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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 integration, 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 performance, 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

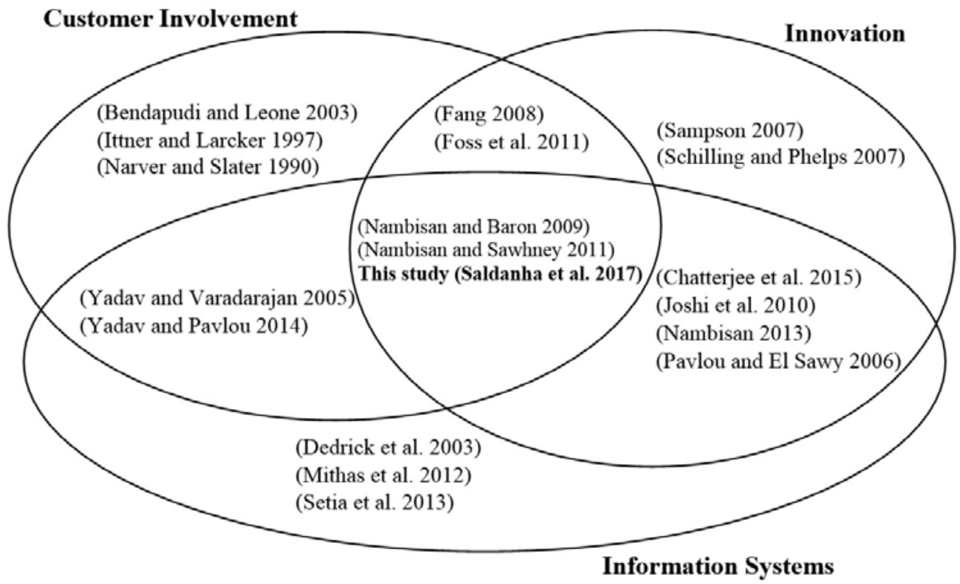
Study	Dependent variable; objective or subjective performance measure	Operationalization of CRM-related independent variable	CRM as a moderator variable?	Key finding and sample
Panel A: Studies suggesting positive implications of CRM for performance				
Jayachandran et al. 2005	Subjective measure of 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) $S_j = x_j'\beta + \gamma_j^A A_j + \gamma_j^L L_j + \varepsilon_j$

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

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

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

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

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

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

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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