers drive product development.	*InformationWeek*
Information-intensive customer involvement (ICI)	We measure ICI with a composite measure created by summing the following two indicators: (1) customers participate in focus groups or formal user feedback and (2) customer opinion is solicited and analyzed.	*InformationWeek*
Alternative measure of RIPC (RIPCAlt)	A binary variable indicating if modern CRM systems are widely deployed in the firm.	*InformationWeek*
Alternative measure of AIPC (AIPCAlt)	Percentage of knowledge workers in the firm who use business analytics tools such as OLAP or data mining to access data stored on the firm's enterprise-class servers and mainframes or data warehouse systems.	*InformationWeek*
RIAISum	Summation of (standardized) RIPC and AIPC.	Computed from RIPC and AIPC
Firm size	(Log of) annual revenue of the firm.	Compustat
IT intensity	Firm's IT budget as share of revenue.	*InformationWeek*
R&D intensity	Ratio of R&D expenditure to sales.	Compustat, SEC filings
IT R&D intensity	Share of the IT budget devoted to R&D.	*InformationWeek*
Prior innovation	Number of patents granted to the firm that had an application date one year prior to the IT data.	U.S. Patent and Trademark Office
Prior profitability	Return on assets for the prior year, calculated as the ratio of net income to total assets.	Compustat
Culture of customer collaboration	How important customer collaboration is as an element of the company's corporate culture. (Ranked on a 1–10 scale where 1 is most important. For ease of interpretation, we transformed it to a 0–9 ranked scale.)	*InformationWeek*
Culture of customer satisfaction	How important customer satisfaction is as an element of the company's corporate culture. (Ranked on a 1–10 scale where 1 is most important. For ease of interpretation, we transformed it to a 0–9 ranked scale.)	*InformationWeek*
Culture of innovation	How important innovation is as an element of the company's corporate culture. (Ranked on a 1–10 scale where 1 is most important. For ease of interpretation, we transformed it to a 0–9 ranked scale.)	*InformationWeek*
IT staff rewards	Three-item summative index of whether the firm provides (1) cash incentives to IT staff members, (2) stock bonuses to IT staff members, or (3) stock options to IT staff members.	*InformationWeek*
ERP	Whether there is a wide deployment of enterprise resource planning (ERP) in the firm.	*InformationWeek*
Industry concentration	Four-firm concentration ratio at the six-digit (or most detailed available) North American Industry Classification System level.	U.S. Census Bureau
High-tech and low-tech industry	Industries are classified as high-tech, low-tech, or neither based on a classification scheme used in prior research (Banker et al. 2011).	U.S. Census Bureau
Industry sector dummies	Industry dummies representing the industry sector to which the firm belongs.	—

Table 2. Descriptive Statistics and Correlations

		Mean	SD	1	2	3	4	5	6	7	8	9
1	Innovation	87.08	151.20	1								
2	ICI	1.70	0.57	0.01	1							
3	PCI	1.15	0.75	0.14*	0.32*	1						
4	AIPC	1.51	0.65	0.11*	0.04	0.06	1					
5	RIPC	2.76	1.08	0.06	0.02	0.03	0.34*	1				
6	IT intensity	4.56	7.38	0.03	-0.02	0.04	0.12*	0.23*	1			
7	R&D intensity	2.55	5.83	0.53*	-0.00	0.15*	0.07	0.09	-0.03	1		
8	IT R&D intensity	3.22	4.26	0.04	0.09	0.17*	0.08	0.11*	0.05	0.20*	1	
9	Firm size	22.32	1.09	0.10	0.14*	0.11*	0.19*	0.13*	-0.02	-0.01	-0.09	1
10	Prior profitability	0.07	0.09	-0.08	-0.01	-0.03	-0.04	-0.03	0.02	-0.18*	0.03	-0.12*
11	Firm age	58.40	39.82	-0.08	-0.01	-0.04	-0.01	-0.07	-0.11*	-0.06	-0.03	0.16*
12	ERP	0.78	0.41	-0.01	0.15*	-0.06	0.21*	0.19*	0.07	-0.02	-0.01	0.10
13	IT staff rewards	2.55	0.72	0.08	0.24*	0.19*	0.21*	0.29*	0.04	0.09	0.06	0.10
14	Culture of innovation	4.95	2.31	0.17*	0.12*	0.13*	0.11*	0.12*	0.05	0.20*	0.13*	0.07
15	Culture of customer collaboration	4.72	2.61	0.07	0.06	0.20*	0.02	0.09	0.04	0.09	0.08	-0.02
16	Culture of customer satisfaction	7.72	1.81	0.06	0.23*	0.05	0.14*	0.18*	0.06	-0.00	-0.00	-0.06
17	High-tech industry	0.59	0.49	0.23*	0.00	0.11	0.09	0.11	0.18*	0.35*	0.15*	0.10
18	Low-tech industry	0.04	0.21	-0.06	0.00	-0.05	-0.01	-0.06	-0.09	-0.09	-0.07	-0.03
19	Industry concentration	33.64	21.29	0.14*	0.03	0.07	0.09	0.07	0.02	0.21*	0.09	0.04
				10	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
10	Prior profitability			1								
11	Firm age			0.15*	1							
12	ERP			0.11	-0.06	1						
13	IT staff rewards			0.11*	-0.02	0.19*	1					
14	Culture of innovation			-0.01	-0.04	0.02	0.07	1				
15	Culture of customer collaboration			-0.09	-0.04	-0.02	-0.03	-0.03	1			
16	Culture of customer satisfaction			-0.02	-0.11*	0.07	0.09	-0.06	0.08	1		
17	High-tech industry			-0.04	0.05	0.00	0.04	0.15*	0.09	0.07	1	
18	Low-tech industry			-0.07	-0.06	-0.10	0.05	0.08	0.04	-0.03	-0.27*	1
19	Industry concentration			0.00	-0.10	0.01	-0.01	0.14*	-0.07	0.02	0.15*	-0.00

Note: * indicates significance at α = 0.05.

work" (Lengnick-Hall et al. 2000, p. 364) and similar operationalizations in prior research in terms of customers being involved in close collaboration (Foss et al. 2011) and customers' work constituting a significant portion of the development effort (Fang 2008).

Control Variables. As control variables, *size* and *prior profitability* account for the abundance of resources (Bharadwaj 2000). *IT intensity* accounts for overall IT investment (Bharadwaj et al. 1999). *Age* and *culture* variables control for cultural differences (Sørensen and Stuart 2000). *R&D intensity* and *ITR&D intensity* control for innovation-related R&D and IT investments, respectively. *Prior innovation* controls for the effects of relative differences in prior innovation capability. *Industry concentration* accounts for competition (Bharadwaj et al. 1999). *High/low-tech industry* and *sector* dummies control for variance in innovation propensity across industries (Banker et al. 2011).

Table 1 provides details of all the variables. Table 2 shows descriptive statistics and correlations.

Empirical Models and Econometric Considerations

The dependent variable (patents) can be treated as a count of innovation events. Because likelihood ratio tests indicated overdispersion in our data, we use negative binomial models, consistent with recommendations in prior research (Cameron and Trivedi 2013), to estimate the equation:

$$\text{Innovation} = f\,(\text{PCI, ICI, RIPC, AIPC, RIPC} \times \text{PCI, AIPC} \times \text{ICI, control variables}) \quad (1)$$

The probability distribution function for the negative binomial model, estimated with maximum likelihood, is:

$$h(y|\mu,\alpha) = \frac{\Gamma(\alpha^{-1}+y)}{\Gamma(\alpha^{-1})\Gamma(y+1)}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu}\right)^{\alpha^{-1}}\left(\frac{\mu}{\mu+\alpha^{-1}}\right)^{y}$$

where $\mu = e^{\beta X}$, X is the vector of independent variables, β is the vector of parameters, α is the overdispersion parameter, and Γ(.) is a gamma integral (Cameron and Trivedi 2013). Y has a mean of μ and variance of $\mu(1 + \alpha\mu)$.

We accounted for potential endogeneity using Garen's (1984) methodology, which is a residual analysis technique to correct for selection bias and has been used in prior studies (e.g., Ghosh et al. 2006).[7] The rationale for the selection mechanism is that AIPC and RIPC may be endogenous because firms may self-select into using AIPC- and RIPC-enabling technologies based on certain factors, some observable to researchers (e.g., firm size) and others unobservable (e.g., managerial traits that lead them to support investments in AIPC, RIPC, and innovation). Garen provides a generalization of Heckman's (1979) two-stage estimator and accounts for the continuous nature of the selection variable. We created a variable that is the sum of the standardized RIPC and AIPC variables. Intuitively, this variable (labeled RIAISum) represents the level of AIPC and RIPC in the firm. Then, we estimated the first stage by regressing RIAISum on factors likely to impact RIPC and AIPC (eq. (2)). We used generalized least squares (GLS) to account for heteroskedasticity (Garen 1984). We then calculated residuals from the first-stage equation and included $\tilde{\eta}$ and the interaction term $\tilde{\eta}$ × RIAISum as endogeneity correction terms in the innovation equation (eq. (3)). Here, $\tilde{\eta}$ corrects for selection bias, and $\tilde{\eta}$ × RIAISum accounts for unobserved heterogeneity over the range of our continuous selection variable. The equations are as follows:

[7]We thank an anonymous reviewer for suggesting the use of Garen's approach.

$$\underline{\textit{Stage 1}}\text{: RIAISum} = \beta_a + \beta_r W + u \quad (2)$$

$$\underline{\textit{Stage 2}}\text{: Innovation} = f(\text{PCI, ICI, RIPC, AIPC, RIPC} \times \text{PCI, AIPC} \times \text{ICI}, \tilde{\eta}, \tilde{\eta} \times \text{RIAISum, controls}) \quad (3)$$

where W is the vector of variables in the first stage, u is the error term, and $\tilde{\eta}$ is the estimate of residuals from the first stage. We used firm and industry characteristics as regressors in the first stage.

Among the variables in the first stage, we include an additional variable ITStaffRewards, which serves as an exclusion restriction and aids in model identification (Greene 2003). IT staff financial rewards are likely to be correlated with AIPC and RIPC because they may be indicative of a firm that is aggressive in IT investments and invests more in sophisticated IT applications that enable AIPC and RIPC. Furthermore, financial rewards for IT staff, in and of themselves, are unlikely to significantly influence the amount of innovation (patenting). Thus, ITStaffRewards is a reasonable exclusion restriction in our study. As the results show, this variable is positive and significant in the first-stage equation, suggesting that it is valid for inclusion in the first stage, and it was nonsignificant when we included it in the second-stage innovation equation.

We also used alternative approaches to address endogeneity. First, we used an extension of Garen's model that has been used in prior research (Luan and Sudhir 2010) for scenarios in which multiple potentially endogenous variables may exist (details in Appendix B), and we found similar results. With this approach, the results are similar. Second, we adopted a method suggested and used in other studies (Bharadwaj et al. 2007; Shaver 1998); again, we obtain similar results (see Appendix B). The similarity of results across three approaches suggests that our findings are robust to alternative selection modeling approaches.

We took several additional steps to assess robustness. First, for each of the three selection modeling approaches, we used negative binomial models and generalized least squares (GLS) models, and we obtained similar results, thus increasing confidence in the reported estimates. Consistent with prior research, because the log of zero is undefined, we used log(1+ patents) as the dependent variable in the GLS estimations (Lerner 1994). Second, the variance inflation factors were well within acceptable limits, suggesting that multicollinearity is not a problem. Moreover, the correlations between variables are well below the threshold of 0.80, suggesting evidence of discriminant validity (Bagozzi et al. 1991; Mithas et al. 2008). Third, because the independent, dependent, and control variables are from different sources and the innovation variable is objective (not perceptual), this mitigates concerns of common method bias. Nonetheless, Harman's one-factor test showed no single major factor, and a "marker variable" test (Lindell and Whitney 2001) showed no substantial changes in correlations among variables after correcting for common method variance, suggesting that common methods bias is not a problem. In addition, because our core theory pertains to interactions, common method vari- ance is less concerning, as such variance reduces the likelihood of detecting interaction effects (Wall et al. 1996). Fourth, similar to prior research, given the summative (formative) nature of our independent variables (use of any measure does not imply use of others), traditional validation procedures were deemed inappropriate (Diamantopoulos and Winklhofer 2001). Nevertheless, when we used principal components analysis, the measures that comprise PCI and RCI loaded positively and significantly onto their first principal components. Finally, we performed several diagnostic checks, including testing for normality of residuals, outliers, and influential observations, and we found no problems or violations of assumptions (Greene 2003).

Results

Table 3 shows the estimates of the second stage (eq. (3)) of the model, which addresses endogeneity by including the endogeneity correction terms calculated from the first stage (Garen 1984).[8] Referring to the negative binomial estimates (columns 1 and 2), we observe a positive and significant relationship between PCI and innovation (column 1; $\beta = .10$, $p < .01$), and we find a nonsignificant coefficient of ICI. These suggest that PCI increases amount of innovation, whereas ICI may not increase amount of innovation. These unconditional effects are consistent with mixed findings in prior research (Carbonell et al. 2009; Fang 2008; Foss et al. 2011; Lawton and Parasuraman 1980) (see Table A1 in Appendix A).

We find support for H1 and H2: the coefficient of RIPC × PCI is positive and significant (column 2, $\beta = .31$, $p < .01$), consistent with H1, and the coefficient of AIPC × ICI is positive and significant (column 2, $\beta = .08$, $p < .01$), consistent with H2. The chi-square tests are also significant, suggesting that the interaction terms are not jointly zero (Greene 2003). The GLS models yield similar results (columns 3 and 4). We also tested models with each interaction term introduced separately and obtain similar results (omitted for brevity). The control variables are largely in the expected directions. For example, firms with higher size, R&D intensity, prior innovation, and more innovative culture have a higher amount of innovation.

We repeated the analyses using alternative measures of AIPC and RIPC. As an alternative measure of AIPC, we used the percentage of knowledge workers in the firm who use business analytics tools to access data stored on the firm's enterprise-class servers and mainframes or data warehouse systems. As an alternative measure of RIPC, we used a binary variable to indicate whether modern CRM systems are widely deployed in the firm. The results remain unchanged (Table 4), suggesting robustness of the results to alternative measures of AIPC and RIPC. We also ran models with no endogeneity corrections and obtain similar results. For further robustness, as we discussed previously, we repeated the analyses using patent data two years subsequent to the IT data, thus incorporating a two-year lag rather than a one-year lag. The results remain unchanged. Finally, when we performed the analyses including two additional interactions (RIPC × ICI, and AIPC × PCI), the findings remained unchanged, and the additional interactions were not significant.

Across a variety of estimation approaches, we find strong support for H1 and H2. Per our estimates, a unit increase in RIPC is associated with an increase in the effect of PCI on amount of innovation by a factor of exp(.31), or 36.34%. Likewise, the effect of ICI increases by exp(.08), or 8.33%, with a unit increase in AIPC. This suggests that the moderating effects are economically significant as well.

We conducted exploratory analyses to examine two-way and three-way interactions. First, we tested the interaction of AIPC and RIPC to explore whether they complement each other. Second, we explored three-way interactions to determine whether AIPC and RIPC, together with customer involvement, increase innovation by helping firms develop customer relationships using RIPC and analyze customer-sourced information using AIPC. The results (Table 5) show a nonsignificant two-way interaction of AIPC and RIPC (column 1, p = n.s.); a positive and significant three-way interaction of AIPC, RIPC, and PCI (column 4; $\beta = .16$, $p < .01$); and a nonsignificant interaction of AIPC, RIPC, and ICI (column 4, p = n.s.). These exploratory analyses suggest that IT capabilities by themselves may not be enough for innovation and that portfolios of customer involvement and IT capabilities may be better for innovation. In particular, product-focused customer involvement is a more important source for innovation that is enabled by IT capabilities than information-intensive customer involvement.

[8]Table A3 shows the estimates of the first stage (eq. (2)). The model is significant, and several variables are statistically significant. For example, as expected, larger firms, firms in high-tech industries, firms with high IT intensity, and firms with more rewards for IT staff have higher AIPC and RIPC.

Table 3. Main Results

	Negative Binomial Models		Generalized Least Squares (GLS) Models	
	(1)	(2)	(3)	(4)
	Innovation	Innovation	log(1 + patents)	log(1 + patents)
Product-focused customer involvement (PCI)	0.10*** (0.02)	0.031* (0.018)	0.05*** (0.01)	0.02** (0.01)
Information-intensive customer involvement (ICI)	-0.32 (0.25)	0.16 (0.20)	-0.10 (0.08)	-0.07 (0.07)
RIPC	0.04 (0.23)	-0.26 (0.26)	-0.05 (0.11)	-0.08 (0.09)
AIPC	0.01 (0.03)	0.05 (0.03)	0.003 (0.01)	0.001 (0.01)
RIPC × PCI (Hypothesis H1)		**0.31*** (0.06)**		**0.12*** (0.02)**
AIPC × ICI (Hypothesis H2)		**0.08*** (0.01)**		**0.07*** (0.01)**
Prior innovation	0.001** (0.0004)	0.001*** (0.0004)	0.50*** (0.05)	0.34*** (0.05)
R&D intensity	0.08*** (0.02)	0.09*** (0.02)	0.05** (0.02)	0.02** (0.01)
Firm size	0.31** (0.13)	0.34*** (0.11)	0.11* (0.06)	0.11** (0.04)
Culture of innovation	0.13*** (0.05)	0.07* (0.04)	0.06** (0.03)	0.05*** (0.02)
High-tech industry	0.02*** (0.004)	0.0005* (0.003)	0.01*** (0.003)	0.006*** (0.002)
ῆ	0.20 (0.25)	0.26 (0.25)	0.09 (0.12)	0.19** (0.09)
ῆ × RIAISum	-0.06* (0.04)	-0.14*** (0.05)	-0.01 (0.02)	-0.03* (0.02)
Wald chi-square/F-statistic	493.13***	582.13***	39.40***	44.81***
Chi-square test/F-test of significant coefficients of interaction		77.42***		53.70***
R-square	0.59	0.65	0.76	0.85
Observations	310	310	310	310

Notes: (1) Robust standard errors in parentheses. (2) Significant at *10%, **5%, and ***1% level. (3) Industry dummies, intercept, and control variables for firm age, *ITIntensity*, *ITR&DIntensity*, prior profitability, culture of customer collaboration, industry concentration, and low-tech industry are also included in all models. (4) We used the Garen (1984) methodology for estimation. (5) Terms containing ῆ are endogeneity correction terms calculated from the first stage. (6) We also tested models by introducing the interaction terms (RIPC × PCI and AIPC × ICI) one at a time and found substantively similar results (omitted for brevity).

Table 4. Sensitivity Analysis Using Alternative Measures of RIPC and AIPC (RIPCAlt and AIPCAlt)

	Negative Binomial Models		**Generalized Least Squares (GLS) Models**	
	(1)	**(2)**	**(3)**	**(4)**
	Innovation	**Innovation**	**log(1 + patents)**	**log(1 + patents)**
Product-focused customer involvement (PCI)	0.07*** (0.02)	0.043* (0.024)	0.03*** (0.01)	0.01* (0.006)
Information-intensive customer involvement (ICI)	-0.30 (0.22)	-0.24 (0.21)	-0.08 (0.08)	-0.08 (0.07)
RIPCAlt	0.07 (0.35)	-0.41 (0.48)	0.17 (0.12)	-0.02 (0.13)
AIPCAlt	0.31 (0.24)	-0.09 (0.37)	0.14 (0.11)	-0.11 (0.16)
RIPCAlt × PCI (Hypothesis H1)		**0.63*** (0.23)**		**0.29*** (0.10)**
AIPCAlt × ICI (Hypothesis H2)		**0.21*** (0.05)**		**0.09*** (0.05)**
Prior innovation	0.001** (0.0005)	0.001*** (0.0003)	0.48*** (0.06)	0.42*** (0.06)
R&D intensity	0.09*** (0.03)	0.12*** (0.03)	0.05** (0.02)	0.08*** (0.03)
Firm size	0.38*** (0.11)	0.23** (0.11)	0.09* (0.05)	0.02 (0.05)
Culture of innovation	0.16*** (0.05)	0.15*** (0.04)	0.05** (0.02)	0.04** (0.02)
High-tech industry	0.02*** (0.004)	0.01*** (0.004)	0.013*** (0.003)	0.007*** (0.003)
$\tilde{\eta}$	0.52** (0.25)	-0.15 (0.33)	0.23** (0.11)	-0.11 (0.14)
$\tilde{\eta}$ × RIAISumAlt	0.003 (0.05)	-0.07 (0.05)	0.02 (0.03)	0.03 (0.03)
Wald chi-square/F-statistic	477.25***	604.06***	33.28***	44.71***
Chi-square test/F-test of significant coefficients of interaction		25.22***		10.18***
R-square	0.60	0.63	0.76	0.79
Observations	310	310	310	310

Notes: (1) Robust standard errors in parentheses. (2) Significant at *10%, **5%, and ***1% level. (3) Industry dummies, intercept, and control variables for firm age, *ITIntensity, ITR&DIntensity*, prior profitability, culture of customer collaboration, industry concentration, and low-tech industry are also included in all models. (4) We used the Garen (1984) methodology for estimation. (5) Terms containing $\tilde{\eta}$ are endogeneity correction terms calculated from the first stage. (6) We also tested models by introducing the interaction terms (RIPCAlt × PCI and AIPCAlt × ICI) one at a time and found substantively similar results (omitted for brevity). (7) We used RIPCAlt and AIPCAlt to calculate RIAISumAlt. We ran the selection equation (not shown for brevity) using RIAISumAlt.

Table 5. Exploratory Analysis: Complementarity Between RIPC and AIPC, and Three-Way Interactions

	(1)	(2)	(3)	(4)
	Innovation	**Innovation**	**Innovation**	**Innovation**
Information-intensive customer involvement (ICI)	-0.30 (0.24)	0.11 (0.22)	-0.25 (0.25)	0.10 (0.21)
Product-focused customer involvement (PCI)	0.10*** (0.02)	0.037* (0.02)	0.13*** (0.04)	0.09** (0.04)
AIPC	0.01 (0.03)	0.01 (0.03)	0.01 (0.04)	0.07* (0.04)
RIPC	0.06 (0.23)	-0.25 (0.26)	-0.24 (0.26)	-0.25 (0.26)
AIPC × RIPC	**-0.02** **(0.03)**	**-0.02** **(0.02)**	**-0.006** **(0.03)**	**-0.02** **(0.02)**
AIPC × ICI		0.07*** (0.01)		0.08*** (0.01)
RIPC × ICI		0.01 (0.01)		-0.00 (0.03)
AIPC × ICI × RIPC		**-0.001** **(0.01)**		**-0.007** **(0.01)**
AIPC × PCI			-0.02 (0.02)	-0.02 (0.02)
RIPC × PCI			0.15* (0.08)	0.06** (0.03)
AIPC × PCI × RIPC			**0.18***** **(0.03)**	**0.16***** **(0.03)**
Prior innovation	0.001*** (0.0004)	0.001*** (0.0005)	0.001*** (0.0003)	0.001*** (0.0004)
R&D intensity	0.08*** (0.02)	0.054** (0.026)	0.12*** (0.03)	0.09*** (0.03)
Firm size	0.30** (0.13)	0.30** (0.12)	0.28** (0.12)	0.36*** (0.12)
Culture of innovation	0.14*** (0.05)	0.10** (0.04)	0.12*** (0.04)	0.08** (0.04)
High-tech industry	0.02*** (0.004)	0.01*** (0.004)	0.02*** (0.004)	0.008** (0.003)
$\tilde{\eta}$	0.21 (0.24)	0.57 (0.50)	0.35 (0.24)	0.27 (0.25)
$\tilde{\eta}$ × RIAISum	-0.07* (0.04)	-0.14*** (0.05)	-0.13** (0.05)	-0.13** (0.05)
Wald Chi-square	505.45***	524.12***	660.74***	786.31***
R-square	0.59	0.62	0.63	0.68
Chi-square test of significant coefficient of the two-way and three-way interactions	$p > 0.10$	$p > 0.10$	10.81***	32.45***
Observations	310	310	310	310

Notes: (1) Robust standard errors in parentheses. (2) Significant at *10%, **5% and ***1% level. (3) Industry dummies, intercept, and control variables for firm age, *ITIntensity, ITR&DIntensity*, prior profitability, culture of customer collaboration, industry concentration, and low-tech industry are also included in all models. (4) We used the Garen (1984) methodology for estimation. (5) We used negative binomial models. GLS models yielded similar results. (6) Terms containing $\tilde{\eta}$ are endogeneity correction terms calculated from the first stage.

Discussion

Findings

Our analysis yields two main findings, consistent across a variety of estimation approaches. First, we find that RIPC complements the link between PCI and amount of firm innovation. The positive and significant sign on PCI, coupled with its positive interaction with RIPC, suggests that RIPC enabled by specific CRM applications helps firms better leverage PCI and generate more opportunities for innovation.

Second, we find that AIPC complements the link between ICI and the amount of firm innovation. The nonsignificant unconditional effect of ICI is consistent with prior research, which has found no significant direct effects of customer feedback and suggestions on innovativeness (Fang 2008; Ittner and Larcker 1997; Lawton and Parasuraman 1980); however, coupled with its positive interaction with AIPC, the results indicate that IT-enabled analytical capabilities help firms derive insights for innovation by mining information obtained from ICI. This suggests that firms may be able to manage information overload from ICI (Hoyer et al. 2010) by using AIPC to make sense of and derive insights from customer opinions and feedback. Thus, although ICI may not by itself increase the amount of firm innovation, AIPC provides firms with the ability to leverage information obtained via ICI and utilize it to create more innovation opportunities.

Our exploratory analysis provides further insights. First, the nonsignificant two-way interaction of AIPC and RIPC suggests that simply adding more IT may not increase innovation unless these IT capabilities are also accompanied by appropriate management interventions. Second, the positive three-way interaction of AIPC, RIPC, and PCI suggests that more innovation accrues to firms that combine PCI with IT capabilities that facilitate analytical information processing and relational information processing.

This study bridges the IS, marketing, and innovation literatures to provide a better understanding of the role of IT in innovation by explicating the role of AIPC and RIPC in complementing specific kinds of customer involvement in product development. We respond to calls for research on the role of IT in facilitating customer co-creation and co-innovation (Nambisan et al. 2017) by adopting an interdisciplinary perspective and integrating IS concepts with those in other business areas (in our case, marketing). We extend the limited but growing literature on IT and innovation by pointing to the salient role of IT in developing intangibles and its intermediate capabilities with respect to leveraging customer involvement (Kohli and Grover 2008). We also contribute to the CRM literature, which has found relatively mixed results related to whether and how CRM technology contributes to firm performance (see Table A2 in Appendix A). For instance, while some studies find positive effects (e.g., Jayachandran et al. 2005), others find negative or nonsignificant effects (e.g., Reinartz et al. 2004). Our study suggests that RIPC enabled by specific CRM applications can complement PCI and facilitate innovation, an outcome that has received scant attention in the extant CRM literature.

Theoretical Contributions and Implications for Research

Our study offers several theoretical contributions and implications for research. First, the results enhance the theoretical understanding of the moderating role of IT-enabled capabilities on the customer involvement–innovation relationship and may help explain related mixed findings in prior research by pointing to previously neglected moderating roles of contingent IT-enabled capabilities such as RIPC and AIPC. The study highlights the need to carefully consider the role of IT to help tease out the impacts of customer involvement on innovation. We believe that our theorizing and findings regarding neglected interactions among customer involvement practices and IT capabilities can spur further research to better understand how digital artifacts support and enable innovation processes in an operand role. The study also has implications for how IT governance practices can create complementarities between IT capabilities and specific customer involvement practices. A broader call for research is to study other IT capabilities that help firms reap innovation from different kinds of customer involvement.

Second, future research might examine how AIPC, RIPC, and other IT capabilities complement other management practices related to innovation, especially in terms of involving other external constituents. For example, supplier involvement is important for innovation (Song and Di Benedetto 2008), and IT capabilities may facilitate effective supplier involvement.

Finally, our study shows that neither managerial practices nor technology artifacts alone are enough to leverage customers and fuel innovation; instead, their disciplined configurations determine the amount of innovation (for a detailed discussion of the configuration view, see El Sawy et al. 2010). Another research path would be to explore where the IT-enabled capabilities identified in our study should reside: the IT function or the marketing function? A cumulative program of research in IS may help identify sets of IT portfolios that, when combined and aligned with business practices (Rai et al. 2012), jointly influence innovation.

What are the implications of our theorizing and findings for digital innovation? Although our study focuses on IT as an enabler of innovation by building on and extending absorptive capacity and complementarities at a granular level, it points to a need for similar theorizing with respect to other forms of digital innovation, "broadly defined as a product, process, or business model that is perceived as new, requires some significant changes on the part of adopters, and is embodied in or enabled by IT" (Fichman et al. 2014, p. 330). While IT-embodied digital product and business model innovations may be more salient for IT-producing or IT-intensive firms whose business model depends on selling or leveraging IT artifacts or digital goods, researchers should also pay attention to segments of business and the economy in which IT will likely play an enabling role in digital innovations. In such cases, the role of IT may be more tacit and contextual in facilitating collaborative partnerships with customers and external constituents and in leveraging their insights for digital innovation to gain competitive advantages that are more sustainable or impactful in terms of the footprint of such innovations. For instance, IT can make possible innovations that touch large populations in base-of-the pyramid markets. Digital innovations such as low-cost water purifiers that can improve the lives of millions of consumers in rural areas bereft of electricity or drinking water are worthy of research to better understand how IT can help unleash such innovations. IT capabilities may help bring digital innovations to market by creating information flows within and across firms and helping identify "new combinations of digital and physical components to produce novel [digital] products" (Yoo et al. 2010, p. 725) and business model innovations.

Such high-impact digital innovations in products and business models demand a certain capacity to engage customers and partners in a variety of activities, including product development, pricing, and logistics. Complexity is a given in such models, and firms need to develop decision-making processes and supportive IT capabilities to manage the risks that arise from this complexity. The role of IT in such cases may be to enhance the absorptive capacity of the innovating firm by facilitating relational capabilities and the sourcing and exchange of ideas within and across firms with customers and other external constituents and to enable the measurement and manipulation of sourced information to create an innovation ecosystem that leverages community (e.g., customers) and market-like features (e.g., innovation tournaments). In other words, the role of IT can be viewed as an enabler of *disciplined autonomy*, where *discipline* refers to standardized templates that IT platforms can provide and *autonomy* refers to loose coupling through governance processes that provide freedom to individuals and business units to source outside information for digital innovation efforts. This virtuous combination of disciplined autonomy that IT can potentially enable also manifests implicitly in newer approaches for creating IT artifacts (e.g., agile software development) (Kude et al. 2015) and emerging phenomena such as IT-enabled ambidexterity (Mithas and Rust 2016).

Regarding digital process innovation, our results point to a broader role of IT to serve as a platform and facilitate innovation ecosystems that comprise firms and internal and external heterogeneous partners (Nambisan 2013; Yoo et al. 2012). As new technologies (e.g., social media) alter the ways firms source ideas from customers and partners (Yadav and Pavlou 2014), firms need IT capabilities to harmonize multiple collaborations. For example, involving a larger set of users in a crowd to collaboratively create innovations may require managing tensions such as the simultaneous encouragement of competition and collaboration, creative abrasion that requires familiarity among a crowd of strangers, and facilitating idea evolution from time-constrained strangers (Majchrzak and Malhotra 2013). Therefore, there is a need to understand the mechanisms and practices that can help firms manage these tensions in a creative way by paying close attention to innovation design, network design (including IT architecture), alliance patterns, and governance issues in network-centric innovation contexts (Majchrzak and Malhotra 2013). Our results have the potential to expand to such crowdsourcing contexts in which analytical and relational IT-enabled capabilities help the firm better govern the process of crowdsourcing for innovation. To leverage such interactions with ecosystem partners for digital process innovation, firms need IT systems that are anticipatory, responsive, supportive of cross-firm collaboration and relationships, and capable of deriving insights that can be integrated with business processes. Increasingly, firms are recognizing the value of investing in IT platforms and IT applications to enable multilateral collaborations among partners and to track opportunities and ideas through the innovation value chain from idea generation to commercialization (El Sawy et al. 2016; Huang et al. 2012; Mithas and Arora 2015). Such IT applications may also have implications for managing digital service innovations in which customers play an even more important role in the service innovation process (Ostrom et al. 2015; Setia et al. 2013). Cultivating RIPC and AIPC can help professional service firms improve their knowledge development processes by effectively identifying individualized customer needs (through RIPC) and applying real-time analytics (through AIPC) to trace, track, and leverage customer inputs (Barrett et al. 2015).

Our study has limitations that can be launching points for further work. First, although the similarity of results across three approaches that account for endogeneity enhances confidence in our findings, we call for additional studies to assess causality and generalizability. Second, future work could examine whether AIPC and RIPC play similar roles with other dimensions of innovation success (e.g., speed, inimitability) and whether there are any trade-offs in the effects of IT capabilities on various dimensions of innovation resulting from customer involvement. Third, further research could explore how AIPC and RIPC complement customer involvement at different stages of innovation. Finally, additional studies in other countries would help assess the generalizability of our findings.

Managerial Implications and Conclusion

For managers, our study points to types of IT capabilities that can help firms harness different types of customer involvement for innovation. In a business climate in which customer focus is critical, firms need IT capabilities that help them usefully integrate and leverage customer inputs. Our results suggest that a vital justification for investing in IT capabilities that underlie RIPC and AIPC is the role of IT in driving innovation by helping firms increase the effectiveness of customer involvement. Thus, managers need to carefully evaluate their firm's IT capabilities when formulating innovation strategies that involve customers. Merely collaborating with or incorporating information from customers may not increase innovation as much as when those business practices are accompanied by relevant IT applications that enable AIPC or RIPC.

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RESEARCH NOTE

LEVERAGING CUSTOMER INVOLVEMENT FOR FUELING INNOVATION: THE ROLE OF RELATIONAL AND ANALYTICAL INFORMATION PROCESSING CAPABILITIES

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Appendix A

Illustrative Prior Studies

Table A1. Illustrative Prior Studies Related to Customer Involvement

Study and type	Dependent variable; objective or subjective performance measure	Operationalization of customer involvement–related independent variable	Moderator variables	Key finding and sample
Panel A: Studies suggesting positive implications of customer involvement for performance				
Gupta and Souder 1998; Q	Subjective measure of cycle time.	Frequency of user contact, clarification of needs by user, users try product, users given prototypes.	None	User involvement helps reduce cycle time. Sample: 38 firms in U.S. manufacturing.
Gruner and Homburg 2000; Q	Subjective measures of new product success (quality, financial success, quality of NPD process, cost of new product ownership).	Intensity of customer interaction in idea generation, product concept development, project definition, engineering, prototype testing, market launch.	None	Customer interaction during early and late stages of NPD process increases new product success; interaction during middle stages yields no performance impact. Sample: 310 firms in Germany.
Auh et al. 2007; Q	Subjective measures of attitudinal loyalty, behavioral loyalty.	Work cooperatively with advisor.	None	Coproduction is positively associated with attitudinal loyalty but not behavioral loyalty. Sample: Clients of global financial services firm.

Table A1. Illustrative Prior Studies Related to Customer Involvement (Continued)

Study and type	Dependent variable; objective or subjective performance measure	Operationalization of customer involvement–related independent variable	Moderator variables	Key finding and sample
Kristensson et al. 2008; CS	N.A.	N.A.	N.A.	Seven key strategies identified for successful user involvement. (e.g., user situations, user roles). Sample: 2 Swedish telecommunications firms.
Carbonell et al. 2009; Q	Subjective measures of innovation speed, technical quality, competitive superiority, and sales performance.	Frequency of meetings with customers, extent of consultation with customers, representation of customers in the project team, number of customer involvement tools used.	Stage of development process (early vs. late)	Customer involvement (CI) improves technical quality and innovation speed but not competitive superiority and sales. The impact of CI on new service performance is independent of stage of development process. Sample: 103 Spanish service firms.
Chien and Chen 2010; Q	Subjective measures of cross-functional integra-tion, new product financial performance, new product process performance.	Seek consumer advice, screen customer opinions, evaluate customer satisfaction, educate customers to give advice, customers participate in developing process.	None	Significant positive effect of customer involvement on the NPD process and on cross-functional integration. Sample: 125 financial services firms in Taiwan.
Panel B: Studies suggesting negative, limited, non-significant, or mixed implications of customer involvement for performance				
Lawton and Parasuraman 1980; Q	Subjective measure of innovativeness: degree of difference from existing products; modification of user behavior.	Whether the company used at least one customer-oriented source from complaints or suggestions from users, formal research of users and their needs.	None	Adoption of the marketing concept is not significantly related to either dimension of product innovativeness. Sample: 107 manufacturing firms.
Atuahene-Gima 1996; Q	Subjective measures of project impact perfor-mance, market success.	Market orientation captures collection and use of input from customers.	None	Market orientation reduces product newness to customers. Sample: 600 firms in Australia.
Heinbokel et al. 1996; FS	Subjective measures of software process quality, product quality and project success.	Customer on project team, contact with users.	None	Customer participation was associated with project difficulties related to process quality, product quality, and overall project success. Sample: 29 software projects.
Ittner and Larcker 1997; Q	Subjective measures of return on assets, sales growth, return on sales, perceived overall performance.	Cross-functional teams with customers, design review by customers, design review teams with customers, customer pilot runs. Product development cycle time is independent variable; customer involvement is moderator.	Customer involvement in product design	Negative interaction of customer involvement with cycle time on growth. No interaction of customer involvement with cycle time on other measures. Overemphasis on customer feedback in design makes firms reactive rather than proactive and pushes them to exceed their capabilities in an attempt to provide products that respond to customer need. Sample: 184 firms in auto, computer sector in Canada, Germany, Japan, and the United States.
Campbell and Cooper 1999; Q	Subjective measures of profitability, impact on sales, time efficiency, time schedule, access to new markets, technical success.	Customer partnership is defined as the formal working relationship between the customer and the manufacturer, involving coordinated development activities to develop new product. Partnering as binary measure.	None	Partnership projects were no more successful than in-house projects. This surprising result holds regardless of the performance metric. Not all NPD is improved by close cooperation with customers. Sample: 88 NPD projects.
Bajaj et al. 2004; Q	Objective measures of design schedule, design cost savings.	Intensity of customer interaction in design phase of NPD, measured as the ratio of the number of customer sign-offs in the design phase to the total design budget.	Oversight by the project manager, budget for specialists in the design phase	Customer interaction (CI) lowers time savings in the design phase (more delays). Oversight and specialists moderate this relationship. CI has no significant effect on cost savings. No moderation effect. Sample: 53 NPD projects in a defense company.

Table A1. Illustrative Prior Studies Related to Customer Involvement (Continued)

Study and type	Dependent variable; objective or subjective performance measure	Operationalization of customer involvement–related independent variable	Moderator variables	Key finding and sample
Lagrosen 2005; CS	N.A.	N.A.	N.A.	Development based on customer information leads to incremental rather than innovative changes. Customer involvement entails direct and indirect costs in form of time.
Fang 2008; Q	Subjective measures of new product innovativeness (NPI), new product speed to market.	Customer participation as an information resource (CPI), Customer participation as a codeveloper (CPC).	Network connectivity, process interdependence	Customer network connectivity negatively moderates the effect of CPI on NPI. Process interdependence positively moderates the effect of CPC on NPI. Sample: 143 NPD projects in chemical, electronic, and industrial project sectors.
Foss et al. 2011; Q	Subjective measure of innovation capacity and profitability of focal firm relative to competitors.	Customers involved in close collaboration, intense communication, strategy of close collaboration.	None	No direct link between customer interaction and innovation. The link is mediated by organizational practices. Sample: 169 Danish firms.
Panel C: This Study				
This Study; Q	Objective measure of amount of firm innovation (patents).	Information-intensive customer involvement (ICI) (customer participation in focus groups or formal user feedback, solicitation and analysis of customer opinion). Product-focused customer involvement (PCI) (custom configuration of products by customers, key customers drive product development).	Relational information processing capability (RIPC); Analytical information processing capability (AIPC)	RIPC positively moderates the relationship between PCI and amount of firm innovation. AIPC positively moderates the relationship between ICI and amount of firm innovation. Sample: 310 U.S. manufacturing firms.

Notes: (1) This table is not exhaustive and lists only few representative studies to show the uniqueness and novelty of the current study in relation to relevant prior work. (2) Abbreviations used: Q = Quantitative, C = conceptual, CS = case study, FS = field study, NPD = new product development, N.A. = not applicable. (3) Much of the text in this table is taken verbatim from the corresponding studies.

Table A2. Illustrative Prior Quantitative Empirical Studies Related to CRM Systems and Organizational Performance

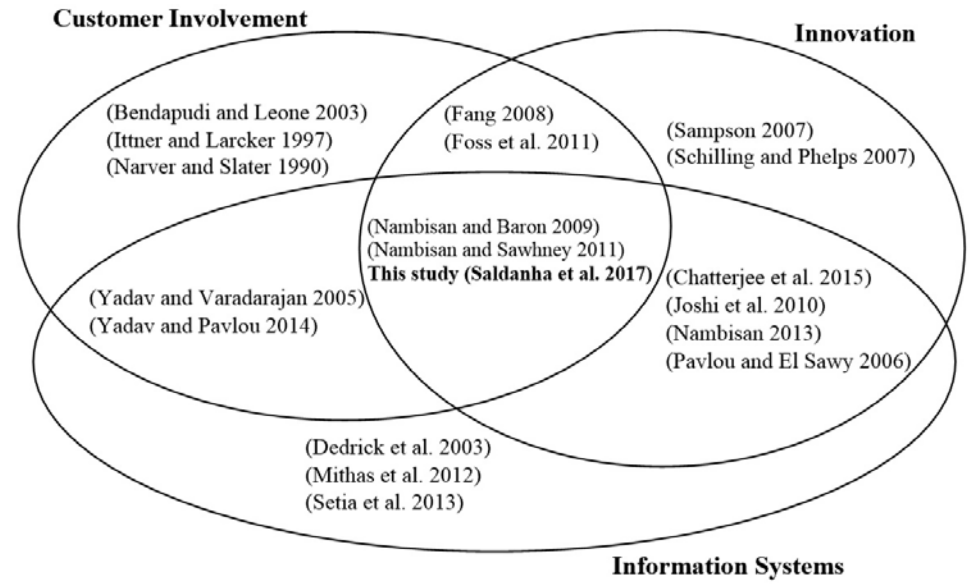
Study	Dependent variable; objective or subjective performance measure	Operationalization of CRM-related independent variable	CRM as a moderator variable?	Key finding and sample
Panel A: Studies suggesting positive implications of CRM for performance				
Jayachandran et al. 2005	Subjective measure of customer relationship performance.	Aggregate measure of CRM use to provide functions such as sales support, marketing support, service support, analysis support, data integration, and access support.	Yes	CRM technology moderates the link between relational information processes and customer relationship performance. Sample: 172 business units of U.S. firms.
Mithas et al. 2005	Customer knowledge, customer satisfaction.	CRM systems for legacy applications and CRM for newer IT applications.	No	CRM applications improve the firm's customer knowledge, which improves customer satisfaction. Sample: 360 U.S. firms.
Srinivasan and Moorman 2005*	Firm customer satisfaction.	CRM investment in product pricing, ordering, building base of customers, brand attachment, quality of customer support, CRM acquisition, CRM retention.	No	CRM improves customer satisfaction. Moderate brick-and-mortar experience is better for leveraging CRM for customer satisfaction than low or high experience. Sample: 187 online retailers.
Coltman 2007	Subjective measures of profitability, revenue generation from new products, transaction costs, sales growth.	CRM capability, including in terms of IT infrastructure, preparedness to implement CRM.	Yes	CRM is positively associated with firm performance and mediated by reactive market orientation and proactive market orientation. No moderating effect of conversion feasibility. Sample: 91 business-to-consumer firms across industries.
Chang et al. 2010	Subjective performance measure: market effectiveness, profitability.	CRM use with respect to sales support, service support, analysis support, data access support.	No	Marketing capability mediates the link between CRM technology use and firm performance. Sample: 209 Korean firms.
Panel B: Studies suggesting negative, limited, nonsignificant, or mixed implications of CRM for performance				
Reinartz et al. 2004	Perceptual and objective measures of economic performance.	Technology that acquires and manages customer information, dedicated CRM technology. Technology for one-to-one communication with customers	Yes	CRM technology positively moderates the link between relationship termination and performance, negatively moderates the relationship initiation–performance link, and has no effect on the relationship maintenance–performance link. Sample: 211 firms in Australia, Germany, Switzerland.
Hendricks et al. 2007	Objective measures of stock returns, profitability.	CRM investment announcements.	No	No effect of CRM investment on stock performance; little effect of CRM on firm profitability. Sample: 81 public firms.
Becker et al. 2009	Subjective measures of CRM performance in terms of initiation, maintenance, and retention.	Technological implementation of CRM for information acquisition, storage, accessibility, and evaluation.	No	Technological CRM is positively associated with CRM initiation and maintenance performance but not with retention performance. Effects are positively moderated by employee support. Sample: 90 European firms across industries.
Reimann et al. 2010*	Customer satisfaction, market effectiveness, profitability.	CRM initiation, CRM maintenance, CRM termination.	No	The CRM–performance link is mediated by differential and cost leadership strategies. Sample: 318 U.S. firms across industries.
Zablah et al. 2012	Subjective measure of financial performance, customer-perceived relationship investment as mediator.	Summative indices of CRM interaction support tools, summative index of CRM prioritization tools.	No	CRM interaction support tools that are positively related to customers' relationship perceptions. CRM prioritization tools have positive effects on larger customers and negative effects on smaller customers. Sample: 295 customer firms.

Notes: (1) This table is not exhaustive and lists only few representative studies to show how this study relates to prior work. (2) Much of the text in this table is taken verbatim from the corresponding studies. (4) * indicates that the study did not examine CRM technology, but rather examined the CRM business practice.

Table A3. Selection Equation [Dependent variable is RIAISum, which is summation of (standardized) RIPC and AIPC]

	RIAISum
IT intensity	0.033** (0.016)
R&D intensity	-0.004 (0.01)
ITR&D intensity	0.05 (0.05)
Firm size	0.28*** (0.07)
Culture of innovation	0.03 (0.04)
Industry concentration	0.008** (0.003)
High-tech industry	0.005* (0.003)
IT staff rewards	0.51*** (0.11)
ERP	0.65*** (0.23)
F-statistic	8.25***
R-square	0.42
Observations	310

Notes: (1) Robust standard errors in parentheses. (2) Significant at *10%, **5%, and ***1% level. (3) Estimates show selection equation for the Garen (1984) methodology. We used generalized least squares (GLS) for estimation (Garen 1984). (4) Industry dummies, intercept, and control variables for firm age, prior profitabiity, culture of customer collaboration, culture of customer satisfaction, and low-tech industry are also included.



Note: This figure is not exhaustive and lists only some representative studies to show where our study fits in relation to relevant prior work.

Figure A1. Illustrative Literature

Appendix B

Additional Approaches for Addressing Endogeneity

This appendix reports additional results for addressing endogeneity. First, we estimated our models using an extension of the Garen (1984) model, which has been used in prior research for scenarios in which multiple potentially endogenous variables may be present (Luan and Sudhir 2010, pp. 446-448). Luan and Sudhir (2010) provide a method that corrects for endogeneity bias in continuous variables in cross-sectional data. This approach extends the Garen method to incorporate multiple endogenous variables. We provide a brief description of the methodology here[1]. Suppose that we want to estimate the outcome equation of the following form to estimate effects of A_j and L_j on S_j:

$$(1) \quad S_j = x_j'\beta + \gamma_j^A A_j + \gamma_j^L L_j + \varepsilon_j$$

where the coefficients γ_j^A and γ_j^L are random coefficients composed of a systematic observed component and an unobserved component; j is the unit of analysis (in our case, a firm):

$$(2) \quad \gamma_j^A = w_j^{A'}\theta^A + \phi_j^A$$
$$(3) \quad \gamma_j^L = w_j^{L'}\theta^L + \phi_j^L$$

where w_j^A and w_j^L are vectors that influence the marginal effects of A_j and L_j on S_j. Consider a set of exogenous variables collected in z_j that influence the firm's choice of endogenous variables A_j and L_j:

$$(4) \quad A_j = z_j'\lambda^A + \eta_j^A$$
$$(5) \quad L_j = z_j'\lambda^L + \eta_j^L$$

Substituting (2) and (3) into (1), we get

$$(6) \quad S_j = x_j'\beta + (w_j^{A'}\theta^A) A_j + (w_j^{L'}\theta^L) L_j + (\phi_j^A A_j + \phi_j^L L_j + \varepsilon_j)$$

Luan and Sudhir show that this equation can be rewritten and estimated consistently as

$$(7) \quad S_j = x_j'\beta + (w_j^{A}\theta_j^A) A_j + (w_j^{L'}\theta_j^L) L_j + g_1\tilde{\eta}_j^A A_j + g_2\tilde{\eta}_j^L A_j + g_3\tilde{\eta}_j^A L_j + g_4\tilde{\eta}_j^L L_j + g_5\tilde{\eta}_j^A + g_6\tilde{\eta}_j^L + \varepsilon_j$$

where $\tilde{\eta}_j^A$ and $\tilde{\eta}_j^L$ are, respectively, the estimated values of η_j^A and η_j^L from (4) and (5), and the g's are the estimated coefficients of the endogeneity correction terms.

Thus, Luan and Sudhir's approach consists of estimating equations (4) and (5), calculating the estimated $\tilde{\eta}_j^A$ and $\tilde{\eta}_j^L$ values, and substituting them into equation (7). In our situation, AIPC and RIPC are the endogenous variables A_j and L_j, and Innovation is the outcome variable S_j. Table B1 shows the estimation of the selection equations (equations (4) and (5)). Table B2 shows the negative binomial and GLS estimations of the innovation equation (equation 7), controlling for the endogeneity-correction terms as suggested by Luan and Sudhir. The findings remain unchanged and similar to the results obtained using Garen's methodology (Table 3).

Second, we adopt a two-step method first introduced by Heckman (1979) and used in other studies (e.g., Bharadwaj et al. 2007; Sampson 2007; Shaver 1998; Xu et al. 2014). We separate our sample firms into two groups: firms with scores above the mean on the sum of the standardized AIPC and RIPC variables, coded as 1, and firms below the mean on the sum, coded as 0. Intuitively, this binary variable (which we label HIGHRIAI) represents a high level of AIPC and RIPC in the firm. In this approach, endogeneity is addressed by calculating the Inverse Mills Ratio (IMR) using estimates from the first stage and including the IMR term in the second-stage equation as an additional predictor. The equations are

Stage 1: P(*HIGHRIAI* = 1) = $\Phi(\beta_a + \beta_r W + u)$
Stage 2: Innovation = f(PCI, ICI, RIPC, AIPC, RIPC × PCI, AIPC × ICI, Inverse Mills Ratio, controls)

[1] A more detailed and complete description is in Luan and Sudhir (2010).

where W is the vector of variables in the first stage; Φ denotes the cumulative standard normal distribution function; and u is the error term. We compute the IMR variable using estimates from the first stage. We calculate the IMR as IMR = $\phi(\beta_r{*}W)/\ \Phi(\beta_r{*}W)$ if HIGHRIAI = 1 and IMR = $-\phi(\beta_r{*}W)/[1-\Phi(\beta_r{*}W)]$ if HIGHRIAI = 0, where W and β_r are, respectively, the vectors of independent variables and estimated coefficients from the first stage probit model, ϕ denotes the standard normal distribution function, and Φ denotes cumulative standard normal distribution function (Bharadwaj et al. 2007; Greene 2003; Shaver 1998). In the second stage, we include the IMR term as an additional control variable. This additional term appears in the equation because of potential endogeneity of AIPC and RIPC (as we discuss in the "Empirical Models and Econometric Considerations" subsection of the main text); namely, unobserved factors may influence AIPC and RIPC and so there is potential for endogeneity.[2]

The results using the Heckman approach (omitted for brevity) are qualitatively similar to the results using the Garen (1984) and Luan and Sudhir (2010) approaches. Like prior research that has used similar approaches and reached similar conclusions (e.g., Xu et al. 2014), the results confirm that although the correction terms may be significant, the estimates are robust, suggesting that endogeneity is not a significant concern in our study.

Table B1. Selection Equations for Luan and Sudhir (2010) Methodology

	AIPC	RIPC
IT intensity	0.02*** (0.005)	0.03*** (0.006)
R&D intensity	-0.006 (0.06)	-0.001 (0.01)
ITR&D intensity	0.004 (0.01)	0.021 (0.015)
Firm size	0.08** (0.03)	0.13** (0.06)
Culture of innovation	0.005 (0.01)	0.02 (0.03)
Culture of customer satisfaction	0.06 (0.09)	0.07*** (0.02)
Industry concentration	0.003 (0.002)	0.007** (0.003)
High-tech industry	0.002* (0.001)	0.004* (0.002)
IT staff rewards	0.06** (0.03)	0.28* (0.16)
ERP	0.25*** (0.09)	0.46*** (0.08)
F-statistic	6.03***	14.84***
R-square	0.31	0.52
Observations	310	310

Notes: (1) Robust standard errors in parentheses. (2) Significant at *10%, **5% and ***1% level. (3) We used generalized least squares (GLS) for estimation. (4) We used standardized values of RIPC and AIPC for estimation. (5) Industry dummies, intercept, and control variables for firm age, prior profitability, culture of customer collaboration, and low-tech industry are also included.

[2]For further details and derivations of expressions for IMR, see Shaver (1998) and Greene (2003).

Table B2. Results Using Luan and Sudhir (2010) Methodology

	Negative Binomial Models		Generalized Least Squares (GLS) Models	
	(1)	(2)	(3)	(4)
	Innovation	Innovation	log(1 + patents)	log(1 + patents)
Product-focused customer involvement (PCI)	0.11*** (0.02)	0.04** (0.02)	0.05*** (0.01)	0.02*** (0.007)
Information-intensive customer involvement (ICI)	-0.33 (0.25)	0.11 (0.21)	-0.10 (0.07)	-0.10 (0.08)
RIPC	0.01 (0.43)	-0.15 (0.40)	0.30 (0.20)	-0.11 (0.16)
AIPC	0.06 (0.08)	-0.04 (0.08)	0.04 (0.03)	-0.01 (0.03)
RIPC × PCI (Hypothesis H1)		**0.30*** (0.06)**		**0.13*** (0.02)**
AIPC × ICI (Hypothesis H2)		**0.08*** (0.01)**		**0.07*** (0.01)**
Prior innovation	0.001*** (0.0004)	0.001*** (0.0004)	0.45*** (0.05)	0.36*** (0.05)
R&D intensity	0.07*** (0.02)	0.08*** (0.02)	0.05** (0.02)	0.02** (0.01)
Firm size	0.28** (0.12)	0.30*** (0.11)	0.07* (0.04)	0.10** (0.05)
Culture of innovation	0.22*** (0.06)	0.13*** (0.05)	0.09*** (0.03)	0.07*** (0.02)
High-tech industry	0.02*** (0.004)	0.007* (0.004)	0.01*** (0.003)	0.006*** (0.002)
$\tilde{\eta}_a$	-1.37 (0.90)	-0.58 (0.89)	-0.54 (0.37)	-0.30 (0.30)
$\tilde{\eta}_r$	1.18* (0.64)	0.89 (0.56)	0.46** (0.22)	0.40** (0.17)
$\tilde{\eta}_a$ × AIPC	-0.24 (0.27)	-0.05 (0.26)	-0.14 (0.10)	-0.16* (0.09)
$\tilde{\eta}_a$ × RIPC	-0.36 (0.26)	-0.44* (0.24)	-0.01 (0.10)	-0.12 (0.09)
$\tilde{\eta}_r$ × AIPC	-0.00 (0.32)	0.15 (0.25)	-0.06 (0.10)	0.06 (0.08)
$\tilde{\eta}_r$ × RIPC	0.05 (0.09)	-0.16* (0.09)	0.01 (0.04)	-0.03 (0.04)
Wald chi-square/F-statistic	564.42***	622.98***	192.98***	245.40***
Chi-square test/F-test of significant coefficients of interaction		70.13***		57.05***
R-square	0.60	0.66	0.79	0.84
Observations	310	310	310	310

Notes: (1) Robust standard errors in parentheses. (2) Significant at *10%, **5%, and ***1% level. (3) Industry dummies, intercept, and control variables for firm age, *ITIntensity*, *ITR&DIntensity*, prior profitability, culture of customer collaboration, industry concentration, and low-tech industry are also included in all models. (4) Terms containing $\tilde{\eta}_a$ and $\tilde{\eta}_r$ are endogeneity correction terms calculated from the first stage. (5) We also tested models by introducing the interaction terms (AIPC × ICI and RIPC × PCI) one at a time and found substantively similar results (omitted for brevity).

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