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Harnessing the value of open innovation: The moderating role of innovation management

Thorsten Oliver Salge*[1], Thomas Marc Bohné[2], Tomas Farchi[3], Erk Peter Piening[4]

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[1]Faculty of Management and Economics, Ruhr University Bochum, Germany

[2]The University of Auckland Business School, The University of Auckland, New Zealand

[3]IAE Business School, Universidad Austral, Argentina

[4]Faculty of Management and Economics, Leibniz University Hannover, Germany

*Corresponding author: oliver.salge@rub.de

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Abstract

In this paper a firm-level contingency model of open innovation is developed and tested. The proposed model contributes to explaining the substantial disparities in open innovation payoff that were found to exist between firms. For this purpose, the role played by firms' innovation management practices is examined. Drawing on longitudinal, cross-sectoral data from 1,170 German firms, econometric analyses reveal that returns from open innovation are greatest when firms employ a dedicated incentive system for innovation, maintain their own research capacity and advocate strong cross-functional collaboration. Striving for technology leadership, in contrast, was not found to have any notable effect on firms' payoff from open innovation. Decision-makers are thus well advised not to take positive returns from open innovation for granted. Rather, they need to achieve excellence in key innovation management practices, if their organisation is to fully harness the potential value of openness.

Keywords: Open Innovation; Innovation Management; Search Theory; Contingency Theory.

1 Introduction

Organisations in both manufacturing and service sectors increasingly embrace a collaborative approach to innovation (Chesbrough 2003; 2011). As part of such an approach, it is ever more common for them to venture beyond their own boundaries in search of external knowledge to fuel their new product development (NPD) efforts (Rosenkopf & Nerkar 2001). Notwithstanding the appeal of involving customers, suppliers, competitors and research institutions into the NPD process, harnessing the potential value of open innovation is all but straightforward (Salge et al. 2011). Indeed, evidence reveals that returns from open innovation not only decrease at the margin, but also vary substantially between firms (Laursen & Salter 2006; Lichtenthaler 2008).

Despite this recognition and valuable recent insights into the performance effects of open innovation (e.g. Almirall & Casadesus-Masanell 2010; Leiponen & Helfat 2010), little is still known about the factors that help distinguish organisations capable of reaping the benefits of open innovation from those that are not (Huizingh 2011). Explaining such discrepancies thus remains one of the most pressing research needs in the area of open innovation (Lichtenthaler 2011). This task is also of considerable practical relevance, as the literature continues to offer only limited guidance on how managers can maximise the return on their investments in open innovation. Firm-level studies have an important role to play in this regard as they can help identify those organisational practices that are particularly vital for effective engagement in open innovation activities (Foss et al. 2011).

It is against this backdrop that we develop a contingency model of open innovation (Bahemia & Squire 2010). Focusing on firms' inbound knowledge search activities (Dahlander & Gann 2010), we suggest that effective innovation management practices are essential if firms are to translate greater search openness into tangible improvements of their innovative performance. In particular, we argue that search openness will yield higher payoffs for those firms that (i) strive for technology leadership in their industry, (ii) employ a dedicated incentive system for innovation, (iii) maintain a strong in-house research capacity and (iv) advocate cross-functional collaboration.

These practices are expected to increase staff members' motivation and ability both to realize the potential benefits of external knowledge and to overcome the challenges associated with recognizing, assimilating and utilizing such inputs. Drawing on longitudinal data from 1,170 German firms distributed across 22 distinct manufacturing and service sectors, this study finds broad empirical support for our theoretical propositions. Of the four innovation management practices, only technology leadership was not found to affect the payoff from search openness in our sample.

Overall, this study extends the emerging literature on the performance effects of open innovation (e.g. Almirall & Casadesus-Masanell 2010; Leiponen & Helfat 2010) by highlighting that notable interfirm discrepancies in the return from search openness can be explained at least in part by differences in firms' innovation management practices. By shifting the focus to firm-level practices, it also complements prior research that identified the nature of the innovation project, the experience of the project leader and the support by the work group as key project-level contingency factors (Salge et al. 2011).

The remainder of this paper proceeds as follows. In Section 2, we describe the conceptual background and set out the reasoning leading to our hypotheses. Section 3 describes the data collection procedure, the variable measurement as well as the estimation procedures employed to test our propositions. Empirical results are then presented in Section 4. Section 5 provides a brief conclusion.

2 Background and hypotheses

2.1 Open innovation

Numerous organisations in both manufacturing and service settings have come to embrace the idea of open innovation, that is, "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the market for external use of innovation" (Chesbrough et al. 2006, p.1). Pressed by recurring calls for ever more frequent and radical new product and service introductions, firms are increasingly discovering the potential benefits of joining forces with a range of external actors including customers, suppliers, competitors or research institutions (Chesbrough 2003). The interactions that occur as part of such a "connect and develop" approach to NPD are frequently bidirectional (Huston & Sakkab 2006). Oftentimes the focal firm not only absorbs external knowledge (inbound open innovation), but also shares internal knowledge with outsiders (outbound open innovation) – transactions that can be pecuniary as well as non-pecuniary (Dahlander & Gann 2010). Although research on the payoff from outbound open innovation is no less essential, this study focuses on inbound open innovation in general and firms' search openness in particular. The latter can be defined as "the number of different sources of external knowledge that each firm draws upon in its innovative activities" (Laursen & Salter 2004, p.1204).

2.2 Search openness and innovative performance

Search openness, i.e. the sourcing of knowledge from a range of distinct external actors, offers a number of potential benefits. These include, for instance, enhanced access to novel and heterogeneous knowledge pertaining to both customer needs and technical solutions (Von Hippel 1994). Similarly, openness provides valuable opportunities for resource pooling and risk sharing (Keupp & Gassmann 2009). Search openness is hence often expected to not only enhance the novelty (new-to-market) and market fit (fit-to-market) of new products, but also to reduce development times (time-to-market) and costs (cost-to-market) (Reichwald & Piller 2009). Consistent with these expectations, empirical firm-level studies showed openness to be positively associated with the financial performance of food processing and retailing firms (Dollinger 1984), the impact of patents filed by firms in the optical disk industry on the subsequent technological evolution in their respective domain (Rosenkopf & Nerkar 2001), the number of new product introductions of industrial robotics firms (Katila & Ahuja 2002), or the revenue share from new really new products introduced by manufacturing firms (Laursen & Salter 2006; Leiponen & Helfat 2010).

However, recent research has started to highlight that harnessing the benefits of search openness is all but simple (Dahlander & Gann 2010). This is not least due to the fact that external knowledge sourcing often involves the crossing of organisational, spatial and technological boundaries (Rosenkopf & Nerkar 2001). Indeed, if the focal firm is to overcome these boundaries and successfully absorb external knowledge, considerable effort and perseverance by all parties involved will be required (Foss et al. 2011). Challenges pertain to all three sequential processes of absorptive capacity (Cohen & Levinthal 1990), that is, to the identification, assimilation and utilisation of external knowledge inputs. In particular, the focal firm needs to negotiate access to external knowledge and evaluate its relevance (identification challenges). Once relevant knowledge has been identified, the focal firm needs to oversee the transfer process and has to develop measures to facilitate the internalisation of external knowledge inputs (assimilation challenges). Following successful assimilation, the focal firm needs to foster the integration of internal and external knowledge and safeguard the appropriation of the resulting returns (utilization challenges). Mastering these challenges is likely to be difficult and resource-intensive in terms of attention, time and money (Salge et al. 2011).

These challenges are likely to be the root cause for two recent empirical observations. First, marginal returns form search openness were found to be decreasing, such that the costs of search openness exceed its benefits at some point. As a result, the relationship between search openness and firm innovative performance was found to take an inverted U-shape at the project- (Salge et al. 2011) and the firm-level (Katila & Ahuja 2002; Laursen & Salter 2006). This suggests that both project teams and firms often lack the resources and capabilities required to successfully absorb a wide variety of

external knowledge inputs. Second and more important for the purposes of this study, prior research uncovered "substantial interfirm heterogeneity in capturing value from open innovation" (Lichtenthaler 2011, p.86). Firms thus vary considerably in their ability to master the challenges associated with search openness – a fact that is reflected in diverging payoff rates. Prior research suggests that these discrepancies can be explained in part by differences between firms in terms of product complexity (Almirall & Casadesus-Masanell 2010), product novelty and research capacity (Laursen & Salter 2006) and industry membership (Grimpe & Sofka 2009).

Despite these important early insights, deepening our understanding of the underlying causes of interfirm differences in returns from open innovation remains one of the most pressing research needs (Lichtenthaler 2011). In particular, we still know very little about specific organizational practices decision-makers can establish in order to reap greater benefits from interactions with external knowledge sources (Foss et al. 2011). While such practices can be manifold, those pertaining to innovation management are likely to enjoy particular salience in the context of search openness. We hence focus our attention on four specific innovation management practices and examine the extent to which each constitutes a possible contingency, upon which firms' return from search openness depends.

2.3 Moderating effects of innovation management practices

Innovation management encompasses a broad array of practices designed to improve the effectiveness and efficiency of the processes, whereby firms generate new ideas, develop new products, services and processes and exploit those commercially (Trott 2011). When it comes to harnessing the value of search openness, innovation management practices are likely to play a pivotal role. In particular, they have the potential to enhance staff members' motivation and ability to overcome the challenges often encountered when sourcing external knowledge. Four specific innovation management practices appear to be particularly vital in this regard. These are reflected in the relative salience of (i) *technology leadership* strategies, (ii) dedicated *incentive systems* for innovation, (iii) in-house *research capacity*, and (iv) *cross-functional collaboration* between departments involved in the innovation process.

First, firms' innovation strategy in general and the extent to which the focal firm seeks to achieve a position of *technology leadership* within its industry in particular, are expected to impact upon staff members' motivation to invest the time and resources needed for effectively identifying, assimilating and utilizing external knowledge inputs (Lane et al. 2006). More specifically, a strong emphasis on technology leadership is likely to alert staff members at all levels about the strategic necessity to develop new products, services and processes ahead of competitors. Once a shared commitment to technology leadership has been established, staff members will be more inclined to focus their attention on the successful absorption of external knowledge (Ocasio 1997). Similarly, they will be more willing to put in the additional effort needed when confronted with challenges that threaten the success of the inbound open innovation activities they are involved in: We therefore propose:

> *Hypothesis 1 The stronger a firm's focus on technology leadership, the higher its returns from search openness.*

Second, staff members' motivation to excel at often resource-intensive external knowledge sourcing activities is likely to be influenced by the degree to which the focal firm has established a dedicated *incentive system* consisting of pecuniary and non-pecuniary incentives for innovation (Holmstrom & Milgrom 1994). The importance of incentives for innovation is not least illustrated by recent findings that both performance-related pay (Laursen & Foss 2003) and pecuniary incentives for knowledge sharing (Foss et al. 2011) are positively associated with firms' innovative performance. As for inbound open innovation, we expect the personal dedication required for absorbing external knowledge to appear all the more worthwhile, when pay, promotion and status are tied to innovation success. Hence:

> *Hypothesis 2 The stronger a firm's incentive system for innovation, the higher its returns from search openness.*

Third, staff members' ability to absorb external inputs is known to depend on their prior related knowledge in the respective technological domain (Cohen & Levinthal 1990). In particular, staff members need to be familiar with its basic scientific foundations and language, if they are to succeed at identifying, assimilating and utilizing knowledge inputs originating from that particular domain. In absence of sufficient prior related knowledge, in contrast, staff members will be unable to determine appropriately the value and relevance of externally held information. Although absorptive capacity can be built and maintained by other means such as dedicated training programmes, the presence of a strong

in-house research capacity is widely considered to be vital in this regard (Cassiman & Veugelers 2006). Despite inconclusive empirical evidence on the role of internal R&D in the context of open innovation (Laursen & Salter 2006), we expect firms' in-house research capacity to act as a moderator enhancing the payoff from search openness. We thus propose:

Hypothesis 3 The stronger a firm's in-house research capacity, the higher its returns from search openness.

Fourth, harnessing the full value from search openness is likely to be contingent upon firms' level of *cross-functional collaboration* among all departments involved in the innovation process (Kahn 1996). When cross-functional collaboration is well developed, the different functional units within the focal firm (e.g. R&D, production, marketing or sales) will maintain a strong net of formal and informal ties, pursue a common innovation strategy, share ideas and knowledge, and support each other in pursuit of their collective innovation objectives (Frishammar & Ake Horte 2005; Luca & Atuahene-Gima 2007). Given the functional interdependencies that characterize the NPD process, it is less surprising that the positive direct effects of cross-functional collaboration on firms' innovative performance are now well documented (e.g. Ernst et al. 2010; Foss et al. 2011). As for search openness, strong cross-functional collaboration provides staff members with access to complementary knowledge, skills and other valuable resources that help them overcome the obstacles and exploit the opportunities they are presented with. We therefore hypothesize:

Hypothesis 4 The stronger a firm's interdepartmental collaboration for innovation, the higher its returns from search openness.

3 Methods

3.1 Setting and data

To test our theoretical propositions, we match data from two consecutive waves of the Mannheim Innovation Panel (MIP). The MIP constitutes Germany's contribution to the Community Innovation Survey (CIS) (OECD 1997), which is the world's largest firm-level innovation survey and a vital source for insights into firms' inbound open innovation activities (e.g. Laursen & Salter 2006; Leiponen & Helfat 2010). Although longitudinal studies using CIS data are still scarce, there are considerable benefits to such an approach. In particular, it allows for a temporal sequencing of dependent and independent variables. This is beneficial especially in strategic action-performance studies where cause and effect relationships are at stake (Boulding & Staelin 1995). The questionnaires for the two waves of the MIP used for the purposes of our study were administered in 2003 and 2004 and yielded response rates of around 20 percent for a total of 3,967 responses in 2003 and 3,574 in 2004. The matched dataset consisting only of firms that responded to both waves comprises 1,170 firms with usable responses. Table 1 describes the composition of our final sample.

Table 1 Sample composition

Sector Membership (Manufacturing)	**%**	**Sector Membership (Services)**	**%**
Mining, Food & Tabacco	2.70	Wholesale Trade	2.05
Textiles	2.39	Vehicle Trade & Repair	1.62
Wood & Paper	3.08	Transportation and Post	3.85
Chemicals	5.73	Banking & Insurance	1.37
Plastics	4.36	Computing & Telecommunications	9.23
Glass & Ceramics	2.65	Technical Services	11.03
Metals	7.95	Business Services	4.70
Machinery	10.94	Housing Services	1.62
Electrical Equipment	7.26	Other Services	2.99
Medical & Other Instruments	8.97		
Transport Equipments	3.16	**Knowledge Sources**	
Furniture	2.31	No External Knowledge Source	30.26
		Customers	56.58
Firm Size		Suppliers	17.35
< 50 Employees	50.51	Competitors	21.28
50 - 249 Employees	29.32	Research Institutions	14.27
> 249 Employees	20.17	Government	16.50

Notes. Sample: N = 1170; Values in percent of all observations in sample.

It becomes apparent that responding firms are distributed across 22 manufacturing and service sectors, with an observable emphasis on mechanical engineering and technical services, which play a particularly vital role for the German economy. As for firm size, nearly 80 percent of the firms in our sample are small and medium sized firms with less than 50 or 250 employees, respectively. With regards to their knowledge sourcing behaviour, around 30 percent of the firms in our sample did not draw on knowledge possessed by customers, suppliers, competitors, research institutions or government to fuel their NPD activities. That said, close to 70 percent sought to absorb knowledge from one or more external source. Consistent with evidence from English manufacturing and health care (Laursen & Salter 2006; Salge et al. 2011), customers are the external knowledge source that firms in our German sample draw on most frequently.

3.2 Measures

Dependent Variable: Following prior open innovation research (Laursen & Salter 2006; Leiponen & Helfat 2010), we use firms' revenue share from really new products (RNPs) as our dependent variable. This variable is measured as the ratio of firms' revenues in 2003 from new-to-the-market products introduced between 2001 and 2003 to firms' total revenues in 2003.

Independent Variable: To measure search openness, we employ an instrument first used by Laursen and Salter (2006). This instrument counts the number of external knowledge sources the focal firm has drawn on between 2000 and 2002 to fuel its NPD processes. While the number of external knowledge sources varies across studies, we focus on those five external knowledge sources that are widely considered as being the most salient for firms' inbound open innovation activities. These are (1) customers, (2) suppliers, (3) competitors, (4) research institutions and (5) government and regulators. Our simple formative indicator of search openness thus ranges from 0 to 4, with 0 indicating a closed and 5 a highly open external knowledge sourcing behaviour.

Moderating Variables: First, we measure firms' strategic focus on *technology leadership* as the arithmetic mean of four items depicted in Table 2. Each item is measured on a four-point Likert-type scale ranging from 0 (no importance) to 3 (high importance). With a Cronbach's alpha of 0.779 scale reliability can be considered as being good. Second, we compute the mean of four Likert-type items to measure the strength of firms' *incentive system* for innovation. The items are also depicted in Table 2 and pertain to both pecuniary and non-pecuniary incentives. The scale ranges from 0 (no importance) to 3 (high importance) and demonstrates good reliability (a = 0.765). Third, we calculate the level of R&D intensity for each firm to capture their *research capacity*. Consistent with established practice, R&D intensity is computed as the ratio between firms' R&D expenditures and their revenues. Fourth, we calculate the mean of four Likert-type items depicted in Table 2 to assess the strength of *cross-functional collaboration* within each firm. The scale ranges from 0 (no importance) to 3 (high importance) and demonstrates very good reliability (a = 0.870). The exploratory factor analysis summarised in Table 2 reveals that the 12 items used to measure the three latent moderating variables technology leadership, incentive system and cross-function collaboration cleanly load on three distinct

factors. The absence of any notable cross-loadings provides initial evidence for discriminant validity of our measurement model.

Table 2 Exploratory factor analysis for latent innovation management constructs

	Technology Leadership	Incentive System	Cross-Functional Collaboration
1. Focus on Technology Leadership	**0.760**	0.041	0.006
2. Focus on Leadership in New Product Development	**0.784**	0.006	0.041
3. Focus on Leadership in New Process Development	**0.815**	-0.018	-0.013
4. Focus on Introduction of Entirely New Technologies	**0.733**	-0.015	-0.026
5. Use of Innovation Performance Indicators for Staff Assessment	0.073	**0.679**	0.062
6. Use of Tangible Incentives for Innovation Managers	0.007	**0.864**	-0.060
7. Use of Intangible Incentives for Innovation Managers	0.015	**0.772**	0.030
8. Use of Incentives for Idea Development by Staff Members	-0.065	**0.701**	0.039
9. Cultivation of Informal Internal Exchange Networks	-0.048	0.016	**0.832**
10. Joint Development of Innovation Strategies	0.045	0.063	**0.782**
11. Open Sharing of Innovation Ideas and Concepts	0.002	-0.020	**0.890**
12. Reciprocal Support with Innovation Challenges	0.011	-0.004	**0.860**
Eigenvalue	*4.592*	*1.776*	*1.296*
Cronbach's Alpha	*0.779*	*0.765*	*0.870*

Notes. Sample: N = 1170; Extraction method: Principal component factor analysis with Promax rotation and Kaiser normalisation; Explained Variance: 63.9 %.

As an additional test for discriminant validity, we performed a series of confirmatory factor analyses using AMOS 14. These revealed that a three-factor solution fitted the model better than a two- or even one-factor solution as indicated by superior fit indices (CFI = 0.988; NFI = 0.981; IFI = 0.988) and a lower root mean square error of approximation (RMESA = 0.035). Overall, there is hence strong evidence for adequate discriminant validity among the three latent innovation management constructs.

Control Variables: We also control for a number of potentially confounding factors. First, we account for differences in *firm size* as captured by the number of full time employees working for the focal firm. Second, we control for diverging *human capital* endowments as reflected in firms' share of employees with college and university degrees measured on a scale from 0 (0 percent) to 8 (>75 percent). Third, a dummy variable is employed to capture whether the focal firm is a member of a formal R&D *collaboration*. Fourth, we control for *firm location* by capturing whether a firm is located in the old or the new German federal states ("Bundeslaender"). Finally, we introduce a full set of *industry dummies* to capture inter-industry differences in the revenue share from RNPs.

3.3 Analysis

The dependent variable *Revenue Share from RNPs* is not observed for all firms. Instead, only those firms that have introduced a novel product or service between 2000 and 2002 are asked to provide information on their revenue share from RNPs. Such item non-response introduces a possible selection bias, provided that error terms of the selection equation and the basic outcome equation are correlated. To account for such bias, we compute a series of two-step Heckman selection models. In a first step, these models estimate the probability of responding, i.e. of providing information of the revenue share from RNPs. To be adequately specified, this selection equation should contain explanatory variables that are not included in the basic outcome equation and more strongly related to the selection variable than to the basic outcome. We employ three additional dummy variables for this purpose. These are (1) the presence of R&D activities, (2) the presence of innovation expenditures and (3) the status as a start-up. In a second step, the basic outcome equation explaining the variance in the revenue share from RNPs is estimated accounting for the results from step one.

4 Results

4.1 Results from descriptive analyses

Table 3 shows descriptive statistics and pairwise correlations for the variables employed in this study. It reveals considerable interfirm variation with regards to all key variables. Moreover, it highlights that the revenue share from RNPs is most strongly correlated with technology leadership, research capacity

and human capital. As for the four innovation management practices, it becomes apparent that cross-functional collaboration is the most and incentive systems for innovation the least widely implemented practice. The relatively high correlations among the innovation management practices, however, suggest that firms tend to successfully adopt several practices in parallel.

Table 3 Descriptive statistics and pairwise correlations

Variable	Mean	S.D.	Min	Max	1.	2.	3.	4.	5.	6.	7.
1. Revenue Share from RNPs	1.73	2.25	0.00	8.00							
2. Search Openness	1.26	1.15	0.00	5.00	0.10						
3. Technology Leadership	1.60	0.84	0.00	3.00	0.27 *	0.18 *					
4. Incentive System	1.31	0.78	0.00	3.00	0.04	0.17 *	0.40 *				
5. Research Capacity	0.04	0.05	0.00	0.15	0.30 *	0.17 *	0.23 *	0.06			
6. Cross-Functional Collaboration	2.08	0.84	0.00	3.00	0.00	0.18 *	0.32 *	0.47 *	0.10 *		
7. Firm Size	284.40	1243.51	1.00	25935	-0.04	0.09 *	0.08 *	0.13 *	-0.03	0.05	
8. Human Capital	4.31	2.49	0.00	8.00	0.21 *	0.15 *	0.05	-0.01	0.43 *	0.02	-0.08 *

Notes. Sample: N = 1170; Dummy variables not included; Significance: * $p < .01$.

4.2 Results from regression analyses

Table 4 presents the estimates for our basic outcome equation predicting firms' revenue share from RNPs using the two-step Heckman selection procedure. Model 1 presents the base model containing control variables and our main effects. Models 2 to 5 then present the estimates for the hypothesized moderating effects of technology leadership (Model 2), incentive system (3), research capacity (4) and cross-functional collaboration (5).

Our base model reveals that firms' human capital, technology leadership and research capacity have a statistically and practically significant effect on firms' revenue share from RNPs. As for search openness, a curvilinear, inverse U-shaped relationship emerges, as indicated by the statistically significant linear and squared terms for search openness in Model 1. The average firm in our sample hence achieves a positive return from levels of search openness. However, consistent with prior evidence (Laursen & Salter 2006; Salge et al. 2011), the marginal benefits are declining, such that the revenue share from RNPs will be highest at moderate rather than high levels of search openness.

Table 4 Heckman selection models predicting firms' revenue share from RNPs

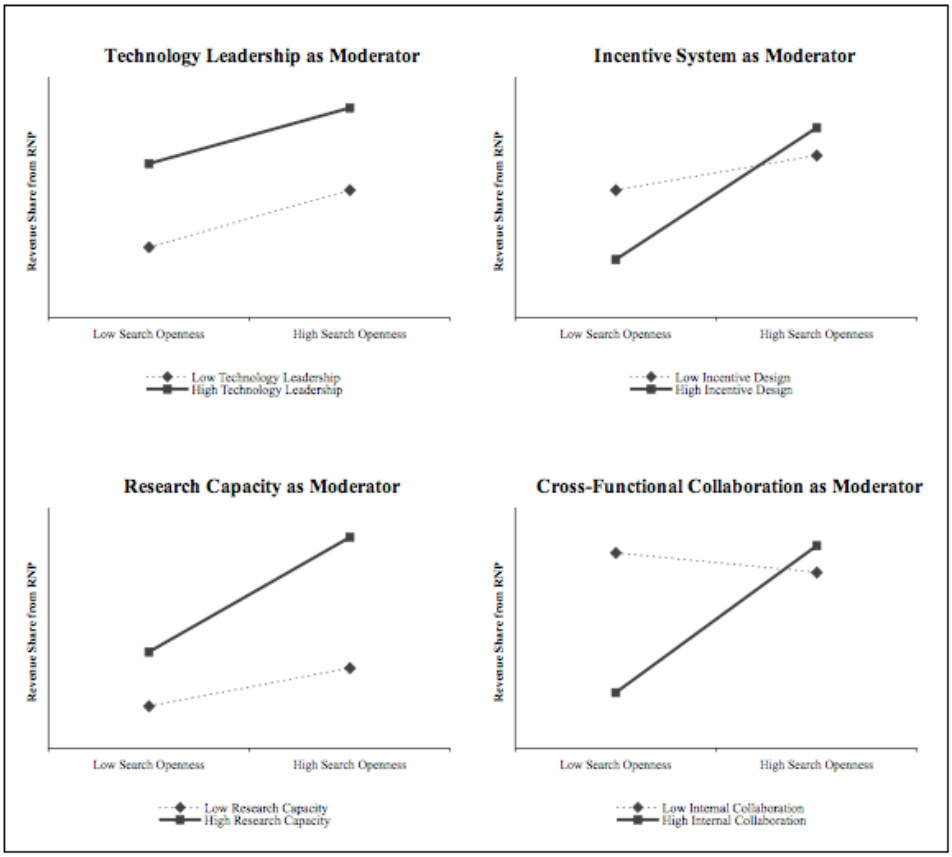
		Model 1		Model 2		Model 3		Model 4		Model 5	
		Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Control Variables											
Intercept		-0.843	(0.763)	-1.334	(1.011)	-1.302	(0.985)	-0.554	(0.746)	-0.760	(0.753)
Firm Size		-0.112	(0.348)	-0.112	(0.348)	-0.175	(0.344)	-0.057	(0.337)	-0.097	(0.343)
Human Capital		0.198	(0.071) ***	0.199	(0.072) ***	0.194	(0.070) ***	0.181	(0.067) ***	0.191	(0.070) ***
R&D Collaboration		0.166	(0.124)	0.167	(0.125)	0.147	(0.121)	0.116	(0.118)	0.151	(0.121)
Firm Location		-0.055	(0.096)	-0.055	(0.096)	-0.056	(0.093)	-0.055	(0.089)	-0.067	(0.093)
Sector dummies			Yes ***		Yes ***		Yes ***		Yes ***		Yes ***
Main Effects											
Technology Leadership		0.345	(0.071) ***	0.345	(0.072) ***	0.343	(0.070) ***	0.322	(0.068) ***	0.340	(0.070) ***
Incentive System		-0.030	(0.055)	-0.030	(0.055)	-0.054	(0.054)	-0.025	(0.051)	-0.023	(0.054)
Research Capacity		0.238	(0.064) ***	0.238	(0.065) ***	0.222	(0.063) ***	0.192	(0.064) ***	0.227	(0.063) ***
Cross-Functional Collaboration		-0.095	(0.075)	-0.095	(0.075)	-0.067	(0.074)	-0.106	(0.070)	-0.088	(0.073)
Search Openness		0.233	(0.113) **	0.235	(0.115) **	0.216	(0.111) *	0.159	(0.112)	0.099	(0.129)
Search Openness^2		-0.080	(0.046) *	-0.080	(0.046) *	-0.091	(0.045) **	-0.071	(0.044)	-0.082	(0.045) *
Interaction Effects											
Technology Leadership x Search Openness	**H1 (+)**			-0.003	(0.049)						
Incentive System x Search Openness	**H2 (+)**					0.126	(0.045) ***				
Research Capacity x Search Openness	**H3 (+)**							0.079	(0.035) **		
Cross-Functional Collaboration x Search Openness	**H4 (+)**									0.130	(0.063) **
Total Observations		1170		1170		1170		1170		1170	
Censored Obs. (Item Non-Response)		578		578		578		578		578	
Uncensored Obs. (Item Response)		592		592		592		592		592	
Wald chi-square		454.890 ***		455.160 ***		466.340 ***		469.430 ***		462.620 ***	

Notes. Standardized two-step Heckman estimates for the basic outcome equation predicting firms' revenue share from RNPs presented. Standard errors in parentheses. Estimates for the selection equation predicting item response not shown but available from the authors upon request.
* p < 0.10; ** p < 0.05; *** p < 0.01.

We now turn our attention to the four innovation management practices technology leadership, incentive system, research capacity and cross-functional collaboration. According to our hypotheses, all four practices were expected to positively moderate the relationship between search openness and firms' revenue share from RNPs. To test these hypotheses formally, we introduced interaction terms between search openness and each of the four innovation management practices.[1] In line with our theoretical arguments these interaction terms are positive and statistically significant for incentive system (Model 3), research capacity (Model 4) and cross-functional collaboration (Model 5). Pursuing a strategy of technology leadership, however, was not found to enhance firm-level payoffs from search openness (Model 2). These findings are robust to changes in the model specification, to the use of a Tobit instead of an OLS estimator in step two of the Heckman selection model and to the use of a two-year instead of a one-year time lag. Hypotheses 2, 3 and 4 are hence supported, while Hypothesis 1 is not.

Figure 1 illustrates these findings graphically. It becomes apparent that firms benefit notably more from greater search openness, when they established a dedicated incentive system for innovation, maintained a strong in-house research capacity and excelled at cross-functional collaboration. Interfirm disparities in returns from open innovation can hence at least in part be attributed to differences in firms' innovation management practices – findings that identify possible avenues for managers in search of greater returns from openness.

Figure 1 The moderating role of innovation management



[1] In line with previous open innovation research (Laursen & Salter 2006), only interaction effects with the linear search openness term are reported, as all interactions with the squared openness term remain statistically insignificant and do not improve the overall model fit. This suggests that the moderating variables affect the slope of the link between search openness and firms' revenue share from RNPs, but not its curvature.

5 Conclusion

This paper sought to shed light on innovation management practices that are particularly effective at increasing firms' returns from search openness and hence are able to explain at least in part the well-documented interfirm differences in open innovation payoffs (Lichtenthaler 2011). Drawing on longitudinal and cross-sectoral data from 1,170 German firms, we found search openness to be most effective at driving revenues from RNPs, when firms were characterized by strong incentive systems for innovation, substantial in-house research capacity and effective cross-functional collaboration. In contrast, a strong focus on technology leadership on its own did not seem sufficient to increase firm-level payoffs from search openness in any notable way. In light of these findings, decision-makers might be well advised not to take positive returns from search openness for granted. Rather, they need to achieve excellence in key innovation management practices, if their organisation is to fully harness the potential value of openness.

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