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CONTENTS

OUTLINE OF THE DISSERTATION PROPOSAL

The marketing literature has established that market knowledge (Atuahene-Gima 1995, 2005; Day 1994; Li and Calantone 1998) is a fundamental resource for product innovation performance. Market knowledge is defined as firm's knowledge about its customers and competitors (Day 1994; Kohli and Jaworski 1990; Narver and Slater 1990). Although the contributions of previous studies are substantial, extant research is lacking in three respects. First, in light of the numerous evidences on the value of market knowledge in product innovation, there is a growing need of theoretical contributions which are able to summarize extant research and open new ways for future investigations. Importantly, such an effort should be addressed to the integration of market orientation literature with different streams of research which have more directly characterized the study of organizational knowledge (e.g., KBV of the firm). In fact, as a second point, the knowledge-based view of the firm (KBV) underscores the importance of several different dimensions of market knowledge in product innovation: breadth, depth, specificity and tacitness (see Galunic and Rodan 1998). However, while studies in marketing emphasize the importance of broad market knowledge as reflected in the concept of market orientation (e.g., Atuahene-Gima 2005; Jaworski and Kohli 1993) there is little or no insight regarding the relative importance of the different dimensions of market knowledge as drivers of product innovation performance. Given the strategic importance of market knowledge, an approach that considers its dimensions and parses out the individual contributions seems appropriate if we are to effectively examine how market knowledge matters in product innovation performance. Third, assumed that a study which addressed the research gap previously identified (i.e., the differential value of different market knowledge dimensions for product innovation performance) resulted in a greater importance attributed to certain characteristics of market knowledge, new research would be called for the investigation of the antecedents of such characteristics.

The present doctoral dissertation will be based on three papers which address the three forgoing issues. A first paper will review studies on market knowledge and product innovation performance in light of the potential overlapping between market orientation theory with knowledge-focused theories such as KBV, providing the theoretical basis for the investigation of the differential value of the different characteristics of market knowledge in the product innovation context. A second paper will investigate empirically the interplay between market knowledge dimensions and two other fundamental factors in NPD processes: cross-functional collaboration and knowledge integration mechanisms. A third paper will research on the antecedents of the most prominent market knowledge dimensions in influencing product innovation performance.

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PAPER 1

MARKET ORIENTATION AND R&D EFFECTIVENESS IN HIGH-TECHNOLOGY FIRMS: AN EMPIRICAL INVESTIGATION IN THE BIOTECHNOLOGY INDUSTRY.

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MARKET ORIENTATION AND R&D EFFECTIVENESS IN HIGH-TECHNOLOGY FIRMS: AN EMPIRICAL INVESTIGATION IN THE BIOTECHNOLOGY INDUSTRY.

ABSTRACT

There seems to be lack of consensus among informed scholars about the importance a of market orientation for high-technology firms. This controversy may be alimented to two limitations of existing research on market orientation and innovation performance. First, extant research often overlooked key innovation outcomes for high-technology firms, such as those related to Research and Development (R&D) performance. Second, it proposed little about organizational conditions which can ensure an optimal integration of market knowledge in the high-technology firms' innovation process. The present study addresses these problems by providing a test of the effect of market orientation on R&D effectiveness and the moderating role of knowledge integration, using a sample of biotechnology firms. Results show that the different dimensions of a market orientation have diverse effects on R&D effectiveness of high-technology firms: while interfunctional coordination is inherently valuable, customer orientation needs to be complemented by knowledge integration, and competitor orientation does not seem to be influential. The authors discuss how these findings contribute to understanding the role of market orientation in high-technology industries, and conclude by providing directions for future research.

INTRODUCTION

The role of market orientation as an antecedent of innovation performance has been extensively documented in the literature (e.g., Baker, and Sinkula, 2005; Gotteland, and Boulé, 2006). However, despite the growing body of evidence on this relationship, the contingent value of market orientation in high-technology contexts is still subject to an open debate. On the one hand, the literature on the impact of the firm's market orientation (e.g., Atuahene-Gima, 2005; Im, and Workman, 2004) and of the firm's marketing competencies (Danneels, 2002; Dutta, Narasimhan, and Rajiv, 1999) on innovation processes has praised the benefits of the presence of a market orientation in the development of innovations in high-technology domains. On the other hand, the evidence produced by the research agenda of Christensen and colleagues (for a review, see Christensen, 2006) has shown how the managerial attention on the target market and the mainstream customers influences the resource allocation in the innovation process and is negatively associated with the firm's ability to co-evolve with technology dynamics.

We believe that this controversy is exacerbated by two key limitations intrinsic in the literature on market orientation and innovation performance. First, the different conceptualizations of innovation performance offered by existing studies of market orientation and innovation (i.e., market performance of the new product, financial performance of the new product, and firm's ability to innovate) are better tailored to traditional manufacturing and service contexts, rather than high-technology ones. In fact, despite the paramount importance of scientific research carried out by the Research and Development unit (R&D) in the innovation process of high-technology firms, no study has yet associated market orientation to R&D performance dimensions. Second, high-technology firms are characterized by a high degree of knowledge complexity and tacitness. When knowledge possesses such characteristics, it tends to be a key factor in gaining competitive advantage (Winter, 1987), and knowledge integration becomes fundamental for several reasons. It allows firms to identify and put together different knowledge elements which are dispersed in the organization (Kogut, and Zander, 1992) and makes them able to capitalize on local knowledge and increase their ability to internalize what they learn from highly different domains, such as basic research and marketing (Grant, 1996). Knowledge integration also endows firms with the collective learning ability, making it possible to combine past and new knowledge (Iansiti, and Clark, 1994), thereby broadening the firm's competency base (Zahra, Ireland, and Hitt, 2000); and it ensures the transfer of knowledge among subunits and it allows this to happen over time (Szulanski, 1996). All these arguments suggest that knowledge integration might be a way to optimize the value of market orientation for R&D effectiveness in high-technology firms; yet, this hypothesis still lies untested.

The purpose of this study is to address these two limitations, by providing a test of the effect of market orientation on R&D effectiveness of high-technology firms. Effectiveness is defined in the literature as the degree to which desired organizational outcomes are achieved (Ostroff, and Schmitt, 1993; Vorhies, and Morgan, 2003). In keeping with this definition, we conceptualize R&D effectiveness as the degree to which the firm's objectives related to desired R&D outcomes, such as generation of new innovation projects and new patents, production of relevant scientific knowledge, the acquisition of a reputation for scientific results, and the ability to attract and recruit outstanding human capital, are met. In our work, we also examine the moderating effect of knowledge integration in the link between market orientation and R&D effectiveness of high-technology firms. Consistent with prior studies (e.g., Zahra, Ireland, and Hitt, 2000), we conceptualize knowledge integration as formal mechanisms – such as formal information exchange meetings, projects committees, use of internal experts and consultants, and formal project reviews - that ensure the capture, analysis, interpretation and integration of different types of knowledge (i.e., scientific and marketing) within the firm. Figure 1 presents our conceptual model.

Overall, our results show that the different dimensions of a market orientation (namely, customer orientation, competitor orientation, and interfunctional coordination) have different effects on R&D effectiveness of high-technology firms: while interfunctional coordination is inherently valuable, customer orientation needs to be complemented by knowledge integration mechanisms, and competitor orientation does not seem to be influential. The remainder of the paper is organized as follows. In the next section we briefly describe our research design. Then, we review the literature on market orientation and innovation performance to show how our study relates to the prior contributions. Next, we develop our hypotheses on the direct effect of market orientation on R&D effectiveness, and the moderating role of knowledge integration. Last, we present and discuss the results and conclude by highlighting our contribution to the literature and suggesting some fruitful directions for future research.

Figure 1 About Here

RESEARCH DESIGN

We chose to set our study in the biotechnology industry. Biotechnology is an ideal laboratory to study strategy issues (Pisano, 2006), and it is considered a representative settings of high-technology industries where R&D effectiveness has the highest importance (Khilji, Mroczkowski, and Bernstein, 2006). We addressed the study's objectives in two steps. The first one consisted of an in-depth qualitative study based on semi-structured interviews in five biotechnology firms that helped us exploring in this context the domain and validity of the R&D

effectiveness, knowledge integration and market orientation constructs. We ran in-depth semi-structured interviews with eight among founders and managers of these companies, with proven international experience in the industry. In doing so, we followed traditional methodological prescriptions on collecting data through personal interviews (Lee, 1999). The semistructured format allowed the researchers to steer the conversation towards the focal topic while leaving respondents free to openly express their views. The interviews lasted between 60 and 150 minutes and were conducted on site, followed by a visit to the company. At least two researchers participated in each interview, took detailed transcripts independently, and integrated them in the analysis phase. Table 1 presents a synthesis of key facts related to the selected firms (Row 1), and an account of how these firms describe the market oriented behaviors and the knowledge integration mechanisms they adopt during their innovation process (Rows 2 and 3). The second step consisted of a follow-up quantitative analysis that tests our model in a larger sample.

Table 1 About Here

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## LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

### Market Orientation and Innovation Performance

A market orientation reflects the extent to which a firm internalizes the marketing concept as a primary organizing principle of the firm (Day, 1994: Kohli, and Jaworski, 1990). With few exceptions (e.g., Appiah-Adu, and Ranchhold, 1998; Greenley, 1995; Kahn, 2001; Langerak et al., 2004a, 200b), empirical findings converge in indicating a positive impact of market orientation on several product innovation outcomes, and across different industrial settings. We reviewed the most relevant studies on the relationship between market orientation
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and innovation performance (see Appendix 1 for a synthesis of these contributions). This list of studies includes and updates two recent comprehensive reviews of empirical evidence about the same relationship (Baker, and Sinkula, 2005; Gotteland, and Boulé, 2006), and integrates them with two sets of complementary information: the domain of the innovation performance measures considered in these studies, and the setting from which the data used to test the analysis were collected.

As for the innovation outcomes, market orientation has been linked to three different domains of product innovation performance. First, market orientation positively influences the new product's *market performance*, defined in terms of new product's market share, sales, perceived product quality, customer acceptance of the new product, and customer satisfaction with the new product. Second, market orientation is positively linked to the new product's *financial performance*, defined in terms of profitability of the new product (e.g., ROI, ROA). Third, market orientation is positively linked to the *firm's ability to innovate*, defined in terms of rate of new product introduction by the firm, propensity to invest in innovation and new market opportunities, time-to-market and other process performance indicators, firm's ability to develop market and technological breakthrough innovations. Although the contribution of existing studies on the market orientation-innovation performance link is substantial, a closer look at the types of innovation outcomes they considered reveals a proclivity toward more traditional business to consumer or industrial business models. However, high-technology firms are often with few or no products in the market (Khilji, Mroczkowski, and Bernstein, 2006); they do not run profitable businesses but collect financial resources by institutional investors to continue investing in R&D (*Business Week*, 2007); and, due to the length and complexity of the R&D process, their ability to innovate is not captured by traditional indicators of new product introduction rate, process performance or number of breakthrough innovations developed (Pisano, 2006). In this respect, the biotechnology industry represents one case in which all the above limitations of traditional innovation outcomes applied to high-technology firms hold.

In addition, the overview of the empirical settings in which the market orientation-product innovation performance has been tested reveals that most studies are based on cross-sectional samples covering a broad set of industries or on traditional manufacturing or service settings. On the contrary, only a few studies are specifically carried out in high-technology contexts. In summary, we advance that, at least in part, the controversy about the value of market orientation for innovation performance in high-technology contexts might be fueled by the fact that: 1) existing studies have considered innovation outcomes which are more suitable for traditional industrial or service contexts, such as new product market and financial performance and firm's ability to innovate; 2) most studies are set in non high-technology contexts (i.e., hotels, banks) or based on a heterogeneous set of industries (e.g., SIC codes of Manufacturing firms); 3) both the previous conditions. Against this backdrop, we next develop hypotheses on the effect of market orientation on R&D effectiveness and test them in a purely high-technology context.

Market Orientation and R&D Effectiveness

In this study we adopt Narver and Slater's conceptualization of market orientation based on three components: customer orientation, competitor orientation, and interfunctional coordination. Customer orientation involves generating information about current and future customers and using it within the firm. Competitor orientation refers to generating information about competitors' strategies and actions, and using it within the firm. Interfunctional coordination refers to aligning organizational subunits to the market oriented vision and objectives, for example through a strong collaboration between marketing and R&D (Li, and Calantone, 1998; Narver, and Slater, 1990).

Our fieldwork interviews revealed a number of market oriented behaviors implemented by the biotech companies in the sample (see Table 1, row 2). Customer oriented behaviors include for example the collection of data regarding the market potential of new technologies, the internal generation of market intelligence (i.e., surveys of medical specialists), external purchasing of market data, early customer involvement in innovation projects, and so forth. Competitor oriented behaviors include the collection of competitive intelligence, periodic review of competitors' patenting activity, and the use of internal experts and consultants to protect the company's intellectual properties from competitors' attempts of imitation (e.g., "patenting around"). Interfunctional coordination includes open communication between scientists and business development personnel, sharing of projects' goals and responsibilities, and common perspectives on innovation priorities by different departments. Although descriptive, these qualitative findings provided two relevant indications. First, consistently across all the interviews, the implementation of market oriented behaviors is triggered by founders or top managers with a broader view of the field, who are increasingly recognizing the need to combine scientific and commercial viewpoints during the normal operative activities of their companies (see also, Khilji, Mroczkowski, and Bernstein, 2006). Second, and more importantly, our in-depth interviews showed that the positive contribution of market oriented behaviors can actually occur earlier in the innovation process by enhancing the R&D effectiveness of the firm.

For example, customer orientation, through the early involvement of customer knowledge in the R&D process, has been mentioned as a source of stimulation for new ideas which may generate streams of new research projects and new patents for the firm; also, customer orientation helps to focus the R&D activity on highly promising projects, which are more motivating for individual scientists and research teams, and therefore more likely to be executed according to their objectives; further, customer orientation infuses a sense of commitment to customer needs which enhance the likelihood that problems and difficulties of the R&D process are overcome and objectives are met. Competitor orientation and benchmarking competitors' strategies and experiences has been mentioned as a powerful way to learn from industry recipes in such domains like the organization of the R&D function, the management of scientific alliances and partnerships, and the implementation of best practices in technology transfer, which might enhance the ability of the firm to achieve its objectives in scientific research. Interfunctional coordination promotes internal cohesiveness and cooperation in the job environment; such an environment supports productivity and generates a positive reputation which may favor the attraction of new skilled personnel in the firm. Also, interfunctional coordination seems to be crucial in preventing the extreme pressure on results posed by the environment to become dysfunctional for R&D effectiveness: lack of cooperation or communication, as well as excessive factional behaviors between R&D and other personnel in the firm could, in fact, generate errors, delays and suboptimal decisions that would have a negative impact on the firm's R&D process effectiveness.

In short, both theory and managers' perceptions provide grounds for linking market orientation to R&D effectiveness of biotech firms. This view suggests a positive effect of market orientation on high-technology firms' scientific outcomes, which so far remained untested in the literature. Thus, we hypothesize that:

H1: The three dimensions of market orientation, (a) customer orientation, (b) competitor orientation, (c) interfunctional coordination, are positively related to R&D effectiveness.

The moderating role of Knowledge Integration

Consistent with prior studies (e.g., Zahra, Ireland, and Hitt, 2000) we conceptualize knowledge integration as formal mechanisms that ensure the capture, analysis, interpretation and integration of different types of knowledge (i.e., scientific and marketing) within the firm. These mechanisms are complementary to interfunctional coordination, yet differ from it in one main respect: while the functional interdependency captured by interfunctional coordination reflects the alignment of goals, joint involvement and mutual recognition subunits in the firm (Li, and Calantone, 1998; Narver, and Slater, 1990), knowledge integration reflects the structures and process through which different sources of knowledge are integrated to realize such common goals and objectives. The literature maintains this important distinction, in particular when the two constructs are examined in the context of high-level competencies such as new product innovation in high-technology firms (see, for instance, Grant, 1996; De Luca, and Atuahene-Gima, 2007), where complexity and error proneness render interfunctional coordination a necessary but not sufficient condition for innovation performance (Hoopes, and Postrel, 1999).

Notably, our fieldwork evidence clearly indicates the importance that managers of biotechnology firms ascribe to formal knowledge mechanisms as a way to implement a market orientation in their organizations (See Table 1, row 3). The use of formal project analysis and reviews, internal committees to screen new business opportunities, cross-functional teams and task forces including scientists and business people, and periodic firm-level overview of the ongoing projects suggests that biotechnology firms attempt to overcome the problems related to developing their market orientation by leveraging organizational structured mechanisms for knowledge integration. This evidence adds to the recognized role of formal knowledge integration in the pharmaceutical (Henderson, and Cockburn, 1994) and other high-tech industries (Danneels, 2006) by indicating that the extent to which biotechnology firms are likely to benefit from market orientation depends on their ability to integrate the acquired market knowledge with their scientific knowledge and deploy both in their innovation process. When knowledge integration is low, the impact of market orientation is likely to be poor, because market and scientific knowledge remain disconnected. This line of reasoning is rooted in a contingency perspective of the resource-based view of the firm, recently defined by Newbert (2007) as the "organizing approach". According to this approach, organizational level conditions, such as knowledge integration, enable the effective exploitation of single resources, such as market orientation, within the firm. When such organizational conditions are high, the resource will be maximally productive, but when they are low the same resource will be of scant importance. Following this line, formal knowledge integration mechanisms were positioned in prior studies as moderator between sources of information and the breadth and depth of the firm's knowledge (Zahra, Ireland, and Hitt, 2000) and between internal and external capabilities and innovation outcomes (Zahra, and Nielsen, 2002); also, De Luca and Atuahene-Gima (2007) highlighted the dual mediator and moderator role played by knowledge integration mechanisms between market knowledge dimensions and product innovation performance[1].

In conclusion, drawing on theoretical arguments, fieldwork evidence and prior studies, we suggest that knowledge integration acts as a moderator in the relationship between market orientation and R&D effectiveness of high-technology firms. Hence, we posit that:

> **H2:** Knowledge integration positively moderates the relationship between the three dimensions of market orientation (a) customer orientation, (b) competitor orientation, (c) interfunctional coordination, and R&D effectiveness.

SURVEY METHODS

Data collection. This study was based in the Italian biotechnology industry, which represents an appropriate context for three main reasons. First, Italy is one of the most prominent European countries in terms of dimensions and quality of biotechnology investments (Earnst & Young, 2006). Second, the fact that biotechnology is highly regulated and presents a natural tendency of geographical dependence (Phene, Fladmoe-Lindquist, and Marsh, 2006) and geographical clustering (Zucker, Darby, and Brewer, 1998) makes our sample consistent with previous empirical studies largely based on country evidence (e.g., Gittelman, 2006; Kaiser, and Prange, 2004; Linskey, 2006). Finally, the geographical proximity between the research team and the empirical setting facilitated control over the quality and consistency of the study's data.

We selected the entire population of biotechnology firms that operate in Italy (163 companies). This list was obtained from a certified census of Italian biotech firms carried out by the Italian association of biotech firms (AssoBiotec); it was adopted because it was the most reliable and complete among the available industry directories. The list is updated to January 2006 and includes only firms which satisfy three specific criteria: 1) are for-profit organizations; 2) carry out R&D activities in the national territory; 3) base their R&D totally or in part on biotechnology activities. This group of firms employs a total of 8,389 people and had total revenues amounting to 2,886 million euros in 2005 (0.2% of the country's GDP). These figures make the Italian biotech industry the fourth largest in Europe after Germany, UK and France. Segmenting the sample for biotech applications, 69% of the firms are from health-related applications (red biotech), 15% from agricultural applications (green biotech), and 10% from industrial and environmental applications (white biotech). The rest is represented by bioinformatics and other instrumental applications.

The conventional method of back translation was used to translate the measures from English into Italian. We pre-tested the instrument with the founders and managers of the five biotech companies involved in the interview study, and with 4 managers of a leading national Biotech Science Park. We collected data through two separate surveys. In the first survey, collected in March 2006, we gathered data on market orientation, knowledge integration, as well as several descriptive indicators (including number of employees, number of projects in the pipeline, number of patents held and issued, number of products in preclinical and clinical phase). In a second survey, six months later, we gathered data on the performance variables. This procedure of collecting the independent and dependent variables at different times allowed us to reduce the extent of common method variance (Podsakoff, MacKenzie, Lee, and Podsakoff, 2003). We ensured full confidentiality on the information and offered a summary of both surveys' results. When contacted by telephone before the survey, 32 firms did not agree to participate, restricting the actual sample to 131. CEOs and other managers in the position of Vice Presidents were selected as informants. Each executive received a copy of the questionnaire and a letter describing the general purpose of the study via email, or fax upon request. Three weeks after the first wave, we sent a copy of the questionnaire and a follow-up letter to nonrespondents.

We received 70 completed questionnaires after the first survey, with a response rate of 53.4% (70/131). After the second survey, we received 50 questionnaires, from the same informants previously contacted. 57.1% of the responses were from CEOs, 38.8% from R&D Vice Presidents, and the rest from Marketing or Business Development Vice Presidents. Analysis of variance (ANOVA) did not indicate significant differences across the three groups of informants in the responses regarding key variables ($F \leq .76$), so we pooled the data for further analyses. Our informants had an average experience of 7.6 years in the firm and 18.8 years of experience in the biotech industry or related industries such as pharmaceuticals. Respondent firms were run by a management team composed on average of 4.4 people. Some had a degree in science (74%), business administration (17%) and engineering (9%) or a postgraduate degree: either a Ph.D. in scientific disciplines (27%), engineering (3%), or an MBA (15%). We also ran an ANOVA test to control whether the respondents to the second survey were significantly different from the non-respondents in their degree of market orientation and knowledge integration, but did not find significant differences ($F \leq .62$).

Measures. For market orientation and knowledge integration scales we borrowed items from prior studies. For R&D effectiveness, we developed a new set of items, based on insights from the in-depth interviews (see Appendix 2 for measures and sources). Items related to the antecedents and the moderator are measured on a 5-point scale, whereas items related to the dependent variables are measured on a 7-point scale. This gives the informants a different psychological framework thereby hindering common method bias.

Dependent variable: R&D effectiveness (α = .85) was measured based on six items assessing the extent to which the biotech company has been able to achieve its R&D objectives such as, for example, new projects, new patents, generation of new scientific knowledge, and attraction of new scientists. To validate R&D effectiveness, we also collected additional subjective and objective indicators of the biotech firms' scientific and organizational performance. First, we measured the *organizational performance* of the biotech firms (3 items, α = .90), which assessed the firm's perceived performance with respect to its stated objectives, its main competitors, and the overall industry performance. Second, when available, we gathered indicators of: a) number of projects in the discovery phase; b) number of projects in the pre-clinical phase; c) number of patents registered in the last three years by the firm; d) number of patents issued and waiting for approval; e) number of patents sold or licensed out by the firm in the last three years. We adjusted all these indicators by the firm size, measured as the number of full time employees, and correlated them with our self-reported measures of R&D effectiveness (r = .22 ; .25; .15; .23; .08). We observed a general pattern of positive correlations between R&D effectiveness and the objective measures of scientific performance; the correlation between R&D effectiveness and organizational performance was also positive and significant (r = .60). On the whole, although objective indicators were not available for all firms in the sample, these correlations buttress the validity of our dependent variable.

Independent and moderating variables. We measured c*ustomer orientation* (α = .84) with three items tapping, for example, the extent to which biotech firms are knowledgeable about the business of potential customers and meet them to learn about their current and prospect needs. We measured *competitor orientation* (α = .89) with three items, asking the informant, for example, the extent to which firms systematically analyze information about competitors. We measured *interfunctional coordination* (α = .84) with four items which assessed, for example, the extent to which people from R&D and other units in the company collaborate for defining objectives and priorities for the new projects. We measured *knowledge integration* (α = .79) with five items, tapping the extent to which biotech firms use a set of formal integration mechanisms to integrate scientific and market knowledge.

Control variables. When testing for the hypothesized relationships we also controlled for several variables which can have an impact on the scientific, business performance of biotech firms. We controlled for *firm size*, measured as the number of full time employees. To prevent skewness, we used the logarithm of the number of employees. We controlled for the *type of application* (dummy coded: 1 = red biotech; 0 = all other applications). We controlled for *firm's* *origin* by introducing two dummy coded variables for start-up and spin-off new ventures; and for the *affiliation* of the firm to science parks and other types of public or private agencies for technology transfer (dummy coded: 1 = affiliated; 0 = not affiliated). Table 2 provides descriptive statistics and correlations among all the study variables.

Table 2 About Here

Reliability and validity of measures

As noted above, all the measures have a Cronbach's alpha of .70 or higher, indicating acceptable reliability. Moreover, corrected item-total correlation scores ranged between .48 and .83, all above the .45 threshold suggested in the literature (e.g. Parker, Wall, and Jackson, 1997). We ran a set of exploratory factor analyses with SPSS 14.0, using Maximum Likelihood estimation with Promax rotation, thus allowing correlation among factors. To ensure an acceptable ratio between observations and items we ran two exploratory factor analyses, grouping theoretically related constructs together; the first group included the three market orientation components and knowledge integration; the second group included R&D effectiveness and organizational performance. All items loaded cleanly on the expected factors, with factor loadings of .57 or above and without significant cross-loadings, indicating convergent validity (see Appendix). We assessed discriminant validity following the guidelines by Fornell and Larcker (1981). A confirmatory factor analysis (CFA) using PLS indicated that for each construct, the average variance extracted (AVE) was greater than the highest squared correlation with other constructs. Based on this evidence of the measures' reliability and validity, we averaged the items of each scale and used these scores in subsequent analyses.

RESULTS

We used hierarchical multiple regression analysis to test the hypotheses on the effect of market orientation on R&D effectiveness. In the first step we entered the control variables; in the second step we added the main effects of customer orientation, competitor orientation, interfunctional coordination, and knowledge integration. Finally, we entered the three interaction terms with the market orientation components. To avoid multicollinearity, we mean-centered the variables involved in the interaction terms (Aiken, and West, 1991); the values of Variance Inflation Factors (VIFs), all below 3.5, indicated no serious multicollinearity concerns. Table 3 reports the results of regression analysis.

Table 3 About Here

Control variables explain 31% of variance (Model 1); among them, the dummies for red biotech firms, startups, and spin-offs show positive and significant effects. When added, the main effects explain an additional 6% of variance (Model 2). The inclusion of the three interaction terms yields a 13% increase in R^2 (Model 3). In this model, only interfunctional coordination has a positive and significant main effect on R&D effectiveness (β=.35, t=1.93), while those of customer orientation and competitor orientation are not significant. Thus, H1c is supported while H1a and H1b are not. The interaction between customer orientation and knowledge integration is positive and significant (β=.48, t=2.16), suggesting that the effect of the former on R&D effectiveness is positive under high knowledge integration between scientists and representatives of other units in the firm. On the contrary, knowledge integration does not moderate the effects of competitor orientation (β=-.22, t=-.99) and interfunctional coordination (β=.15, t=.68) on R&D effectiveness. Thus H2a is supported while H2b and H2c are not.

DISCUSSION

The objective of this study was to investigate the impact of market orientation on R&D effectiveness and the contribution of knowledge integration as a moderator of this relationship[2]. Our findings indicate that the impact of a market orientation on R&D effectiveness should be read by considering its different dimensions and across levels of knowledge integration. A customer orientation is not inherently valuable for R&D effectiveness; however, this dimension of market orientation shows a positive and significant contribution to R&D effectiveness under high degrees of knowledge integration mechanisms between market and R&D within the firm. Interfunctional coordination increases R&D effectiveness directly, and its positive effect holds across different levels of knowledge integration. Contrary to what hypothesized, competitor orientation does not seem to influence R&D effectiveness, either directly or through the moderation of knowledge integration. One possible explanation for this non-significant finding may be that, despite its cost, competitor orientation fails to generate significant performance benefits due to the stringent IP protection regime which characterizes biotechnology and other high-tech industries. Another explanation might refer to managers' perceptions of the performance evaluation made by financial investors. With respect to this, a benchmarking/imitation strategy might not lead to sufficient pay-offs considering the substantive financial resources required by high-technology firms.

Our study contributes to current literature in two main respects. First, we contribute to previous work on the market orientation and innovation by adding a new dependent variable related to the scientific performance – R&D effectiveness – which offers a better perspective to understand the impact of market orientation on innovation performance in high-technology contexts. R&D effectiveness can usefully complement existing measures of innovation performance and organizational performance in studying the effects of market orientation within a broader nomological network (Baker, and Sinkula, 2005). Second, while part of the current debate on the role of the market orientation in high-tech markets seems to be polarized by positions that sustain its potential drawbacks (e.g., Christensen, 1997) or, on the contrary, its advantages (e.g., Slater, and Narver, 1998), our findings on the moderating role of knowledge integration highlight the role of organizational capabilities as moderating conditions. Indeed we show how in high-technology industries a market orientation is not relevant per se, but its contribution depends to a great extent on the quality of formal knowledge integration. In particular, beyond the ability of a firm to support its interfunctional coordination between marketing and R&D, it is the formal mechanisms to integrate customer knowledge within scientific knowledge in the innovation process that impact on the R&D performance of the firm. In fact in high-technology industries the fundamental role of R&D needs not to be contrasted with a market view but needs instead to be combined through dedicated integration mechanisms. We suggest that a salient point is related to tackle this discussion not with an *either/or* approach regarding the positive or negative role of customers in front of technological innovation, but to embrace it with a more critical attention on how one can use and exchange customer knowledge in a high-technology and science driven context such as biotechnology and other industries. The risk is to juxtapose a tension toward the market in a context that is naturally pulled by technology, thus giving rise to intra-organizational conflict and cultural clash (Leonard Barton, 1992). In high-technology firms, a market orientation needs not to be added to R&D in the innovation process, it needs to blend with it.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

Our study is inevitably subject to a number of limitations which should be borne in mind while interpreting its results. In particular, our work is entirely based on evidence from one country. If on one side Italian biotech firms are fully involved in the international scientific networks and markets, on the other side the specific contextual characteristics could limit the generalization of our results. Moreover, the constraints on the sample size given by the limited dimension of the industry have to be taken into account. Furthermore, the cross-sectional design limits our ability to infer causal relationships among our study variables. Finally, the use of a single respondent represents a limitation. However, the use objective indicators to validate R&D effectiveness, the separation between the survey for the dependent and independent variables, and the significant interaction findings, ensure a strong ward against common method variance.

Besides overcoming the above limitations, our study opens several fruitful avenues for future research. First, we found that a focus on competition in high-technology settings seems not significantly related to R&D effectiveness. Our findings provide additional insights into an existing debate on what seems to be the more ambiguous dimension of market orientation in terms of performance implications. Indeed, market orientation scholars have advocated a general positive relationship between this construct – including competitor orientation – and performance across different environmental conditions (e.g., Jaworski, and Kohli, 1993; Slater, and Narver, 1994). However, other scholars (Armstrong, and Collopy, 1996) have pointed to the general negative influence of competitor-orientation on decision making and performance.

Future research is needed to understand better the effects of competitor orientation on innovation and business performance. Second, our study considered R&D effectiveness as a relevant outcome of market orientation. However, prior contributions on the biotech industry (Khilji, Mroczkowski, and Bernstein, 2006) indicate that other performance dimensions, such as funding, inter-firm collaboration, and networking abilities are also important. Future research can complement our research and other existing studies by testing these promising insights. Third, our findings on the salience of market orientation for high-technology firms open the way for studying its antecedents in this specific context, together with organizational and/or external factors which can favor its development. Fourth, in our interviews we found that market oriented behaviors in biotech firms are implemented top-down; future research can move from this insight and focus on how individual characteristics and leadership styles of managers and founders of high-technology firms affect the degree and effectiveness of their market orientation. Fifth, our results show that red biotech (b=.35, t = 2.38), and start-ups (b=.41, t=2.37) perform better than the respective baseline groups in terms of R&D effectiveness; indeed, in a context of low scale economies, such as the biotech and other science-based industries, such variables can approximate the brightness and productivity of scientific human capital. Future research might look more closely at the existence of different clusters of high-technology firms, within and across industries, which can benefit from market orientation in different ways. Relatedly, we found that the affiliation to a science park do not increase R&D effectiveness. Future research might investigate the role of scientific parks and other technology transfer devices in promoting high-tech firms' performance in presence of a market orientation. Last our results present a potential implication from a policy angle, which can be considered in future research. Indeed, Arora, Fosfuri, and Gambardella (2001) report how several industries (including chemicals, software, and biotechnology) have witnessed the emergence of a division of labor at the inventive level and are becoming increasingly influential in addressing innovation at the industrial level. By highlighting the positive attraction by downstream markets in biotechnology, our results contribute to specify the characteristics of this neo-market pull view and to extend it to further contexts. In respect to this, future research might explore whether in countries where venture capitalists and financial markets are less efficient and liquid, such strategic orientation towards the end markets might provide an important engine for growth.

In conclusion, we believe that our study sheds further light on the understanding of the role of market orientation for innovation in high-tech markets. If it is true that the managerial attention paid to customer preferences and market dynamics complements the traditional supply-side view of competencies by providing a new, fruitful, demand-based view of strategy (Henderson, 2006), we would like future research to follow our general guidelines in order to tease out further contingencies for gaining competitive advantage in high technology markets.

ENDNOTES

1. Moving from similar considerations, other scholars (e.g., Atuahene-Gima, 2005; Gatignon, and Xuereb, 1997) view interfunctional coordination as an informal knowledge integration, and test its moderating role of in the relationship between the other two dimensions of a market orientation (customer and competitor orientation) and innovation outcomes. Our approach differs from these works in two respects. First, following the seminal work of Narver and Slater (1990), we conceive interfunctional coordination as a dimension of market orientation. Second, we distinguish between interfunctional coordination and formal integration mechanisms and focus on the moderating role of the latter, which have the advantage of providing more clear-cut implications about the market orientation's demands in terms of organizational design.

2. Market orientation scholars have warned that the costs, in terms of time and money, to build and maintain a market orientation may in part counterbalance its positive effect on revenue-based performance (e.g., Jaworski and Kohli, 1993, p. 65; Kohli and Jaworski 1990, p. 15; Slater and Narver, 1994, p. 220); these studies consistently call on managers to pay attention to the cost-benefit ratio of their market orientation, by not overlooking its potential negative effects on efficiency-related outcomes. We accounted for this point by testing the effects of market orientation on a three-item measure of R&D efficiency, assessing the extent to which initial allocations of money, time and other resources to R&D projects are respected. Empirical results do not indicate a negative effect of market orientation on R&D efficiency. Rather, interfunctional coordination has a positive and significant effect.

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Figure 1
Conceptual Model

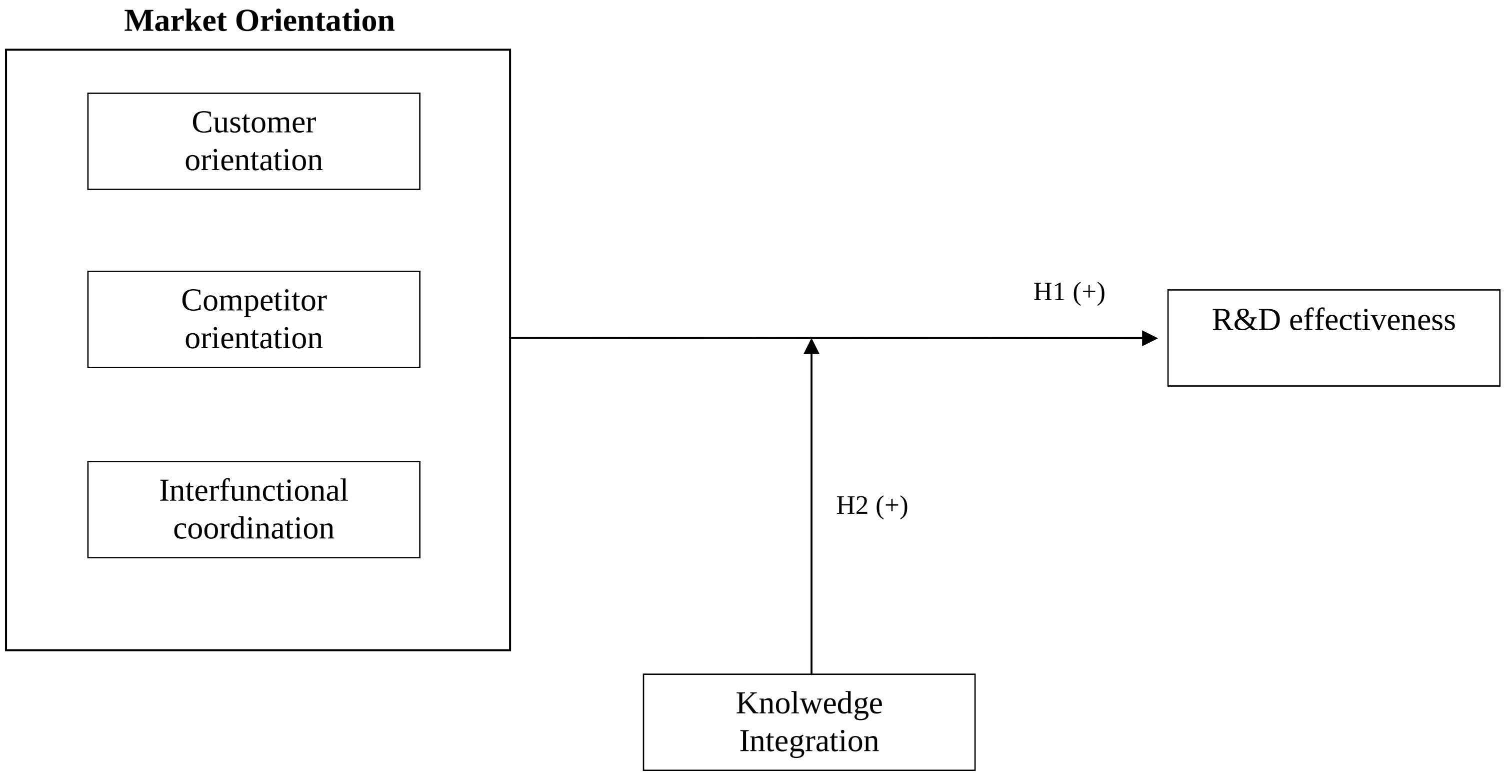

Table 1
Key Facts and Findings from In-depth Qualitative Analysis

	Biotech 1	Biotech 2	Biotech 3	Biotech 4	Biotech 5
1. Firm characteristics and history a) Foundation b) Type of firm c) Core competence d) Size e) Organization & management	a) 2001 b) Spin-off from multinational pharmaceutical firm c) Drug-discovery process technology d) About 60 employees (80% are researchers) e) 2 co-founders assisted by a CFO; 5 people in charge of research; 1 person dedicated to corporate communication; IT & administrative service units platforms	a) 2002 b) Spin-off from multinational pharmaceutical firm c) Urology and inflammatory diseases d) About 70 employees (50% researchers) e) 4 departments: finance, business, general administration, R&D (preclinical and clinical); 2 founders (CEO and CSO) supported by CFO, CAO and CBO.	a) 1996 b) Academic Spin off c) Drug-discovery, clinical development d) 76 collaborators (62 of which are full time employees) e) Balanced top management team (president is a scientist, CEO is an MBA). One specialist takes care of business development (*Licensing, Patenting, Institutional Communication)*	a) 1941, biotech since 1988 b) Fully integrated pharmaceutical firm with distribution of licensed products c) Discovery and development of therapeutic compounds: DNA cloning, phage display, identification and purification of fragments of human antibodies to be used as therapeutic tool. d) Mid sized firm. Research structure with 100 scientists e) Fully structured divisional organization	a) 1927. M&A and technology transformation during time. Investment in biotech starting from early 1970s. b) Fully integrated pharmaceutical firm with distribution of licensed products c) Discovery and development of diagnostic compounds; distribution of licensed products d) 3,500 employees (17% in R&D) e) Family owned, but structured as a mid-sized firm
2. Market orientation a) Customer orientation b) Competitor orientation c) Interfunctional coordination	a) Data on market potential of the new technologies gathered from specialized providers b) Monitoring of scientific trajectories of other firms in the same or similar domains c) Scientists and business personnel share the same vision on how to manage each projects and the relationship with customers	a) Use of professional marketing research (surveys to urology specialists on medical needs and sales potential); Continuous search of unmet medical needs; use of publications and corporate communications to attract new target customers. b) Early focus on competitor intelligence from the pre-discovery phase c) Joint influence of R&D and marketing during market intelligence collection and analysis.	a) Generalist evaluation of early stages molecules. Sales forecasts and NPV analysis for more developed compounds. b) Constant monitoring of competitors' strategies by the CEO. c) Frequent and informal communications between scientists and CEO.	a) Market research is considered important. Dedicated internal market research department, subscription to international databases. b) use of consultants and specialized information providers for understanding competition in specific markets. c) Strong importance of informal communication and the sharing of common goals between scientists and marketing.	a & b) Free exploration in the first stages; finer customer and competitor analysis before entering the clinical phases; more fine grained analysis the closer the product is to the market launch c) importance of joint involvement and communications by R&D and marketing on all major project's decisions.
3. Knowledge integration	Regular meetings (weekly) involving all the personnel to share projects experiences; regular meeting among management team to screen and select opportunities; planned cross-functional brainstorming on innovation opportunities.	"*Lead team*" meeting every two weeks (leading scientists + management team); "*business development*" meetings every two weeks (the business group meets researchers); management team meeting every week for strategy issues; use of external experts and consultants	Weekly meetings for projects review at the top-management team level.	Two strategic committees with all the top management that put together all the functions; other more operative committees on single projects.	Two committees: marketing committee (composed of marketing and project leaders) and R&D committee (scientists); the two committees work in close contact and meet on a regular basis.

Table 2
Measures, Correlations, and Descriptive Statistics [a]

	Variables	1	2	3	4	5	6	7	8	9	10
1	Customer Orientation	1.00									
2	Competitor Orientation	.42**	1.00								
3	Interfunctional Coordination	.46**	.44**	1.00							
4	Knowledge Integration	.17	.42**	.34**	1.00						
5	R&D Effectiveness	.08	.22	.36**	.37**	1.00					
7	Red Biotech (dummy variable)	.03	.22†	.11	.23†	.40**	1.00				
8	Start-up (dummy variable)	-.18	-.02	.12	.03	.10	.04	1.00			
9	Spin-off (dummy variable)	.16	.28*	.06	.23†	.15	.00	-.53**	1.00		
10	Science Park (dummy variable)	.22†	.15	.18	.12	-.04	-.06	-.07	.16	1.00	
11	Firm Size	.25*	.01	-.19	.26*	.14	.31**	-.31**	.11	-.19	1.00
	# of items	3	3	4	5	7	n.a.	n.a.	n.a.	n.a.	n.a.
	Mean	3.53	3.45	3.96	2.97	4.70	.70	.41	.29	.24	3.33
	Standard Deviation	1.06	1.07	.91	.93	1.25	.46	.50	.45	.43	1.83
	Skewness	-.51	-.40	-.69	.18	-.53	n.a.	n.a.	n.a.	n.a.	.56
	Kurtosis	-.24	-.63	-.06	-.50	-.15	n.a.	n.a.	n.a.	n.a.	-.25

[a] † p<.10; *p<.05; **p<.01 (two-tailed test); Sample size ranges between 47 and 70.

Table 3
Effects of market Orientation on R&D Effectiveness: Moderated Regression Analysis [a]

	Model 1		Model 2		Model 3	
	β	t-value	β	t-value	β	t-value
Control variables						
Red biotech (dummy)	.43	3.11***	.38	2.50**	.35	2.38**
Start-up (dummy)	.44	2.64**	.38	2.14**	.41	2.37**
Spin-off (dummy)	.32	1.99*	.31	1.73*	.24	1.40
Science Park (dummy)	-.08	-.56	-.04	-.25	-.05	-.33
Firm Size	.05	.32	.14	.77	.06	.33
Main effects						
Customer Orientation			-.15	-.84	-.12	-.68
Competitor Orientation			-.13	-.65	-.04	-.23
Interfunctional Coordination			.27	1.48*	.35	1.93**
Knowledge Integration			.08	.53	-.10	-.59
Interaction effects						
Customer Orientation × Knowledge Integration					.48	2.16**
Competitor Orientation × Knowledge Integration					-.22	-.99
Interfunctional Coordination × Knowledge Integration					.15	.68
R^2	.31		.37		.49	
Adjusted R^2	.22		.21		.31	
F-value	3.64***		2.36**		2.73**	
ΔR^2			.06		.12	
Incremental F			.84		2.80*	
N	47		47		47	

[a] Standardized betas (t-values) are reported
*p<.10; **p<.05; ***p<.01 (One-tailed for main effects and interactions; two-tailed for controls).

Appendix 1

Empirical Studies on Market Orientation and Innovation Performance (1994-2007)

	Empirical Setting		**Innovation outcomes**	
Author	**Category**	**Description**	**Category**	**Dependent Variable Domain**
Agarwal, Erramilli and Dev (2003)	Low-tech	Hotels.	FAI	Propensity to invest in new capabilities; new ways to serve customers.
Appiah-Adu and Ranchhod (1998)	High-tech	Biotechnology.	NPMP	Introduction of successful new products or services.
Appiah-Adu and Singh (1998)	Mixed	SME from a broad range of industries (industrial/consumer and goods/services).	NPMP	NP market success.
Atuahene-Gima (1995)	Mixed	Chemical, pharmaceutical and biotechnology; food and beverage; electrical, electronic and scientific equipment; metal and industrial equipment; computer software; ICT; banking and trusts; insurance and others.	NPMP NPFP FAI	Sales and profitability of the NP; opportunities for cost efficiency and proprietary advantage; enhanced sales and profits from other products; new market opportunities.
Atuahene-Gima (1996)	Mixed	Chemical, pharmaceutical, biotechnology; cosmetics, food and beverages; electric and electronic appliances; metals; industrial equipments; professional and scientific equipments; banking; insurance; computers; ICT and others.	NPMP NPFP	Sales and profits of the NP.
Atuahene-Gima (2005)	High-tech	Electronic Industry.	NPMP FAI	% of NP sales, frequency of NP introduction, NP introductions relative to competitors, number of NP introduced.
Atuahene-Gima and Ko (2001)	Mixed	Industrial machinery; chemical and pharmaceutical; electrical and electronics; food and beverage; metals; finance; computer and software; telecommunications; scientific equipment; transportation equipment and others.	NPMP NPFP FAI	NP sales and profits + NP development activities (Timing of market entry, NP Quality, Market Synergy, Launch Proficiency, Management support for Innovation).
Atuahene-Gima, Slater and Olson (2005)	Mixed	US manufacturing firms (SIC codes from 20 to 30 excluding tobacco).	NPMP NPFP	NP sales and profits.
Baker and Sinkula (1999)	Mixed	Broad range of industries.	NPMP FAI	NP introduction rate relative to competitors, NP success rate relative to competitors, degree of product differentiation, competitors' ability to copy the NP, NP cycle time relative to competitors.
Baker and Sinkula (2005)	Mixed	Original equipment manufacturers and consumer products.	NPMP FAI	see Baker and Sinkula (1999).

	Empirical Setting		Innovation outcomes	
Author	**Category**	**Description**	**Category**	**Dependent Variable Domain**
Baker and Sinkula (2007)	Mixed	Original equipment manufacturers and consumer products.	NPMP FAI	see Baker and Sinkula (1999).
Calantone, Garcia and Dröge (2003)	Mixed	Automotive; electronics; publishing; manufacturing/R&D laboratories.	FAI	NP development speed (reduction of development cycle time).
Frambach, Prabhu and Verhallen (2003)	Mixed	Food; clothing/textile/wood/paper; (petro)chemicals; machinery equipment; metals and construction materials; fabricated metal products, finished products and others.	FAI	Number of NP launched and number of NP under development.
Gatignon and Xuereb (1997)	Mixed	Durable goods, consumer packaged goods, industrial technology, computers.	NPMP NPFP	ROI and objectives achievement.
Gotteland and Boulé (2006)	Mixed	58 industrial sectors in France.	NPMP NPFP	NP sales and profits.
Greenley (1995)	Mixed	Random sample from Dun and Bradstreet dataset of UK companies	NPMP	New product success rate and sales growth
Han, Kim and Srivastava (1998)	Low-tech	Banking Industry.	FAI	Absolute number of technical and administrative innovations implemented.
Im and Workman (2004)	High-tech	US High-technology firms.	NPMP NPFP	Market, financial and product quality performance.
Kahn (2001)	Low-tech	Apparel and textile.	NPMP FAI	Proficiency in pre-launch and launch/post-launch activities (on a 0-100% scale).
Kyriakopoulos and Moorman (2004)	Low-tech	Food processing.	NPMP NPFP	NP sales, market share and profit margins (objective measures).
Lado and Maydeu-Olivares (2001)	Low-tech	Insurance Industry.	NPMP FAI	Rate of NP introduction and NP performance.
Langerak, Hultink and Robben (2004a)	Mixed	Metal (primary and fabricated); machinery equipment; electrical equipment; transportation equipment; measuring instruments.	NPMP NPFP	NP market and financial performance, customer acceptance, product quality and timing performance.
Langerak, Hultink and Robben (2004b)	Mixed	see Langerak, Hultink and Robben (2004a)	NPMP NPFP	see Langerak, Hultink and Robben (2004a)
Lukas and Ferrel (2001)	Mixed	Manufacturing firms.	FAI	Absolute number of innovations implemented.
Matear et al. (2002)	Low-tech	Service Firms.	FAI	Proficiency of new service development activities in the organization (infrastructure and implementation).
Matsuno, Mentzer and Ozsomer (2002)	Mixed	Food; tobacco; textiles; apparel; lumber and woods; furniture; paper; printing; chemical; petroleum; rubber; leather; stone, clay, glass, and concrete; metal; machinery; electronic and electrical equipment; transportation equipment; and measuring instruments.	NPMP	Percentage of NP sales over total sales relative to competitors.

	Empirical Setting		Innovation outcomes	
Author	**Category**	**Description**	**Category**	**Dependent Variable Domain**
Mavondo, Chimhanzi and Stewart (2005)	Low-tech	Professional services and hospitality industry medium-size firm.	FAI	Product innovation, process innovation, administrative innovation.
Menguc, Auh and Seigyoung (2007)	Mixed	Food; machinery; automotive; construction materials; chemicals.	FAI	R&D expenditures for product development, R&D expenditures for process development, emphasis on being ahead of competition, rate of product innovation.
Moorman and Rust (1999)	Mixed	Retailing, services, nondurable consumer goods, durable consumer goods, wholesale distribution, industrial/commercial products, governmental products	NPFP FAI	NP financial performance, speed of development, creativity.
Narver, Slater and MacLachlan (2004)	Mixed	Technology-based products and services; pulp paper and other commodities; financial services; transportation; public utility; other manufacturing industries.	NPMP	NPP relative to competitors.
Oczkowski and Farrell (1998)	Mixed	Dun and Bradstreet top 861 publicly listed and Top 1164 privately owned companies	NPMP	NP market success.
Pehlam and Wilson (1996)	Low-tech	Manufacturing, wholesaling, business services and constructions SMEs	NPMP NPFP	NP success, growth in market share, profitability (ROI, ROA), product quality
Pelham (1999)	Mixed	Plastics, fabricated and basic metals, packaging, chemicals, instruments, machinery, electronic/electrical equipment	NPMP	NP sales, product quality, customer retention rate.
Perry and Shao (2005)	Low-tech	Advertising agencies.	NPMP NPFP FAI	Enhanced ability to respond to competitors' offering, increased ability to respond to clients' requests, enhanced agency's image, competitive advantage (qualitative outcomes); increased profitability, revenues from new clients, revenues from existing clients (quantitative outcomes)
Ramaseshan and Caruana (2002)	Mixed	Chemical and oil; pharmaceutical and medical equipment; food and beverage; electrical and electronics; scientific and medical equipment; publication; 1communication and information technology; engineering and construction; financial services.	NPMP NPFP FAI	See Atuahene-Gima (1995)
Sandvik and Sandvik (2003)	Low-tech	Hotels.	FAI	Innovation introduction rate.
Slater and Narver (1994)	Low-tech	Forest Products and diversified manufacturing firms.	NPMP	NP success relative to competitors in the SBU's principal served market.
Subramanian and Gopalakrishna (2001)	Mixed	Fast moving consumer goods, media and others.	NPMP	Managers' satisfaction with new product/service success.

	Empirical Setting		Innovation outcomes	
Author	**Category**	**Description**	**Category**	**Dependent Variable Domain**
van Riel, Lemmink and Ouwersloot (2004)	Mixed	ICT; electronics; internet-related; consultancy; telecommunications; imaging; engineering; medical and others.	NPMP NPFP FAI	Short term and long term market and financial success, customer satisfaction, reputation, brand equity, competitive position, increased in-house technological knowledge, employee satisfaction, innovation opportunity.
Vazquez, Santos and Alvarez (2001)	Mixed	Food manufacturing; chemicals; metals; precision machinery.	FAI	Number of commercialized innovations, product innovativeness, firm's ability to innovate.
Verhees and Meulenberg (2004)	Low-tech	Rose growers.	FAI	Average age of the new variations introduced.
Wei and Morgan (2004)	Mixed	Computer hardware; pharmaceuticals; optical equipment; consumer electronics; textiles; toys; food processing.	NPMP	Managers' satisfaction with the NP, market strength and overall performance of the NP.
Wren, Souder and Berkowitz (2000)	High-tech	High-tech companies in 6 countries.	NPMP	NP market success.
Zhou, Yim and Tse (2005)	Mixed	Appliances; beverages; snacks; cosmetics; clothes and shoes; cigarettes and liquors; cleaning products; automobiles; PCs and other consumer goods.	FAI	Product innovativeness, radical innovation, similarity with competitors' products (technology-based innovation); difficulty for mainstream customers to evaluate and understand the product, high switching costs, major learning effort for mainstream customers, long time for mainstream customers to understand NP benefits (market-based innovation).

Note: NPMP = new product market performance; NPFP = new product financial performance; FAI = firm's ability to innovate.

Appendix 2.
Measures Description and Properties

Measure and source	Item Description	Corrected Item-Total Correlation	Factor Loading
Customer Orientation α = .84 (Li and Calantone 1998) [a]	*In our company:* 1. We regularly meet customers to learn their current and potential needs for new products. 2. We fully understand our customers' business. 3. We systematically process and analyze customers' information.	.66-.77	.64-1.04
Competitor Orientation α = .89 (Li and Calantone 1998) [a]	*In our company:* 1. Information about competitors' products and technologies are fully integrated as a benchmark in our innovation process. 2. We systematically analyze information about competitors. 3. Our knowledge of competitors' strengths and weaknesses is thorough.	.74-.81	.70-.93
Interfunctional Coordination α = .84 (Li and Calantone 1998) [a]	*In our company:* 1. R&D and Business Development/Marketing personnel frequently interact. 2. R&D and Business Development/Marketing personnel openly communicate. 3. R&D and Business Development/Marketing personnel fully collaborate in establishing innovation projects' goals and priorities. 4. R&D and Business Development/Marketing personnel share similar views and finalities.	.61-.76	.58-.97
Knowledge Integration α = .79 (adapted from De Luca and Atuahene-Gima 2007) [b]	*To what extent your firm employs the following mechanisms to integrate scientific and market knowledge:* 1. Internal committee to select the best innovation opportunities. 2. Formal meetings among different subunits for screening and evaluating innovation projects. 3. Use of internal experts and/or consultants to synthesize project information. 4. Formal analysis and discussion of past successful innovation projects. 5. Formal analysis and discussion of past failures in innovation.	.48-.68	.57-.80
R&D effectiveness α =.85 (new scale based on interviews) [c]	*Rate the extent to which in the last 3 years your company's R&D has achieved its stated objectives in terms of:* 1. Generation of new innovation projects 2. New patents 3. Quality and relevance of scientific output 4. Industry reputation for scientific results 5. Generation of new knowledge on target technology/market domains 6. Scientific/technological leadership in your environment.* 7. Ability to attract and recruit new scientist with outstanding knowledge and skills.	.58-.72	.67-.91

[a]: 1= strongly disagree; 5 = strongly agree; [b]: 1= never used; 5 = widely used; [c]: 1= to no extent; 7 = to a great extent;

*Items deleted during the purification phase

PAPER 2

MARKET KNOWLEDGE DIMENSIONS AND CROSS-FUNCTIONAL COLLABORATION: EXAMINING THE DIFFERENT ROUTES TO PRODUCT INNOVATION PERFORMANCE.

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MARKET KNOWLEDGE DIMENSIONS AND CROSS-FUNCTIONAL COLLABORATION: EXAMINING THE DIFFERENT ROUTES TO PRODUCT INNOVATION PERFORMANCE

Abstract

There is consensus in the marketing literature that market knowledge and cross-functional collaboration are two fundamental resources for successful product innovation. However, few studies examine the dimensions or characteristics of market knowledge, and how and why these resources influence product innovation performance. Drawing on contingency theory and knowledge-based view of the firm, the authors argue that knowledge integration mechanisms may account for the effects of market knowledge dimensions (i.e., breadth, depth, tacitness and specificity) and cross-functional collaboration on product innovation performance. They found that market knowledge specificity and cross-functional collaboration affect product innovation performance via knowledge integration mechanisms. In contrast, whereas the effect of market knowledge depth is partially mediated, market knowledge breadth has a direct, unmediated effect on product innovation performance. A test of an alternative moderating perspective showed that the effects of market knowledge depth and cross-functional collaboration on product innovation were negatively moderated by knowledge integration mechanisms. By showing the differential effects of market knowledge dimensions on product innovation performance, the authors provide a more refined understanding of the interplay between market knowledge, its integration and the firm's performance in product innovation. The authors also conclude that by overlooking the role of knowledge integration mechanisms, previous research may have provided an overly optimistic view of the value of cross-functional collaboration in product innovation.

The marketing literature has established that product innovation performance is enhanced by three distinct yet highly complementary factors: *market knowledge* (Atuahene-Gima 1995, 2005; Day 1994; Li and Calantone 1998); *cross-functional collaboration* (e.g., Griffin and Hauser 1996; Kahn and Mentzer 1998, Song and Parry 1997) and *knowledge integration mechanisms* (Madhavan and Grover 1998; Maltz and Kohli 2000; Ruekert and Walker 1987). By *market knowledge*, we mean the firm's knowledge about its customers and competitors (Day 1994; Kohli and Jaworski 1990; Narver and Slater 1990). *Cross-functional collaboration* refers to the degree of cooperation and the extent of representation by marketing, R&D and other functional units in the product innovation process (Kahn 1996; Li and Calantone 1998; Song, Montoya-Weiss and Schmidt 1997). By *knowledge integration mechanisms* (herein after KIM), we mean the formal processes and structures which ensure the capture, analysis, interpretation and integration of market and other types of knowledge among different functional units within the firm (Olson, Walker and Ruekert 1995; Zahra, Ireland and Hitt 2000). The inability of firms to manage the interplay of these factors lies at the root of many failures in product innovation. For example, Fisher, Maltz and Jaworski (1997, p. 54) report several examples such as Texas Instruments unsuccessful early entry into the desktop PC business, and HP's early entry into the laptop business with a technology-oriented 23-pound laptop.

Although the contributions of previous studies are substantial, extant research is lacking in three respects. First, the knowledge-based view of the firm (herein after KBV) underscores the importance of several different dimensions of market knowledge in product innovation: breadth, depth, specificity and tacitness (see Galunic and Rodan 1998). However, while studies in marketing emphasize the importance of broad market knowledge as reflected in the concept of market orientation (e.g., Atuahene-Gima 2005; Atuahene-Gima, Slater and Olson 2005; Jaworski and Kohli 1993; Li and Calantone 1998) there is little or no insight regarding the relative importance of the different dimensions of market knowledge as drivers of product innovation performance. Given the strategic importance of market knowledge, an approach that considers its dimensions and parses out their distinct contributions seems appropriate if we are to effectively examine how market knowledge matters in product innovation performance.

Second, previous studies have focused almost entirely and separately on the effects of market knowledge (e.g., Atuahene-Gima 1995, 2005; Li and Calantone 1998) and cross-functional collaboration (e.g., Kahn 1996; Song, Montoya-Weiss and Schmidt 1997) on product innovation outcomes. No detailed explanations are offered as to how and why KIM matters in these relationships. Yet, KIM is often implicitly assumed as a salient factor in transforming market knowledge and cross-functional activities into product innovation performance (Griffin and Hauser 1996; Hoopes and Postrel 1999). This state of the literature in unwelcome because a key assumption KBV is that it is not knowledge itself but rather its integration among functional units in the firm that drives sustainable competitive advantage (Grant 1996a). For this reason, product innovation is often characterized as a process by which a firm *transforms* knowledge embedded in cross-functional teams into new products (Madhavan and Grover 1998, p. 2). Understanding how market knowledge and cross-functional collaboration are transformed into innovation outcomes through KIM may shed light on the salience of this factor which KBV suggests is at the root of the firm's competitive advantage.

Third, KIM has traditionally been positioned as a moderator in the relationship between sources of information and the breadth and depth of the firm's knowledge (Zahra, Ireland and Hitt 2000) and between internal and external capabilities and innovation outcomes (Zahra and Nielsen 2002). Still, there is another view based on structural contingency theory which suggests that because knowledge characteristics (e.g., complexity) make communication flow difficult among functional units, knowledge becomes a key contingency factor that determines the nature of integration designs (Thompson 1967). Further, the increased information processing requirements resulting from interdependence among functional units can only be met by corresponding increases in information processing capacity through the design of coordination mechanisms (e.g., Galbraith 1973; Thompson 1967). This view implies that market knowledge and cross-functional collaboration affect performance through their effects on the design of knowledge integration mechanisms.

Extant research in marketing has paid little attention to these different perspectives of the role of KIM. The moderating view suggests that both market knowledge and cross-functional collaboration are inherently valuable such that KIM determines the strength of their effect on innovation performance. In contrast, the insight of the mediating view is that these resources are not inherently valuable and that they may affect innovation performance via their effects on KIM. Because marketing theory has placed considerable weight on the value of market knowledge and cross-functional collaboration for effective product innovation, and because of the widely held belief among managers that value creation involves knowledge integration among functions, examining these perspectives is particularly important in advancing this research stream. If the 'active role' of KIM is as a mediator rather than as a moderator or if it plays both a mediator and moderator roles, marketing managers may need to re-evaluate their stance toward the role of market knowledge and cross-functional collaboration *per se* in product innovation. Findings will also shed light on what level of importance needs to be placed by both researchers and managers on the *inherent value* of both of these resources. Figure 1 presents the conceptual model with which we explore these ideas.

INSERT FIGURE 1 HERE

Theory Development

Contingency theory has been one of the major strands of thinking about firms and their structures and strategic actions (Galbraith 1973). Drazin and Van de Ven (1985) noted two fundamental strands of contingency theory. The first is the "fit as mediation" view (Venkatraman 1989) which involves positing that managers choose or adopt organizational structures, processes and strategies that reflect the particular circumstances of their organizations (Galbraith 1973, p. 2). In particular, because the organization is essentially an "information processing network" the objective of organizational design is to achieve an efficient correspondence between the information processing requirements of its strategic contingencies and the information processing capabilities of its integration mechanisms (Galbraith 1973, p. 6). Thus, this theory asserts that by increasing the information processing demands in the firm, strategic interdependence or collaboration among functions dictate the type and degree of organizational integration mechanisms adopted to transfer knowledge within the firm (see Kumar and Seth 1998; Thompson 1967).

KBV suggests that knowledge is sticky – meaning that its characteristics make it difficult, costly and uncertain to transfer and recombine within the firm (e.g., Galunic and Rodan 1998; Grant 1996a; Szulanski 1996). For this reason Birkinshaw, Nobel and Ridderstråle (2002) and others (e.g., Germain and Droge 1997) have argued that the characteristics of knowledge complicate the process of transfer by increasing uncertainty and ambiguity and through this complication increase the likelihood that firms will develop appropriate KIM. In this view, knowledge characteristics are the fundamental quality to which managers adapt organizational integration structures. Consistent with KBV, market orientation theory indicates that market knowledge generation is an outside-in process and that firms use internal processes to integrate the acquired knowledge (Day 1994; Jaworski and Kohli 1993). If one accepts the KBV tenet that it is not knowledge per se but rather its integration that affects competitive advantage (Grant 1991, 1996b), then these arguments suggest that KIM is a mediator of the link between market knowledge dimensions, cross-functional collaboration and firm performance. The second strand of contingency theory is the interactive fit argument or "fit as moderation" view (Venkatraman 1989). This view proposes that the firm's performance is attributable to a match between its strategic behaviors and the internal and external environment conditions (Atuahene-Gima and Murray 2004; Zeithaml, Varadarjan and Zeithaml 1988). This suggests the effect of market knowledge and cross-functional collaboration on performance is moderated by KIM. Given the limited attention it has received, we focus on the mediating view of KIM although we also examine empirically the moderating view.

Effect of Market Knowledge Dimensions on KIM

Knowledge integration mechanisms (KIM). According to Barki and Pinsonneault (2005, p. 166) integration captures the extent to which distinct but interdependent functional units, departments and resources are coordinated, or made to constitute a unified whole. The task of integration or coordinating interfunctional interactions is often accomplished by the use of structures and processes (see Griffin and Hauser 1996; Sobek, Liker and Ward 1998). As Olson, Walker and Ruekert (1995, p. 49) put it integration mechanisms are "*lateral linkage devices or structural coordination mechanisms*" that firms use to coordinate cross-functional interactions (emphasis in original) (see also Griffin and Hauser 1996, p. 203). Following Zahra, Ireland and Hitt (2000, p. 930), we define KIM in this study as structures and processes such as use of documentation, information sharing meetings, analysis of successful and failed projects, project reviews and briefings by external experts and consultants that ensure the capture, analysis, interpretation and combination of knowledge within the firm. These structures and processes allow managers to systematically determine and understand what has been learnt in the product innovation process, to interpret and articulate the importance of the learning, and to devise ways to exploit the knowledge competitively (Zahra and Nielsen 2002).

Market knowledge dimensions. Information about the market environment, particularly about customers and competitors, is the source of stimulation for the firm's knowledge (Day 1994; Nonaka 1994, p. 27) and the driver of a market-oriented strategy (Day and Nedungadi 1994, p. 32). This implies that a firm that correctly identifies, collects and uses information about customer and competitor conditions is deemed knowledgeable about the market. Knowledge about technology and other environmental properties are important, but they are so only to the extent that they enhance the understanding of customers and competitors' behavior. For this reason, Srinivasan, Lilien and Rangaswamy (2002, p. 49) showed that the firm's ability to sense and respond to technology developments per se is different from its market orientation – the ability to sense and respond to customers and competitors. Hence, we define *market knowledge* as the firm's knowledge of its customers' behaviors and needs as well as its competitors' behavior. We examine the effects of four characteristics of market knowledge: breadth, depth, tacitness, and specificity on KIM next.[1]

Knowledge breadth refers to the number of different knowledge domains the firm is familiar with (Bierly and Chakrabarty 1996). Prabhu, Chandy and Ellis (2005, p. 116) offer a similar view referring to knowledge breadth as the range of fields over which the firm has knowledge. We define *market knowledge breadth* as the firm's understanding of a wide range of diverse customer and competitor types and factors that describe them. In other words, a firm is said to have broad market knowledge when it has knowledge of a wide variety of current and potential customer segments and competitors and also uses a diverse set of parameters relating to customers (e.g., needs, behaviors and characteristics) and competitors (e.g., products, markets and strategies) to describe and evaluate them (e.g., Zahra, Ireland and Hitt 2000). This concept highlights the broad understanding of customers and competitors deeply rooted in the market orientation construct.

Firms with a broad knowledge base have higher potential to recombine different elements of the knowledge to improve opportunity recognition and creative potential (Kogut and Zander 1992). However, knowledge breadth might hamper knowledge recombination because the high degree of heterogeneity of knowledge elements contributes to the complexity of transfer across functional units (Galunic and Rodan 1998). In contrast, limited market knowledge can be easily disseminated to and internalized by members of different departments. Further, because customer segments and competitors' strategies change over time, broad market knowledge may involve frequent and numerous variations that further increase the difficulties of cross-functional transfer. Also when the market knowledge is broad, not all of it can be usefully employed into every innovation project. Bringing in marginally useful information or leaving out relevant ones might be detrimental for performance (Leonard-Barton 1992). Thus, the increased difficulties in sharing broad knowledge lead managers to develop KIM to provide the necessary information processing capacity for the organization. Empirically, Germain and Droge (1997) found that the breadth of the firm's knowledge about a task is antecedent to processes for knowledge integration because these processes are the necessary mechanisms to combat excessive compartmentalization of the diverse knowledge. Hence,

H_1. The broader the market knowledge, the greater the use of knowledge integration mechanisms.

Market knowledge depth. Prabhu, Chandy and Ellis (2005) describe technical knowledge depth as the amount of within-field knowledge possessed by the firm. McEvily and Chakravarthy (2002) also argue that complex knowledge reflects the degree to which knowledge consists of many different, unique and interdependent elements such that knowing how one element works reveals little about how the different elements work together. Consequently, we define *market knowledge depth* as the level of sophistication and complexity of a firm's knowledge of its customers and competitors. It captures the level of sophistication with which the firm is able to connect the unique and interdependent relationships among the factors that describe key issues about customers and competitors. Knowledge of the interdependencies of elements such as customer needs, behavior and preferences, competitor products and strategies would indicate that a firm has deep understanding of its market. Thus, while breadth captures the expansiveness dimension of knowledge, depth captures the vertical dimension.

Two reasons account for why market knowledge depth should affect KIM. First, deep market knowledge implies high and complex interdependencies among the knowledge elements (McEvily and Chakravarthy 2002). The transfer of such knowledge is error prone, involves higher risks of misinterpretation and misapplication in product innovation (Galunic and Rodan 1998). This is because deep functional knowledge limits the ability to draw new conclusions and find new links among diverse pieces of knowledge. Second, deep market knowledge implies differential functional expertise in collecting and disseminating market information. This leads to different thought-worlds (Leonard-Barton 1992) which further increase the uncertainty and ambiguity of knowledge transfer (Szulanski 1996). For these reasons, deep knowledge tends to lead to rigidities in knowledge transfer and sharing hindering the ability of the firm to assimilate knowledge. Consequently, firm develop coordinating structures to provide functional units with the means to understand and develop confidence in each others' analysis and interpretation (Hoopes and Postrel 1999). Hence,

H_2. The deeper the market knowledge, the greater the use of knowledge integration mechanisms.

Market knowledge tacitness defines the extent to which market knowledge is not explicit, but rather difficult to codify and communicate (e.g., Nonaka 1994). Market knowledge is tacit when individuals and functional units find it difficult to articulate explicitly what they know about customers and competitors and are unable to effectively explain the causal relationships between their actions and the associated outcomes. Tacitness slows the internal transfer of market knowledge because tacit knowledge cannot be fully codified and articulated even by an expert. It can only be transferred from one person to another through a long process of apprenticeship which necessarily involves face-to-face interactions, review of successful and unsuccessful projects and frequent advice from the experts (Galunic and Rodan 1998; Szulanski 1996). As an embedded knowledge, tacit knowledge requires the development of KIM to unearth its potential value (Madhavan and Grover 1998). Birkinshaw, Nobel and Ridderstråle (2002) found that the degree of observability (i.e., explicitness) of technology knowledge was *negatively* related to knowledge integration structures. Hence,

H_3. The more tacit the market knowledge, the greater the use of knowledge integration mechanisms.

Market knowledge specificity refers to the extent to which the firm's knowledge is tailored to the requirements of specific contexts in which it is maximally effective, while loses its value in other contexts (Galunic and Rodan 1998). For example, a firm's knowledge can relate to the attitudes of a specific customer segment toward a specific product or strategy. Specific competitor knowledge may result from an in-depth analysis of the behavior, products and strategies of a particular competitor. In both cases, the knowledge acquired is valuable only in the context of the focal firm. For example, Lenovo's knowledge of the computer market was so specific to the Chinese context that it had to acquire IBM's PC division to increase its ability to compete on the global level.

Specific market knowledge is likely to be acquired and used by experienced people and experts in specific market domains. Hence, one could argue that the transfer of such knowledge is unproblematic even in the absence of KIM. However, we have three reasons for a positive effect of specific market knowledge on KIM. First, because specific market knowledge is valuable in the context in which it has been generated, its value is highly time-sensitive. Because it needs to be exploited in a timely manner, Subramani and Venkatraman (2003) showed that specific knowledge engenders strong norms of joint decision-making, a key aspect of KIM. Second, specific knowledge diminishes knowledge recombination impairing timely and effective contextual use (Galunic and Rodan 1998. p. 1197). Third, specific market knowledge reflects the use of idiosyncratic routines in the collection and use of market information by different functions. As Galunic and Rodan (1998) argued, by producing specific knowledge these routines make the transfer of knowledge to other functions difficult. These properties of specific knowledge increase the implementation of KIM to ensure early settlement of communication difficulties and allow timely flow and recombination of knowledge from different functional units in the product innovation process.

H_4. The more specific the market knowledge, the greater the use of knowledge integration mechanisms.

Effect of Cross-functional Collaboration on KIM

Cross-functional collaboration refers to the degree of cooperation, the extent of representation and contribution by marketing, R&D and other functional units to the product innovation process (Kahn 1996; Li and Calantone 1998; Ruekert and Walker 1987; Song, Montoya-Weiss and Schmidt 1997). Cross-functional collaboration is intangible, volitional and unstructured in that it only reflects the recognition by functional units of their strategic interdependence and the *need for* them to cooperate to the benefit of the organization (Galunic and Rodan 1998, p. 1198; Kahn 1996; Kahn and Mentzer 1998; Olson et al. 2001). It ensures the alignment of goals among functional units. In contrast, KIM permits regular patterns of interactions that allow the transfer, recombination and use of knowledge from different functions. It therefore responds to the problem of coordinating different knowledge elements to execute complex organizational tasks.

Anecdotal evidence supports the distinction between cross-functional collaboration and KIM. First, in spite of the high degree of cooperation among its functional units, Toyota has established coordinating mechanisms including standardized reporting and documentation, formalized work processes (e.g., project reviews), problem-solving meetings and integrative leaders to ensure knowledge sharing and integration among its different units (Sobek, Liker and Ward 1998). Second, a study of the most innovative firms in the world indicate that two such firms, Southwest and BMW, have adopted mechanisms such as co-location, face-to-face meetings and standard documentation to integrate the knowledge among members of their cross-functional teams in spite of their high degree of cooperation proclivity (*Business Week* 2006). The distinction of the two constructs is salient because coordinating knowledge, in particular specialized and complex knowledge, among different units is problematic for firms even when perfect goal-congruence (or full collaboration) is established among them (Grant 1996b, p. 114).

Contingency theory offers two principal reasons why cross-functional collaboration predicts KIM. First, cross-functional collaboration implies increased resource dependency among functional units and thus a greater need for enhanced information processing capability to coordinate the acquired knowledge. As the need for sharing knowledge and other resources among functional units increases, their interdependence grows along with the volume of resource flows and with them increases the use of coordinating mechanisms (see Olson, Walker and Ruekert 1995, p. 53). Thus, increased collaboration represents a critical strategic contingency for designing coordination mechanisms (Galbraith 1973; Kumar and Seth 1998, p. 581). As Kahn and Mentzer (1998) suggest, collaboration reflects the willingness of different functional units to cooperate, yet firms need to provide structural mechanisms to put such willingness into action. Indeed, Birkinshaw, Nobel and Ridderstråle (2002) found that functional interdependence influenced the design of inter-unit knowledge integration mechanisms in the firm.

Second, the transfer and flow of knowledge among interdependent units is often costly, ambiguous and uncertain because of the diversity of functional information, backgrounds, experiences, and thought-worlds. This complicates analysis, interpretation and hinders the likelihood of novel recombinations of the firm’s knowledge (Galunic and Rodan 1998). For this reason, Madhavan and Grover (1998) argue that the collective knowledge of functional units constitutes only potential knowledge. As a result, Ruekert and Walker (1987, p. 6) hold that to obtain value from cross-functional interactions “mechanisms [must] evolve to help reduce the uncertainty and ambiguity of resource, work, and assistance flows …” Similarly, Garud and Nayyar (1994, p. 372) point out that firms develop integration mechanisms because of the uncertainty and ambiguity in translating embedded collective knowledge into knowledge embodied in the new product (see also Griffin and Hauser 1996, p. 209). In brief, we argue that increased functional collaboration leads to greater use of knowledge integration mechanisms to regulate communication flow and learning in new product projects.[2]

H_5. The greater the cross-functional collaboration, the greater the use of knowledge integration mechanisms.

Market Knowledge, Cross-functional Collaboration and Product Innovation Performance

Market knowledge. Extant research considers market knowledge as the fundamental driver of product innovation performance (Atuahene-Gima 1995, 2005; Li and Calantone 1998; Moorman and Miner 1997). Few studies have, however, provided detailed insights into the effects of different market knowledge characteristics on product innovation performance. *Market knowledge breadth* engenders product innovation performance because it increases the ability of the firm to make connections among disparate market information, ideas and concepts to gain broader and insightful perspectives (Reed and DeFillippi 1990). This logic underpins the general idea about the positive role of market orientation in product innovation (Atuahene-Gima 1995, 2005; Li and Calantone 1998). A firm with broad market knowledge has heterogeneous information and understanding of customers and competitors allowing it to design products that match the diverse needs of its customer segments. By enhancing the firm's purview of the market, broad market knowledge also increases the ability of the firm to quickly implement and execute complex tasks in product innovation processes (Kogut and Zander 1992). It does this by enhancing the chances of what Prabhu, Chandy and Ellis (2005*)* call 'happy accidents" whereby concepts from different knowledge domains are applied in unexpected ways.

A new product based on *deep market knowledge* limits the ability of competitors to observe and understand the whole set of distinct and interdependent knowledge elements that underlies it (Reed and DeFillippi 1990). This is because market knowledge depth reflects complex understanding of the causal interdependencies among customer problems and requirements, and potential competitor strengths and responses and thereby increases the likelihood of the emergence of new ideas that are highly unique to the firm (Galunic and Rodan 1998). As McEvily and Chakravarthy (2002) found, competitor efforts to reconstruct such a product are likely to be undermined or lead to partial and erroneous results. Prabhu, Chandy and Ellis (2005, p. 116) also contend that knowledge depth results in superior products because it permits the cross-fertilization of knowledge elements that increases flexibility in generating complex patterns of new knowledge.

Tacit market knowledge leads to better new product performance because it allows differences in cross-functional logics (Galunic and Rodan 1998). Prahalad and Bettis (1986) suggest that such differential logics ensure thoughtful deliberations, generates new perspectives, novel strategic alternatives, analyses and interpretations that enhance the efficiency of the firm's innovation activities. Also tacit knowledge develops in a "community of interaction" (Nonaka 1994) and thus is highly embedded in the social system of the firm. Competitors find it difficult to imitate the social context within which the focal firm develops its new products (Reed and DeFillippi 1990).

Finally, *specific market knowledge* enhances innovation performance because it ensures a long-term relationship with specific contexts (e.g., customer segment) that generates highly idiosyncratic insights for product innovation. This protects the new products developed by the firm from imitation because competitors lack the contextual customer knowledge that went in the process. Further, a new product based on specific market knowledge is more likely to be differentiated to suit the peculiar customer and competitor conditions (McEvily and Chakravarthy 2002).

Cross-functional collaboration. The positive effect of cross functional collaboration on product innovation performance is well-documented in the literature (see Griffin and Hauser 1996; Luo, Slotegraaf and Pan 2006; Song and Parry 1997). The logic is that cross-functional collaboration ensures that marketing, technical and other functional capabilities are combined to develop a product which satisfies customer needs. It does these by improving the efficiency of knowledge use and allowing quality decision-making in new product project teams (Madhavan and Grover 1998).

H_6. The greater the market knowledge (a) breadth, (b) depth, (c) tacitness and (d) specificity, the better the product innovation performance.

H_7. The greater the cross-functional collaboration, the better the product innovation performance.

Mediating Effect of KIM on Product Innovation Performance

The direct effects arguments for market knowledge and cross-functional collaboration on product innovation performance are persuasive. However, a careful inspection indicates that the arguments implicitly assume a role for knowledge integration mechanisms. As argued previously, both KBV and contingency theory suggest that because of the stickiness of market knowledge and the increased information processing demands resulting from cross-functional collaboration, they constitute factors that determine the firm's integration mechanisms (Birkinshaw, Nobel and Ridderstråle 2002; Galbraith 1973; Germain and Droge 1997; Kumar and Seth 1998; Thompson 1967). Indeed, KBV suggests that it is not *knowledge per se* but rather its integration that ensures competitive advantage (Grant 1991, 1996a). Specifically, KIM ensures better performance because it enhances the likelihood of finding solutions in the product innovation process by infusing the functional units with collective learning capability. Implicit in this argument is the notion that KIM connects knowledge to performance. Because KIM is mandated processes for learning, they provide milestones that ensure a sense of order in cross-functional knowledge sharing, use and learning. By providing a formal structure for knowledge integration, KIM also allows a common forum for periodic feedback that ensures quality decision-making and completeness of a project team's activities. In so doing KIM reduces wasteful explorations and errors in product innovation (Sheremata 2000). Thus, dimensions of market knowledge and cross-functional collaboration affect product innovation performance indirectly through their effects on KIM. This discussion suggests the following hypotheses:

H_8. The greater the knowledge integration mechanisms, the better the product innovation performance.

H_9. Knowledge integration mechanisms mediate the effects of market knowledge (a) breadth, (b) depth, (c) tacitness and (d) specificity on product innovation performance.

H_{10}. Knowledge integration mechanisms mediate the effect of cross-functional collaboration on product innovation performance.

Research Methods

Sample and Data Collection

China is an ideal context for this study. The extreme complexity and dynamism of this transitional environment means that firms must confront not only the challenges of new (often dysfunctional) competition, but also collapsing capabilities (Li and Atuahene-Gima 2001). For this reason, cross-functional collaboration and mechanisms for utilizing market knowledge in product innovation become critical for firms to sustain innovation performance. The instrument was prepared in English and then translated into Chinese. It was checked for accuracy following the conventional back-translation process. We pretested the instrument with 25 managers who had at least 3 years business experience in China to examine the face validity and to assess informants' understanding of the survey questions. The study was conducted with a sample of 750 firms selected randomly from a mailing list of 2500 high technology firms provided by a local consulting firm.

Like previous studies in China (Atuahene-Gima 2005; Li and Atuahene-Gima 2001), we collected the data on-site. An interviewer scheduled appointments with the marketing manager/director as a first informant who then nominated a second knowledgeable informant. The interviewer presented the key informants with the survey questionnaire, and collected the questionnaire upon completion. We motivated respondents by assuring them of confidentiality and by offering a summary of the research results and a free workshop on the research findings - information that would be meaningless to them in the absence of accurate data (Li and Atuahene-Gima 2001). We received 363 usable questionnaires for a response rate of 48%. We compared a sample of 50 participating firms with a sample of non-participating firms for which we had data on sales, R&D expense and number of employees. ANOVA tests indicated no significant differences between the two groups on number of employees (F = 1.01), sales in the most recent year (F = 0.89) and R&D expenditure as percentage of sales (F = 0.98).

Ninety percent of the first informants were from marketing and sales, 4% CEOs/general managers and 6% product development managers. These informants had a mean industry experience of 8.18 years and mean firm experience of 4.77 years. Seventy-three percent of the second informants were product development director/managers; 9% marketing/sales, 11% CEOs/general managers, and 7% from R&D. These informants had mean industry experience of 7.76 years and mean firm experience of 4.55 years. We also examined the quality of the informants by asking them to indicate on a 10-point scale their degree of knowledge of (1 = "not at all knowledgeable," 10 "extremely knowledgeable") and involvement in (1 = "no involvement," 10 "very high involvement") product development issues in the firm. The means of the two items for the first and second informants were 7.55, 7.40 and 8.00, 7.78, respectively. Using a multigroup analysis we obtained the following results: unconstrained CFA model for the marketing and non-marketing groups: [χ^2 = 2225.7 (d.f. = 1440)]; constrained model for marketing and non-marketing groups with equality constraints for structural paths, variances and covariances: [χ^2 = 2307.6 (d.f. = 1540)] (Chi-Square difference: [Δ χ^2 = 81.9 (Δ d.f. = 100), p>.10]. Given these results of tests of invariance we pooled the data for analysis.

Measures of Constructs

Market knowledge dimensions. We measured *market knowledge breadth* with four items by asking respondents, for example, to evaluate their firms' market knowledge on a continuum from "limited" to "wide-ranging" (Zahra, Ireland and Hitt 2000). We measured *market knowledge depth* with four items, by asking the respondents, for example, to evaluate their firms' customer knowledge on a continuum from "basic" to "advanced" (Zahra, Ireland and Hitt 2000). We measured *market knowledge tacitness* with four items addressing the degree to which a firm's market knowledge could be formally documented, communicated and learnt without personal experience (Szulanski 1996). Based on Reed and DeFilippi (1990), we measured *market knowledge specificity* with three items reflecting the extent to which market knowledge was specific to the firm's environment.[3]

Cross-functional collaboration. Based on prior studies (e.g., Li and Calantone 1998) we measured cross-functional collaboration with three items reflecting the extent of cooperation among functions; we asked the respondents, for instance, to rate the extent to which different functional units cooperate in establishing goals and priorities for the firms' product innovation.

Knowledge integration mechanisms. Two previous studies (Zahra, Ireland and Hitt 2000; Zahra and Nielsen 2002) informed the measure of knowledge integration mechanisms. We drew five items that addressed the extent to which a firm uses a set of formal processes (e.g., information sharing meetings, formal analysis of projects) to capture, interpret and integrate knowledge.

Product innovation performance. Based on Moorman (1995), we measured this construct with five items asking respondents to indicate the extent to which the firm has *achieved its product development objectives such as* market share and profitability.[4]

Control variables. In testing our hypotheses, we controlled for *firm size* and *slack* which reflect the firm's resources and market power to exploit existing competencies, build new ones, and develop innovations (Chandy and Tellis 1998). To prevent skewness, we measured firm size by the logarithm of the number of employees. Slack was measured with three items tapping the availability of excess resources to fund new projects. We controlled for environmental uncertainty because the KBV suggests that knowledge integration becomes even more critical in uncertain and competitive environments (Grant 1996a). Also, functional units tend to perceive higher interdependence and are therefore motivated to implement integration mechanisms in uncertain environments (Ruekert and Walker 1987). We examine two aspects of uncertainty. First, market uncertainty reflects the speed of change in customer needs and preferences and in competitor actions and was measured by three items covering the speed of change of customer needs and competitive conditions. Second, technological uncertainty reflects the speed of change and instability of the technology environment and was measured by four items tapping the speed and unpredictability of technological changes.

Finally, the degree of *radicalness* of the firm's product innovation activities was controlled to capture the firm's learning capability which influences propensity for knowledge sharing and product innovation outcomes (see McGrath 2001). We measured product innovation radicalness by three items assessing the newness of the firm's innovation activities in terms of, for example, customers targeted and products offered. The Appendix presents all the measures and their sources.

Assessing the Reliability and Validity of Measures

We performed an exploratory factor analysis (EFA) with varimax rotation for data obtained from both informants. Both the first and second informants' responses resulted in a total of 11 factors with eigenvalue greater than 1, accounting for 68.58% and 68.50% of the total variance respectively. For both informants, all the items loaded cleanly on the expected factors, without significant cross-loadings. Then, the measurement model was tested for both informants with a confirmatory factor analysis (CFA), using AMOS 6.0. All the items loaded significantly on the expected constructs indicating convergent and discriminant validity of the measures. The fit indices showed that the model fit the data reasonably well for both the first [χ^2/df = 1.56; GFI = .87; CFI = .94; RMSEA = .04] and the second informant [χ^2/df = 1.43; GFI = .88; CFI = .95; RMSEA = .03]. In each case the constructs had acceptable levels of reliability, average variance extracted and discriminant validity.[5]

Next, we submitted data from the two informant groups to two multigroup analyses to assess the invariance of the measurement model. First, we specified a model in which factor loadings, variances and covariances in the two groups were constrained to be equal and compared it with a baseline model with no equality constraints, using Chi-Square difference test (Byrne 2001). Results suggested the absence of significant differences in factors loadings, variances and covariances (Unconstrained model: χ^2 = 2153.11 (*df* = 1440); constrained model: χ^2 = 2218.32 (*df* =1540); $\Delta\ \chi^2$ = 65.21 (Δ *df* = 100), p>.10). Second, we assessed the invariance of items and latent variables means between the two groups. Following the guidelines by Steenkamp and Baumgartner (1998) we first compared the raw score means for each single item with a one-way ANOVA and found no statistically significant differences between the two-informant groups (.22< *F* <.99). Then, we estimated two CFA models in which the latent variable means were first freely estimated and then constrained to equality (Sörbom 1974). Results suggested the absence of significant differences in latent variable means between the two groups of respondents (Unconstrained model: χ^2 = 2602.04 (*df* = 1478); Constrained model: χ^2 = 2607.84 (*df* = 1489); $\Delta\ \chi^2$ = 5.80 (Δ *df* = 11), p>.10). This indicates that the pattern of factor loadings as well as the latent variables means, variances and covariances do not differ significantly across the two groups. As a further evidence of consistency between the two informants, we computed the interrater agreement index (r_{wg}) for each measure (James, Demaree and Wolf 1984). For constructs measured on the 5-point scale, this index ranges from -1 to 1, indicating minimum and maximum agreement respectively.[6] The lowest r_{wg} index for the whole set of items was .83, indication of a high level of agreement between the two informants (see Appendix).

Given these results, we ran a third CFA on the combined items for the two informants. This model performed reasonably well [χ^2/df = 1163.2/720 = 1.62; GFI = .86; CFI = .94; RMSEA = .04] (see Appendix). Based on Fornell and Larcher (1981), we tested for discriminant validity of the constructs by examining if the square root of the average variance extracted (AVE) of each construct (shown in the diagonal in Table 1) was greater than the highest correlation between latent variables involving the focal construct (shown above the diagonal in Table 1). Market knowledge breadth had slightly weak discriminant validity. As a fallback, we followed Bagozzi, Yi and Philips (1991) and examined whether for each pair of constructs involving market knowledge breadth a one-factor model fitted the data better than the hypothesized two-factor model. In each case the χ^2 of the constrained one-factor model was significantly greater than the χ^2 for the unconstrained two-factor model, suggesting discriminant validity.[7]

Given these results we used the average of the responses of the two informants for all the remaining analyses to reduce the potential for common method variance (Slater and Atuahene-Gima 2004). Table 1 reports descriptive statistics and correlations among the study variables. Note that product innovation performance was measured on a 7-point scale. This provides a different psychological frame to the informants compared with the other variables measured on 5-point scales thereby hindering common method bias.

INSERT TABLE 1 HERE

Analysis and Results

Direct effects. We used regression analysis to test the direct effects of market knowledge characteristics and cross-functional collaboration on KIM and product innovation performance. As shown in Table 2 (Model 1), market knowledge breadth (b = .16, p<.01), market knowledge depth (b = .20, p<.01), market knowledge specificity (b = .13, p<.01) and cross-functional collaboration (b = .31, p<.01) have a positive and significant effect on KIM. These results support to H_1, H_2, H_4 and H_5. The effect of market knowledge tacitness effect on KIM is not significant, thus H_3 is not supported

The results in Model 2 show that market knowledge breadth (b = .26, p<.01), market knowledge depth (b = .18, p<.01) and market knowledge specificity (b = .09, p<.05) have positive significant effects on product innovation performance, while the effect of market knowledge tacitness is not significant. These results support to $H_{6a, b, d}$ but not H_{6c}. Cross-functional collaboration is unrelated to product innovation performance, failing to support H_7. Among the control variables, organizational slack (b = .16, p<.01) and technology uncertainty (b = .16, p<.01) are positively related to KIM, while only firm size is related to product innovation performance (b = .21, p<.01).

INSERT TABLE 2 HERE

Mediating effect of KIM. We followed the three-step regression procedure recommended by Baron and Kenny (1986) to examine the mediating role of KIM. As shown earlier, market knowledge breadth, depth and specificity have positive and significant effects on product innovation performance. Also all the dimensions of market knowledge but tacitness as well as cross-functional collaboration are positively related to KIM. Upon its entry in Model 3 (Table 2) KIM shows a positive and significant effect on product innovation performance ($b = .14$, $p<.05$), supporting H_8. The inclusion of KIM leads to a slight decrease in the effect size of market knowledge breadth (from .26 to .24) and of market knowledge depth (from .18 and .15) but both remain significant, suggesting partial mediation. The effect of market knowledge specificity on product innovation performance was not significant, suggesting full mediation.

Recall that market knowledge tacitness and cross-functional collaboration are unrelated to product innovation performance. Testing for mediation for these variables violates Baron and Kenny's (1986) first test condition. However, several recent studies in various fields of research argue that this constraint may be relaxed without hampering the validity of the mediation analysis (see Preacher and Hayes 2004, p. 719; Shrout and Bolger 2002, p. 429-430; Smith et al. 2005, p. 354-355).[8] Specifically, Sobel test (Sobel 1982) allows one to investigate indirect effects for independent variables irrespective of the significance of their total effects on the dependent variable. With the exception of market knowledge tacitness, the Sobel test indicated significant indirect effects for market knowledge breadth ($b =.04$; $t = 1.71$, $p < .05$), market knowledge depth ($b =.05$; $t = 1.86$, $p < .05$), market knowledge specificity ($b =.02$; $t = 1.71$, $p < .05$) and cross-functional collaboration ($b = .08$; $t = 2.06$, $p < .05$), supporting $H_{9a, b, d}$ and H_{10} but not $H_{9c.}$

Structural equation modeling (SEM). We examined the robustness of the preceding results with SEM. The first model (SEM1) examined the direct effects of the independent variables on product innovation performance with the path from KIM constrained to zero. The fit indices [χ^2 (df) = 1206.80 (751), CFI = .94, RMSEA = .04] suggested a good fit with the data. The second model (SEM2) involving a full mediation of the effects of the independent variables by KIM also showed a good fit with the data [χ^2 (*df*) = 1228.10 (755), CFI = .94, RMSEA = .04]. Finally, based on modification indices, a third partial mediation model (SEM 3) which allowed a direct effect of market knowledge breadth on product innovation performance showed a good fit also [χ^2 (df) = 1203.50 (754), CFI = .94, RMSEA = .04]. Model comparisons with the χ^2 difference test indicated that SEM3 performed better than both SEM1 [$\Delta\chi^2$ (Δdf) = - 3.3 (3), p > .10] and SEM2 [$\Delta\chi^2$ (Δdf) = -24.6 (1), p < .001].

With the exception of a nonsignificant effect of market knowledge depth, the structural paths in SEM3 were consistent with the results obtained using the regression analysis with KIM (b = .18, t = 1.70, p < .05) and market knowledge breadth (b = .39, t = 3.50, p < .01) significantly related with product innovation performance.[9] Following recommendations by Brown (1997), Shrout and Bolger (2002) and others (see footnote 8), we again tested the significance of the specific mediation effects as follows: market knowledge breadth (total effect b = .85, p < .05, direct effect = .83 p < .05; indirect effect b = .03, n.s.), market knowledge depth (total effect b = .16, n.s.; direct effect = .09, n.s.; indirect effect b = .07, p < .10); market knowledge specificity (total effect b = .14, n.s.; direct effect = .10, n.s.; indirect effect b = .04, p < .10); and cross-functional collaboration (total effect b = -.05, n.s.; direct effect = -.17, n.s.; indirect effect b = .12; p < .10).[10]

Overall, the results of this study appear to indicate that (1) market knowledge specificity and cross-functional collaboration influence product innovation performance via KIM; (2) market knowledge depth has both direct and indirect effect (via KIM) on product innovation performance, (3) market knowledge breadth has a direct, non-mediated effect on product innovation performance; and (4) product innovation performance is not influenced, either directly or indirectly, by market knowledge tacitness.

Discussion

Our goal in this article was to advance the marketing literature by untangling the complex relationships between market knowledge dimensions, cross-functional collaboration, knowledge integration mechanisms and product innovation performance. We found that market knowledge depth and specificity affect product innovation performance via KIM. Notice that although the direct effect size of KIM on product innovation performance is small relative to the effect of market knowledge breadth, it plays the additional role of linking not only market knowledge depth and specificity but also cross-functional collaboration to product innovation performance. These results echo the view that being a sticky asset, knowledge is a contingency variable such that design for knowledge integration mechanisms needs to take into account the nature of the knowledge base of the firm (e.g., Birkinshaw, Nobel and Ridderstråle 2002; Germain and Droge 1997).

We found no support for the direct positive effect of cross-functional collaboration on product innovation performance. Instead, we found that cross-functional collaboration positively affect product innovation performance via KIM. This is consistent with structural contingency theory argument that the increased information processing demands resulting from the interdependence of functional units determine the degree of knowledge integration mechanisms adopted. Although cross-functional collaboration and KIM are important factors in the product innovation process, as widely reported in the marketing literature, we offer the new insight that the latter factor is the route that makes the former a more valuable resource in product innovation.

In summary our findings imply that market knowledge specificity, cross-functional collaboration (and in part market knowledge depth) are only potential resources which may not be inherently valuable for product innovation performance. Being distal antecedents, their potential for enhancing product innovation performance may be realized, totally or in part, through KIM. However, the situation appears more complex as the effect of market knowledge breadth on product innovation performance is direct, not via KIM. Therefore market knowledge breadth appears to be the most potent driver of product innovation performance among the different dimensions of market knowledge examined in the present study. This is an important finding which suggests that types of market knowledge may have different intrinsic properties, a nuanced insight that appears not yet recognized in extant contingency theory and in the KBV.

The non-significant effect of market knowledge tacitness on KIM was a surprise as prior research has found that it increases the difficulty of knowledge transfer. The lack of relationship between market knowledge tacitness and product innovation performance echoes the mixed perspectives about the effect of tacitness in extant research (see Galunic and Rodan 1998; Hedlund

1994; McEvily and Chakravarthy 2002). We conducted a series of post-hoc moderating tests with other variables in this study but found no significant non-linear and/or moderated effects of market knowledge tacitness on product innovation performance. One possible explanation for our finding may be gleaned from the work of Nonaka (1994). He that argued tacit knowledge is created by individuals and initially shared within homogeneous "communities of interaction" such as cross-functional units. To overcome problems of different thought-worlds among such units firms may rely on project leaders with A-shaped capabilities to "craft a unifying vision that does justice to all the disciplines represented" (Madhavan and Grover 1998, p. 4). As Griffin and Hauser (1996, p. 209, emphasis added) note, "These successful developers may have *internalized* a process that allows them to get product to market successfully". This suggests that, unlike other market knowledge dimensions integration of tacit market knowledge may be achieved through the tacit skills of effective team leaders, rather than through formal KIM. This appears to explain why firms like Toyota employ "integrative leader" as one of the key knowledge integration mechanisms in product development (Sobek, Liker and Ward 1998, p. 40).

As mentioned earlier, in other contexts scholars have argued convincingly that KIM is a moderator. We evaluated this view and found that the only significant interactions effects were between KIM and cross-functional collaboration ($b = -.11$, $t = -1.95$, $p < .05$) and market knowledge depth ($b = -.16$, $t = -2.93$, $p < .01$).[11] These findings are contrary to expectations but are novel. They suggest that KIM plays not only a mediation role but also an unexpected negative moderating role.

Moorman and Miner (1997) found that environmental "turbulence can reduce the value of shared knowledge within organizations" (p. 101). Although they measured shared knowledge or organizational memory more broadly, the routine component of memory and our concept of KIM may overlap to some extent. For this reason, we tested the interaction effects of technology/market turbulence and KIM on product innovation performance but found no significant results. One possible reason might be that we focus more narrowly on structured mechanisms for knowledge integration, while the concept of organizational memory included collective beliefs, physical artifacts as well as behavioral routines which may interact more strongly with environmental turbulence.

Theoretical contributions

This study contributes to marketing theory of product innovation in five main respects. First, the direct effect of market knowledge breadth sheds new light on the importance ascribed to the concept of market orientation in product innovation and the importance marketing theory places on broad understanding of customers and competitors (Atuahene-Gima 1995, 2005; Jaworski and Kohli 1993; Narver and Slater 1990). However, the indirect positive effects of market knowledge depth and specificity also underscore the need for market orientation theory to embrace a more fine-grained notion of market knowledge. Without this, marketing theory is unlikely to unearth new insights of the role of market knowledge in product innovation like the ones we offer here.

Second, the results regarding the effects of market knowledge dimensions suggest that theoretical exploration of the failure of firms in product innovation should not be ascribed mainly to their failure in cross-functional collaboration as suggested by many previous research and anecdotal reports. Rather, we suggest that it may be possible for firms to fail even where they have effective and efficient cross-functional collaboration, if they do not have broad, deep and specific market knowledge. This study suggests that examining only the direct effects market knowledge and cross-functional collaboration separately may lead to incorrect view of their power and thus erroneous implications of their role in product innovation.

Third, we clarify how and why KIM matter in product innovation performance by showing simultaneously their mediating and moderating roles. We show that KIM coverts some market knowledge dimensions and cross-functional collaboration into product innovation performance. This new insight suggests that by failing to consider the mediating role of KIM previous research may have assumed away the information processing demands in product innovation and thus may have reached a premature, and perhaps painted an overly optimistic, view of the importance of market knowledge and cross-functional collaboration *per se* in product innovation. More important, these findings suggest an important qualification of the dual tenets of KBV - that knowledge is necessary but not sufficient condition for competitive advantage and that effective integration of knowledge is the key driver of competitive advantage. We show in this study that KIM plays an important role in product innovation performance, as predicted by KBV, by partially mediating the effects of market knowledge depth and completely mediating the effects of market knowledge specificity and cross-functional collaboration on product innovation performance. In other words, and consistent with KBV contention, market knowledge depth and specificity as well as cross-functional collaboration may not be intrinsically valuable; their value may be realized through KIM.

In contrast, contrary to KBV tenet, market knowledge breath is valuable, in and of itself, because it has direct, unmediated effect on product innovation performance. Thus, it is a sufficient condition for product innovation performance. These differential strengths of market knowledge characteristics suggest, crucially, that the KBV appears to understate the inherent value of some types of market knowledge. For these reasons, this study suggests the need for future research to focus on the explicit articulation of the types of market knowledge and the consideration of their different roles in understanding the firm's effectiveness in product innovation. Without such an approach, more nuanced understanding of the role of market knowledge may be missed.

Finally, given the complexity of the study context, the negative moderating effects of KIM suggest that at high levels it may stifle the effects of market knowledge depth and cross-functional collaboration on product innovation performance. It appears that although some characteristics of market knowledge and cross-functional collaboration may make KIM necessary, the degree of KIM must be tempered by the amount of contextual complexity faced by the firm and the resulting need for functional flexibility and perhaps autonomy (Eisenhardt and Martin 2000). It appears that at high levels KIM may stifle the flexibility and creativity of cross-functional interactions and in the use of deep market knowledge (Kumar and Seth, 1998, p. 583). Although previous studies in other contexts have found positive moderating roles for KIM, the new insight we offer is that there may be a threshold of KIM level beyond which market knowledge depth and cross-functional collaboration may have detrimental effects on performance. Thus, the use of KIM appears to involve a trade-off between their necessity occasioned by stickiness of market knowledge and the information processing demands of cross-functional collaboration on the one hand and the implementation costs of KIM. This is a trade-off that has until now not been uncovered in extant research.

Managerial Implications

The argument that market knowledge and cross-functional collaboration enhance product innovation performance has gained wide acceptance among practitioners. Our study supports this conclusion but at the same time qualifies it in several ways for managers. First, our study calls on managers to consider the attributes of the market knowledge they utilize into new product projects in order to properly design knowledge integration mechanisms. Marketing managers are fervent adherents of the market orientation tenet concerning the value of acquiring broad and comprehensive knowledge about customers and competitors. This notion is justified given the research on the positive effects of market orientation on product innovation outcomes. However, this study digs deeper into the features of market knowledge by finding that although broad market knowledge is important, managers need to pay equal attention to deep and specific market knowledge. These dimensions of market knowledge appear to influence the design of knowledge integration mechanisms which, in turn, affect product innovation performance. Hence, the new insight for managers is that broad market knowledge is inherently valuable for product innovation performance. But emphasizing breadth over other market knowledge characteristics and integration mechanisms may be detrimental for the achievement of the full potential of the firm's new product projects. Managers need to endow new project teams with the human and financial resources to acquire and apply broad, deep and specific market knowledge in new product development activities. In this respect, our measures of market knowledge characteristics could serve as guides for managers wanting to collect and use customer and competitor knowledge matching these characteristics.

Second, the results suggest that it is the structured knowledge integration processes which enable the translation of cross-functional collaboration into better product innovation performance. This means that managers who encourage cross-functional collaboration as an end in itself to the neglect of formal knowledge integration processes may not achieve their intended objectives in product innovation. Toyota provides a good example of a company that value cross-functional collaboration but takes the extra step of deploying KIM (Sobek, Liker and Ward 1998). Finally, managers must be creative in balancing the need for KIM engendered by information processing demands of cross-functional collaboration and market knowledge and the need for functional flexibility in collaboration and in using of market knowledge. Our results suggest that KIM is not without costs of implementation which may trap the unwary and thus lead to less effective use of market knowledge and cross-functional collaboration.

Limitations and future research directions

This study has several limitations that should caution the interpretations of the findings. First, we used cross-sectional data which cannot suggest causal relationships. In particular, we note that if one's theoretical lens is organizational learning and knowledge creation one could theorize that KIM is antecedent to dimensions of market knowledge we discussed here (e.g., Zahra, Ireland and Hitt 2000). However, our focus was on knowledge integration viewed from a structural contingency theory lens, more specifically on the view of knowledge as a contingency variable (Birkinshaw, Nobel and Ridderstråle 2002; Germain and Droge 1997; Olson, Walker and Ruekert 1995). This perspective suggests that the type of knowledge determines the nature of coordination mechanisms for knowledge integration (Galbraith 1973). Future studies based on the former lens could examine how KIM affect the dimensions of market knowledge.

Second, the generalizability of the results is limited because we used data from a sample of firms in China. Third, extant research (Olson, Walker and Ruekert 1995; Sobek, Liker and Ward 1998) and contingency theory describes several integrative mechanisms (Galbraith 1973) which we did not consider here and which should be investigated in future research for their ability to leverage market knowledge in product innovation. Fourth, our exclusive focus on market knowledge is a limitation given the role that technological knowledge plays in product innovation. A more explicit incorporation of the nature of technological knowledge along the dimensions used for market knowledge in future studies may provide a better view of knowledge integration and product innovation performance.

Although we controlled for several factors which account for variance in growth, market power and technological skills of firms (e.g., firm size, slack, environmental conditions, and radical innovation), we did not include some potentially influential covariates, such as industry maturity

(Eisenhardt and Tabrizi 1995) company age (Sinkula 1994) and R&D strength (Li and Calantone 1998) considered in previous studies. This might limit the definitive evaluation of the relative importance of the antecedents of KIM and product innovation performance in the current study and offers a chance for future researchers to take steps in this direction. Finally, two of our scales, market knowledge breadth and KIM did not meet the .50 threshold for average variance extracted, suggesting the need for further scale development. In addition to alleviating these limitations, there are other fertile avenues for further research.

First, our study highlights the key role that market knowledge characteristics play in enhancing KIM and product innovation performance and underscores the central importance accorded to knowledge and its integration in the concept of market orientation. However, despite the numerous studies on market orientation, scholars are yet to recognize the distinctions between different knowledge characteristics espoused in the KBV. We argue that market oriented firms may differ with respect to the type of market knowledge they collect and use in their product innovation processes. Hence, we suggest that two firms with the same degree of market orientation which have differential levels of market knowledge breadth, depth, tacitness and specificity may display markedly different effectiveness in product innovation. This implies that examining the role of market orientation in product innovation without isolating and accounting for the fine details of market knowledge characteristics may lead to an incomplete understanding or even misleading results.

Second, our findings underscore the need for researchers to examine factors that may be more proximate antecedents of product innovation performance and thus potential drivers of the effect of cross-functional collaboration. We need to move past our exclusive focus on the direct effects of cross-functional collaboration and begin examining factors which may moderate or mediate its role in product innovation. These include different types of firm internal and external environments, such as internal commitment and competitive uncertainty (Song and Parry 1997); different managerial styles and routines in the product innovation process, such as product standards and market definition (Dougherty 1992), functional relationship experience and such other. Indeed, with the exception of Maltz and Kohli (2000), we and other scholars in the marketing literature seem to have a positive bias towards cross-functional collaboration. However, cross-functional collaboration involves potential bottlenecks such as functional competition, conflicts and personality differences. Although not exhaustive, these aspects point to important opportunities for future research to provide a deeper examination of how cross-functional relationships and knowledge affect innovation.

The results of this study, along with those in previous studies suggest that we have very little understanding of the value of tacit knowledge. McEvily and Chakravarthy (2002) suggest that tacitness may involve two dimensions: characteristic ambiguity and linkage ambiguity and that the former is antecedent to the latter dimension. Given KBV arguments that tacitness is a key factor that could erect imitation barriers to protect the firm’s advantage, research is needed on whether these two dimensions apply to market knowledge and whether they offer similar or differential advantages in product innovation. Finally, future research should look more closely at the dynamic interplay among market knowledge characteristics and technological knowledge characteristics in the linkage between cross-functional collaboration and KIM in product innovation. We believe that given the potential synergies between market and technological knowledge in product innovation future research should tease out subtler, and yet still important, combined effects of the different characteristics of these kinds of firm knowledge.

In conclusion, this study challenges researchers and managers to take a more sophisticated look at how and why market knowledge and cross-functional collaboration affect product innovation outcomes. We believe that by delineating the differential relative effects of the dimensions of market knowledge and cross-functional collaboration; and by showing the dual mediating and moderating roles of KIM, this study brings us a little closer to illuminating in a more systematic way how such a goal may be achieved. With future work that builds on this study and further work that incorporates the role of technological knowledge, we will surely begin to have a more comprehensive account of the complexity of the processes by which firms develop successful product innovations.

Footnotes

1. Galunic and Rodan (1998) identify another characteristic of knowledge – knowledge *dispersion*. In this study, we contend that this characteristic is reflected in the construct of market knowledge breadth as it captures different elements underlying market knowledge (Turner and Makhija 2006).

2. One can question the direction of causality here. There are, however, in addition to structural contingency theory several other arguments supporting our interpretation. First, rational managers would invest in costly KIM processes only when they are satisfied that different functions are willing and able to collaborate. Second, rational managers know that structure such as KIM may be ineffective in imposing collaboration – a human and social condition. Indeed, prior research suggests that an attempt to impose cross-functional collaboration through an early implementation of KIM may yield the opposite result (Kahn 1996). Xie, Song and Stringfellow (2003, p. 233) also noted that merely imposing a cross-functional structure for product innovation cannot ensure that different functional units will collaborate.

3. Unlike other studies (e.g., Atuahene-Gima 2005, Li and Calantone 1998; Narver and Slater 1990) that differentiate between customer and competitor knowledge, we take a holistic measurement approach to the concept of market knowledge. Given the characteristics of knowledge we describe here are the same for customer and competitor knowledge we did not have any theoretical rationale to expect differential effects of customer and competitor knowledge on KIM. Hence, to reduce the complexity of the model and the burden on our informants we chose a more aggregated measure of market knowledge.

4. We took steps to ensure that respondents did not confuse this measure of the achievement of the firm's product innovation objectives with its overall performance. We measured overall firm performance relative to competitors with 8 items such as return of sales, growth in profit, return on assets, sales growth, market share growth, cash flow, overall operational efficiency and reputation for performance. We performed three discriminant tests for product innovation performance and firm performance. First, a CFA two factor solution gave a χ^2 (df) = 351.20 (64). When we constrained them into one factor, we obtained χ^2 (df) = 773.30 (65). Therefore we have significant change in χ^2 of 422.10 (1), p < .000, suggesting discriminant validity. Second, we performed discriminant test using the Fornell and Larcker (1981) approach. The AVE for both product innovation performance (.72) and firm performance (.71) were greater than the squared correlation between them (.66). Finally, the correlation between product innovation performance and firm performance was .81 with a standard error of .02. The two standard error confidence interval for this correlation estimate is .77; .85. Because it does not include 1, discriminant validity is demonstrated (Anderson and Gerbing 1988).

5. The exceptions were the average variance extracted for KIM and market knowledge breadth for the second respondent which were slightly below the highest squared correlation with the other latent variables, indicating weak discriminant validity. For these two constructs, we performed an additional test based on Bagozzi, Yi and Philips (1991). In all cases the two-factor model fit the data better than the constrained one-factor model. Detailed results of these analyses are available upon request from the first author.

6. For the 7-point scale adopted for product innovation performance, $-1.25 \leq r_{wg} \leq 1$.

7. The results were as follows: market knowledge breadth versus market knowledge depth [Unconstrained model: χ^2 (*df*) = 138.26 (19); Constrained model χ^2 (*df*) = 279.28 (20); $\Delta\chi^2$ (Δ*df*) = 141.02 (1)]; Market knowledge breadth versus market knowledge specificity[Unconstrained model: χ^2 (*df*) = 79.08 (13); Constrained model χ^2 (*df*) = 461.05 (14); $\Delta\chi^2$ (Δ*df*) = 381.97 (1)]; Market knowledge breadth versus market knowledge tacitness [Unconstrained model: χ^2 (*df*) = 89.83 (19); Constrained model χ^2 (*df*) = 544.78 (20); $\Delta\chi^2$ (Δ*df*) = 454.95 (1)]; Market knowledge breadth versus cross-functional collaboration[Unconstrained model: χ^2 (*df*) = 96.33 (13); Constrained model χ^2 (*df*) = 250.23 (14); $\Delta\chi^2$ (Δ*df*) = 153.90 (1)]; Market knowledge breadth versus knowledge integration mechanisms[Unconstrained model: χ^2 (*df*) = 238.20 (26); Constrained model χ^2 (*df*) = 488.29 (27); $\Delta\chi^2$ (Δ*df*) = 250.09 (1)]; Market knowledge breadth versus technology uncertainty [Unconstrained model: χ^2 (*df*) = 95.89 (19); Constrained model χ^2 (*df*) = 525.09 (20); $\Delta\chi^2$ (Δ*df*) = 429.20 (1)]; Market knowledge breadth versus market uncertainty[Unconstrained model: χ^2 (*df*) = 86.16 (13); Constrained model χ^2 (*df*) = 355.42(14); $\Delta\chi^2$ (Δ*df*) = 269.26(1)]; Market knowledge breadth versus organizational slack[Unconstrained model: χ^2 (*df*) = 77.78 (13); Constrained model χ^2 (*df*) = 395.53 (14); $\Delta\chi^2$ (Δ*df*) = 317.75 (1)]; Market knowledge breadth versus innovation radicalness [Unconstrained model: χ^2 (*df*) = 83.75 (13); Constrained model χ^2 (*df*) = 260.34 (14); $\Delta\chi^2$ (Δ*df*) = 176.59 (1)]; Market knowledge breadth versus product innovation performance [Unconstrained model: χ^2 (*df*) = 193.21(26); Constrained model χ^2 (*df*) = 535.17 (27); $\Delta\chi^2$ (Δ*df*) = 341.96 (1)].

8. For example, Shrout and Bolger (2002, p. 429) support recommendations to set aside the first step of Baron and Kenny (1986) approach, arguing that "Because a test of the $X \rightarrow Y$ association may be more powerful when mediation is taken into account, it seems unwise to defer considering mediation until the bivariate association between *X* and *Y* is established." Similarly, Preacher and Hayes (2004, p. 719) note several errors that could occur by strict adherence to that condition and argue that it is quite possible to find that an indirect effect is significant even when there is no evidence for a significant direct effect.

9. Differences between estimated coefficients in regression analysis and SEM can be due to different estimation approaches (OLS versus Maximum Likelihood) or to the fact that regression analysis does not account for measurement error.

10. As for indirect effects (both with Sobel's test and SEM) we report unstandardized coefficients and one-tailed significance levels. As for SEM, we obtained total, direct and indirect effects estimates and significance using AMOS 6.0 bootstrap estimation procedure with 1000 resamples.

11. To test interactions with SEM we followed the procedure suggested by Ping (1995) to build the interaction terms. First, for each pair of constructs X and Z forming an interaction, we mean-centered all their indicators x_1-x_n and z_1-z_m. Second, for each pair of constructs X and Z we computed a single indicator representing the latent product xz as $(x_1+\ldots x_n)(z_1+\ldots z_m)$. Third, we specified a model including the two focal constructs and their interaction term. The loading and error for the latent product are given by two equations:

$$\lambda_{xz} = (\lambda_{x1}+\ldots\lambda_{xn})(\lambda_{z1}+\ldots\lambda_{zm})$$

$$\theta_{\varepsilon xz} = (\lambda_{x1}+\ldots\lambda_{xn})^2 VAR(X)(\theta_{\varepsilon z1}+\ldots\ \theta_{\varepsilon zm}) + (\lambda_{z1}+\ldots\lambda_{zm})^2 VAR(Z)(\theta_{\varepsilon x1}+\ldots\ \theta_{\varepsilon xn})+ (\theta_{\varepsilon x1}+\ldots\ \theta_{\varepsilon xn})(\theta_{\varepsilon z1}+\ldots\theta_{\varepsilon zm})$$

for which all the terms on the right hand side are taken from the measurement model (Ping 1995).
The fit indices for the five models containing the relevant interaction terms are as follows: KIM and Market knowledge breadth interaction [χ^2 (*df*) = 1306.49 (823), CFI = .94, RMSEA = .04]; KIM and market knowledge depth interaction [χ^2 (*df*) = 1325.09 (823), CFI = .94, RMSEA = .04]; KIM and market knowledge tacitness interaction [χ^2 (*df*) = 1298.10 (823), CFI = .94, RMSEA = .04] KIM and market knowledge specificity interaction [χ^2 (*df*) = 1327.92 (823), CFI = .94, RMSEA = .04] KIM and cross-functional collaboration interaction [χ^2 (*df*) = 1284.85 (823), CFI = .94, RMSEA = .04].

TABLE 1

Correlation Matrix and Measures Descriptive Statistics[a]

		1	2	3	4	5	6	7	8	9	10	11	12
1	Market Knowledge Breadth	**.70**	.70	.09	.07	.57	.58	.47	.23	.17	.45	.54	N.A.
2	Market Knowledge Depth	.56	**.71**	.-01	.04	.62	.53	.41	.19	.06	.43	.35	N.A.
3	Market Knowledge Tacitness	.07	-.02	**.78**	.23	.11	.18	.07	.31	.23	.03	.12	N.A.
4	Market Knowledge Specificity	.06	.04	.24	**.77**	.20	.02	.15	.17	.27	.31	.20	N.A.
5	Knowledge integration mechanisms	.49	.51	.10	.20	**.69**	.62	.43	.30	.13	.54	.34	N.A.
6	Cross-functional collaboration	.44	.42	.12	.04	.53	**.72**	.27	.10	.03	.36	.39	N.A.
7	Product innovation performance	.41	.41	.04	.11	.39	.26	**.86**	.23	.17	.35	.24	N.A.
8	Technological uncertainty	.19	.19	.28	.14	.28	.12	.20	**.75**	.58	.19	.26	N.A.
9	Market uncertainty	.18	.08	.24	.22	.13	.07	.14	.49	**.73**	.22	.40	N.A.
10	Organizational slack	.38	.38	.02	.25	.45	.34	.31	.18	.19	**.80**	.36	N.A.
11	Radical Innovation	.42	.29	.11	.17	.29	.31	.19	.22	.32	.31	**.73**	N.A.
12	Firm Size	.07	.12	-.04	-.17	.06	-.02	.24	-.01	-.02	.07	-.03	N.A.
	Number of items	4	4	4	3	5	3	5	4	3	3	3	N.A.
	Mean	3.69	3.60	3.39	3.03	3.59	3.65	4.60	3.33	3.33	3.32	3.40	4.73
	Standard deviation	.60	.58	.76	.84	.68	.61	1.08	.74	.69	.76	.71	1.5
	Skewness	-.14	-.04	-.31	-.01	-.64	-.17	-.52	-.16	-.26	-.30	-.09	.55
	Kurtosis	.61	.00	-.05	-.45	.69	-.02	.22	-.20	-.01	-.12	-.06	.07

Notes: (i) The diagonal elements are square roots of the AVE. The upper-right triangle elements are the correlations among the latent variables (PHIs). The lower-left triangle elements are correlations among the composite measures (unweighted mean of the items for each construct); (ii) N = 363 except for size where N = 351; (iii) N.A. = Not Applicable.

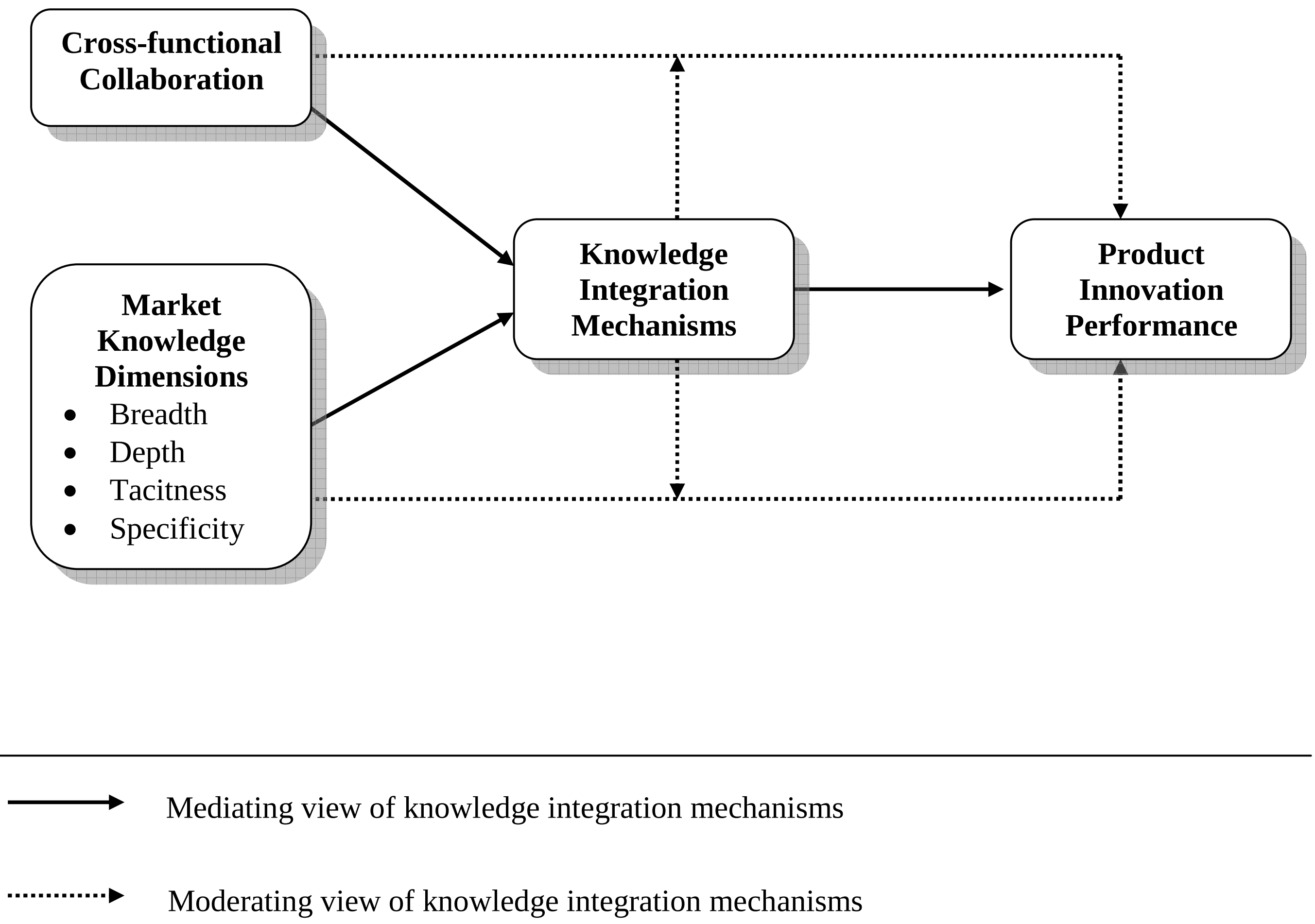
TABLE 2

Results of regression analysis: Standardized path-coefficients (t-values)

	Knowledge Integration Mechanisms	Product Innovation Performance	
Independent variables	**Model 1**	**Model 2**	**Model 3**
Control Variables			
Organizational Slack	.16	.10	.08
	(3.38) **	(1.94)	(1.53)
Radical Innovation	-.02	-.05	-.04
	(-.41)	(-.87)	(-.83)
Firm's Size	.04	.21	.21
	(1.05)	(4.52) **	(4.42) **
Technology Uncertainty	.16	.08	.06
	(3.52) **	(1.43)	(1.00)
Market Uncertainty	-.07	.03	.04
	(-1.45)	(.49)	(.66)
Main Effects			
Market Knowledge Breadth	.16	.26	.24
	(3.13) **	(4.40) **	(3.99) **
Market Knowledge Depth	.20	.18	.15
	(3.88) **	(3.08) **	(2.58) **
Market Knowledge Tacitness	.01	-.01	-.01
	(.13)	(-.26)	(-.27)
Market Knowledge Specificity	.13	.09	.07
	(3.00) **	(1.79) *	(1.43)
Cross-functional Collaboration	.31	.04	-.01
	(6.73) **	(.73)	(-.07)
Mediating Effect			
Knowledge Integration Mechanisms			.14
			(2.19) *
F-value	30.82 **	14.78 **	14.02 **
R^2	.48	.30	.31
Adjusted R^2	.46	.28	.29
ΔR^2			.01
F-Change			4.80 *

N = 351; * *p*<.05; ** *p*<.01 (One-tailed for hypotheses; Two-tailed for control variables).

FIGURE 1
Conceptual Model of the Role of Cross-Functional Collaboration, Market Knowledge Dimensions and Knowledge Integration Mechanisms in Product Innovation



APPENDIX
Confirmatory Factor Analysis of Measures

Measure and source	Description	SFL	t-value	r_{wg}
Product Innovation Performance[a]	*Rate the extent to which your firm has achieved the following product development objectives:*			
(Atuahene-Gima, Slater and Olson 2005)	• Market share relative to the firm's stated objectives	.76	16.72	.91
	• Sales relative to stated objectives	.81	18.49	.92
AVE = .74	• Return on assets relative to stated objectives	.93	23.12	.92
CR = .93	• Return on investment related to stated objectives	.93	23.09	.92
α = .94	• Profitability relative to stated objectives	.87	20.76	.91
Market knowledge breadth[b] (Zahra, Ireland and Hitt 2000)	*Compared to major competitors, our firm's knowledge of…*			
	• competitors' strategies is narrow vs. broad	.63	12.27	.90
	• competitors' strategies is limited vs. wide ranging	.60	11.55	.87
AVE = .49	• our customers is narrow vs. broad	.78	16.12	.90
CR = .79	• our customers is limited vs. wide ranging	.76	15.80	.91
α = .81	• competitors' strategies is specialized vs. general*			
	• our customers is specialized vs. general*			
Market knowledge depth[b] (Zahra, Ireland and Hitt 2000)	*Compared to our major competitors, our firm's knowledge about:*			
	• competitors' strategies is shallow vs. deep	.68	13.40	.90
	• competitors' strategies is basic vs. advanced	.62	11.80	.89
AVE = .50	• this firm's customers is shallow vs. deep	.76	15.58	.90
CR = .80	• this firm's customers is basic vs. advanced	.78	16.16	.88
α = .82				
Market knowledge tacitness[c] (Szulanski 1996)	*Market knowledge competencies are difficult to…*			
	• comprehensively document in manuals or reports	.86	19.29	.84
	• comprehensively understand from written documents	.88	19.91	.85
AVE = .61	• identify without personal experience in using them	.68	13.93	.86
CR = .86	• precisely communicate through written documents	.68	13.94	.84
α = .86	• There is no precise list of market knowledge skills necessary to successfully perform our activities*			
Market knowledge specificity[c] (New items based on Reed and DeFilippi 1990)	*Please indicate your agreement with each of the following statements with respect to your firm's market knowledge:*			
	• Our knowledge of customers and competitors are quite specific to our kind of business	.66	13.16	.84
AVE = .60	• It will be very difficult for an employee to transfer market knowledge acquired in our firm to other business environments	.86	17.74	.84
CR = .82				
α = .81	• Our market knowledge and skills are tailored to meet the specific conditions of our business	.79	16.23	.83
	• Our market knowledge largely depends on the human and physical assets we have dedicated to acquiring information about market conditions*			
Knowledge integration mechanisms[d] (Zahra, Ireland and Hitt 2000; Zahra and Nielsen 2002)	*To what extent does your firm use each of the following activities to capture, interpret, and integrate knowledge and information about market and technology conditions?*			
	• Regular formal reports and memos that summarize learning	.72	14.84	.87
AVE = .47	• Information sharing meetings	.77	16.19	.88
CR = .82	• Face to face discussions by cross-functional teams	.71	14.32	.88
α = .83	• Formal analysis of failing product development projects	.60	11.70	.85
	• Formal analysis of successful product development projects	.59	11.46	.86
	• Use of experts and consultants to synthesize knowledge*			
Cross-functional collaboration[e] (Li and Calantone 1998)	*In this organization different departments…*			
	• Cooperate fully in generating and screening new ideas for new products	.75	14.81	.88
AVE = .52	• Fully cooperate in establishing goals and priorities for our strategies	.79	14.96	.86
CR = .76				
α = .75	• Are adequately represented on project teams and other strategic activities	.61	11.52	.87
Technological uncertainty[c] (Jaworski and Kohli 1993)	*Please indicate your agreement with each of the following statements with respect to your firm's environment.*			
	• It was very difficult to forecast technology developments in our industry	.68	13.99	.83
AVE = .56	• Technology environment was highly uncertain	.86	19.03	.83
CR = .83	• Technological developments were highly unpredictable	.82	17.82	.84
α = .83	• Technologically, our industry was a very complex environment	.59	11.54	.84

Market Uncertainty[c] (Jaworski and Kohli 1993) AVE = .53 CR = .77 α = .76	*Please indicate your agreement with each of the following statements with respect to your firm's environment.*			
	• Customer needs and product preferences changed quite rapidly	.58	10.91	.88
	• Customer product demands and preferences were highly uncertain	.82	15.20	.87
	• It was difficult to predict changes in customer needs and preferences	.76	16.57	.85
	• Market competitive conditions were highly unpredictable*			
Organizational slack[c] (New scale) AVE = .64 CR = .84 α = .84	*Please indicate your agreement with each of the following statements with respect to your firm.*			
	• We have uncommitted resources that can be used to fund strategic initiatives at short notice	.72	14.89	.86
	• We have a large amount of resources available in the short run to fund our initiatives	.88	19.57	.83
	• We will have no problems obtaining resources at short notice to support new strategic initiatives	.79	16.82	.83
	• We have a large amount of resources at the discretion of management to fund new strategic initiatives*			
Radical innovation[e] (McGrath 2001) AVE = .53 CR = .77 α = .77	*To what extent does each of the following factors describe this firm's product development?*			
	• The products offered was new to the firm and the industry	.78	15.40	.88
	• The customer or client needs served were new to the firm	.72	14.04	.88
	• The users of the products or services were new to the firm	.69	13.23	.87
	• The new products were based on revolutionary changes in technology*			

Fit Indices: χ^2/df = 1163.2/720 =1.62; GFI = .86; TLI = .94; CFI = .94; RMSEA = .04 (p=1.00)

[a] 7-point scale (1 = low; 7 = high)

[b] 5-point semantic differential scales (anchoring points in italics)

[c] 5-point scale (1 = strongly disagree; 5 = strongly agree)

[d] 5- point scale (1 = never used; 5 = widely used)

[e] 5-point scale (1 = to no extent; 5 = to great extent)

* Items dropped from the scale during measure purification phase.

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PAPER 3

MARKET INFORMATION SEARCH PROCESSES, MARKET AND TECHNOLOGY KNOWLEDGE DIMENSIONS, AND FIRM PERFORMANCE: A CONTINGENCY MODEL AND EMPIRICAL TEST

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MARKET INFORMATION SEARCH PROCESSES, MARKET AND TECHNOLOGY KNOWLEDGE DIMENSIONS, AND FIRM PERFORMANCE: A CONTINGENCY MODEL AND EMPIRICAL TEST

Abstract

Recent research in marketing has established that market knowledge breadth and depth are important drivers of firms' performance. However, few studies have investigated the antecedents of these important dimensions of market knowledge as well as the possible factors which can moderate their effects on performance. Drawing on theories of organizational learning and search, the authors argue that different types of market information search processes adopted by firms determine the breadth and depth of their market knowledge. Results show that both proximal search and distal search are positively related to market knowledge breadth and depth. Also, the authors find that the effect of the two types of search on market knowledge breadth and depth are differently moderated by the degree of cross-functional collaboration. Regarding outcomes, the study confirms the positive relationship between market knowledge breadth and depth, and firm performance. More importantly, these relationships are moderated in complex a way by technology knowledge breadth and depth. Building on prior research, the authors develop four new market and technology knowledge combinations and found that Z- (broad market and broad technology knowledge) and H-shaped (deep market and technology knowledge) combinations perform better than T^m (broad market and deep technology knowledge) and T^t (broad technology and deep market knowledge) combinations.

Marketing scholars have focused their attention on the role played by marketing resources and capabilities in the achievement of competitive advantage and performance (Dutta, Narasivam and Rajiv, 1999). Among those resources, market knowledge – that is the firm's knowledge of its customers' needs and behaviors as well as competitors' behaviors - is considered at the heart of the firm's competitive capabilities (Day 1994a). This research stream rests on the central tenet of knowledge-based view of the firm (KBV) which argues that a firm's competitive advantage stems from its capacity to collect and use market and other types of knowledge. Recent studies in this research stream has underscored that the value of market knowledge for generating competitive advantage may lie in its dimensions (or characteristics). In particular, depth and breadth are two salient dimensions of a valuable market knowledge base (McEvily and Chakrabarthy 2000; Prabhu, Chandy and Ellis 2005). *Market knowledge breadth* is the firm's understanding of a wide range of diverse customer and competitor types and factors that describe them. *Market knowledge depth* is the level of sophistication and complexity of a firm's knowledge of its customers and competitors.

Using this dimensional framework, De Luca and Atuahene-Gima (2007) predicted and found support for the argument that market knowledge dimensions affect firms' product innovation performance through knowledge integration mechanisms. The same study did not find any evidence of a moderating role for such mechanisms. This work is important not only because it supports the theoretical link between market knowledge and organizational outcomes, but also because it demonstrates the potential usefulness of the concept of market knowledge dimensions for a more detailed and nuanced understanding of organizational performance. Nevertheless, their work did not examine what learning processes produced the different market knowledge dimensions in the first place and what potential moderators affect their linkage with performance. In short, we believe that while this dimensional conceptualization of market knowledge is not controversial there has been a dearth of research on how firms develop deep and broad market knowledge and their conditional effects on firm performance.

Our first contribution in this paper is to argue that while the concept of market knowledge dimensions is increasingly recognized as valuable addition to the literature, there is still a lack of understanding of how the firm's information search processes affect these dimensions of market knowledge. Market knowledge is the outcome of processes of organizational learning (Duncan and Weiss 1979, p. 84). Among the different processes of learning, information search represents the most actively and consciously pursued by managers, on a continuous basis, to acquire new knowledge often in response to new problems or opportunities (Huber 1991). Research suggests that firms can choose between two options for developing their market knowledge (Levinthal and March 1993; March 1991). The first, termed *proximal search*, is to search in the neighborhood of their current market knowledge domain with the aim of refining their existing knowledge, and improve efficiency and reliability of their market behaviors (Atuahene-Gima 2005; Katila and Ahuja 2002). The second option, labeled as *distal search*, is to move away from the current market knowledge domain in search of new problems to be addressed and new knowledge to be acquired (Atuahene-Gima 2005; Katila and Ahuja 2002). To date, we lack understanding of the nature of the relationships between these market information search processes and the dimensions of market knowledge. In addition to information search process, collaborative efforts of cross-functional units of the firm represent perhaps one of the most salient mechanisms for collecting and leveraging the firm's market knowledge (Grant 1996; Kohli and Jaworski 1990). Yet, its specific role in producing different types of market knowledge is unknown. Exploring this line of inquiry is important because if we accept that market knowledge is a critical antecedent to firm performance then it becomes relevant to understand how firms can build the specific breadth and depth of knowledge they need through these two factors: information search processes and cross-functional collaboration.

Indeed, a more complete view should not only consider the antecedent role of these two salient factors, but also how they interact in affecting the dimensions of market knowledge. Extant market research has established cross-functional collaboration as a key factor in leveraging the use of market knowledge (Narver and Slater 1990; Kohli and Jaworski 1990). However, prior research typically takes an omnibus view of market knowledge when examining its connection with cross-functional collaboration. Thus, we believe that it would be inappropriate to interpret empirical findings of those studies as though they provide a definite insight about the role of cross-functional collaboration in determining the nature of the firm's market knowledge dimensions. We suggest that by not examining the different dimensions of market knowledge, extant research provides minimal understanding of how cross-functional collaboration facilitates the acquisition and use of market knowledge. Hence, our second contribution relates to how cross-functional collaboration moderates the effect of the different types on information search processes on market knowledge depth and breadth. If we uncover that cross-functional collaboration plays differential antecedent and moderating roles, then there will be a need first, for caution in touting its benefits and, second for the search of other potential factors to leverage different types of market knowledge.

Accepted wisdom is that market knowledge affects firm performance, and that it needs to be combined with technology knowledge for maximum effect (Moorman and Slotegraaf 1999). In this literature few studies have considered the interactions of the dimensions of both market and technology knowledge. Not surprisingly, Prabhu, Chandy and Ellis (2005) call attention to the need to examine the interaction of technology knowledge dimensions with those of market knowledge. Our last contribution is to respond to this call by developing a fine-grained analysis of the interaction of market and technology knowledge dimensions on firm performance. This contribution is new and important in the marketing literature as without it scholars' and managers' understanding of how the complex interplay between different types of the firm's knowledge affects its activities and performance remains severely limited.

Our empirical results indicate market knowledge breadth is related positively with proximal and distal search processes whereas market knowledge depth is affected positively only by proximal search. While cross-functional collaboration is positively related to both market knowledge breadth and depth, it negatively moderates the relationship between both search processes and market knowledge breadth. In contrast, cross-functional collaboration buffers the relationship between distal search and market knowledge depth, and it enhances the positive effect of proximal search on market knowledge depth. Regarding the effects of market knowledge breadth and depth on firm performance, we show that they are positive but these relationships are also moderated in very complex ways by technology knowledge breadth and depth. With these results, our overarching contribution in this paper is a systematic exploration of the distinction between dimensions market information search processes, market and technology knowledge and their differential relationships. Extant literature typically considers these concepts in omnibus fashion; rarely are the different types distinguished and compared simultaneously for their complex linkages. Thus, our results suggest that while the celebrations of market information search, market knowledge and cross-functional collaboration in the marketing and other literatures are well-placed, they need to be more carefully specified. Figure 1 presents the conceptual model developed to explore these topics.

INSERT FIGURE 1 HERE

Theory Development

A firm acquires knowledge through learning (Huber 1991; Levitt and March 1988; Walsh 1995). Information search represents the learning process most actively and consciously pursued by managers, on a continuous basis, to acquire new knowledge (Huber 1991; Katila and Ahuja 2002). Information search requires managers to play an active role in finding problems to be solved, and searching for information to solve those problems (March 1991; Nelson and Winter 1982; Nickerson and Zenger 2004). As a consequence, the information search process impacts the type of knowledge resulting from the learning process (Katila and Ahuja 2002; Rosenkopf and Nerkar 2001; Smith, Collins and Clark 2005). In this study, we argue that in order to improve new market knowledge a firm that adopts a proximal search process scans its served market segments and current competitors, while a firm that adopts a distal search explores new market segments and studying other companies that are not yet direct competitors.

Different research streams have posited a relationship between information search types and specific market knowledge characteristics or dimensions. Proximal search has been traditionally associated with market knowledge depth. For example, market orientation researchers underline that a responsive market orientation reflects proximal information search involving the adaptation to evolving expressed needs of customers and continuous deepening of their the knowledge about served markets (Narver, Slater and MacLachlan 2004). Also research on service quality and customer satisfaction demonstrates that monitoring the level of perceived quality and customer satisfaction regularly allows the firm to adapt to its customers' evolving preferences and build a competitive advantage (Parasuraman, Zeithaml and Berry 1985). Finally, literature on product innovation confirms these results by showing that a firm exploiting its current competences increases its incremental innovation performance (Atuahene-Gima 2005). On the other hand, distal search is theorized to be related to market knowledge breadth. For example, when a firm's market orientation is proactively driven by the discovery and satisfaction of future customers' needs it leads the firm beyond its current experienced market domain and makes it confront new and different problems (Narver, Slater and MacLachlan 2004): by so doing the firm continuously broadens its market knowledge. Research on market experimentation echoes this view, underlining that the exploration of new competitive territories allows the firm to develop new capabilities and new business opportunities (Hamel and Prahalad 1991; Day 1994a). Finally, recent work shows that a firm exploring new competencies increases its radical innovation performance (Atuahene-Gima 2005).

In conclusion, theory and prior research underline that proximal search enhances knowledge depth whereas distal search enhances market knowledge breadth. Since these arguments are well sustained in the literature we do not develop formal hypotheses in this study and simply test them in our empirical analysis; rather, we extend prior thinking on the link between information search and market knowledge dimensions, by arguing that search types can have further effects on market knowledge dimensions. Specifically, we posit that proximal search can lead to market knowledge breadth, and that distal search can lead to market knowledge depth – an idea that has been overlooked in the extant literature.

Effects of Proximal and Distal Search Processes on Market Knowledge Dimensions

Drawing on different research streams within organizational learning theory, we present three explanations in support of a direct relation between proximal search and market knowledge breadth. First, by searching for market information within the current organizational experience domain, such as industry, a firm can learn vicariously from the experience of its current customers and competitors (Ingram and Baum 1997). The logic is that although a firm may focus only on few market segments and a limited portion of consumers' preference space, an industry can cover most market segments and a great deal of preference space. Thus, each firm can broaden its knowledge about un-served customers by observing competitors that are actually serving them, and the products they offer. As suggested by Levinthal and March (1993: 104), "the best strategy for any individual organization is often to emphasize the exploitation of successful exploration of others".

Second, recombining existing market knowledge is an important mechanism to broaden the knowledge about customers and competitors. As suggested by organizational learning researchers, knowledge is made up of pieces of information connected in a shared meaningful manner (Huber 1991; Walsh 1995). Combining those pieces in a new way is more effective for firms with a great deal of experience about that domain, and may give life to completely new knowledge (Katila and Ahuja 2002; Nahapiet and Ghoshal 1998; Smith, Collins and Clark 2005). By searching in the neighborhood of its current market domain, a firm can collect information to be combined with existing knowledge to gain insights on new market segments or new competitors. As suggested by Katila and Ahuja (2002: 1191), "Although exploratory search has a key role in knowledge creation […], exploitation also has a role, that of *combining existing solutions to generating new combinations*".

Third, unorthodox interpretations help firms broaden their market knowledge. Once information is searched, managers apply mental models to interpret them (Huber 1991; Walsh, 1995). Literature on managerial cognitions demonstrate that different knowledge structures can stem from the same information set if different mental models are applied to interpret it (Porac and Thomas 1990; Day and Nedungadi 1994; Reger and Palmer 1996). Likewise, March, Sproull and Tamuz (1991, p. 8) suggest that "the learning potential of any historical event is indeterminate. Because both the scope of an event and the depth of its decomposition into elements are arbitrary, so also the richness of experience". That implies that events can be experienced more richly: by means of near-histories – "events that almost happened" - and hypothetical histories – "events that might have happened under certain unrealized but plausible conditions" - managers can leverage on the experienced market domain to move away and build new market knowledge structures. Drawing on these three arguments, we posit that:

H_1: Proximal search process is positively associated with the firm's market knowledge breadth.

Regarding the direct relationship between distal search and market knowledge depth, we argue that there are two different explanations in support of this relation. First, literature on managerial learning shows that managers dealing with different tasks that are represented in similar ways tend to transfer their skills across fields of knowledge by developing more abstract principles or schemas (Schilling et al 2003). Schemas allow people to transfer learning from one domain to another through the development of higher-order cognitive structures which apply to both. This mechanism is confirmed also by prior research on the role of managerial cognition for organizational change. This research documents that even in the presence of distal search behaviors a refinement of prior knowledge sets is more likely than the development of completely new capabilities (Garud and Rappa 1994; Tripsas and Gavetti 2000; Van de Ven and Polley 1992). Weick (1991) also underlines that when organizations deal with entirely new environmental stimuli they tend to reinforce and refine their prior repertoire of knowledge. Thus, by searching distal information a firm can deepen its knowledge of current customers and competitors.

Second, prior research highlights that benchmarking is an important mechanism for market-based learning (Vohries and Morgan 2005). Managerial literature presents benchmarking as a multi-step process aimed at the internalization of best practices used by companies exhibiting superior performance in specific processes (Brownlie 1999; Iacobucci and Nordhielm 2000). Vohries and Morgan (2005) demonstrate that, when applied to marketing capabilities, a firm can achieve greater performance by benchmarking cross- rather within- industry. This suggests that a firm searching for information in a distant knowledge domain can gain a deeper understanding of its current market domain. Hargadon and Sutton (1997) investigate the outstanding innovative performance of IDEO and showed that innovation is mostly dependent on IDEO's ability to gain knowledge of existing solutions in some industries and re-use them in other industries where they are unknown to improve existing products. This gives further emphasis to the idea that searching for information across industries and current markets domains may foster the deepening of market knowledge. Hence, we posit that:

H_2: Distal search process is positively associated with the firm's market knowledge depth.

Effect of Cross-functional Collaboration on Market Knowledge Dimensions

Cross-functional collaboration is defined as the degree of cooperation and the extent of joint representation by different departments or organizational subunits in the firm decision making processes (Griffin and Hauser 1996). Collaboration involves mutual recognition by different functional units of their strategic interdependence, complementarity of respective knowledge domains and the need to integrate them. Prior research on the locus of organizational learning suggests that knowledge is not created at the organizational level, but rather by organizational subunits such as teams (Edmondson 2002), communities of practice (Brown and Duguid 1991) or functional departments (Carlile 2002), and then integrated cross-functionally. However, the process of integrating and validating knowledge across functions may encounter three distinct sources of hindrance (see Carlile 2002). First, from an information processing perspective (Galbraith 1973), organizational learning can be impeded because different departments may lack adequate information processing capability to integrate their respective language systems. Second, even assuming a shared language, functional knowledge often crystallizes into different and divergent systems of interpretations, such as thought-worlds (Dougherty 1992), which restrain organizationwide sharing of new knowledge.

Third, new knowledge creation at the organizational level is often “at stake”, meaning that cross-functional learning is not without consequences; for example, one department can feel threatened by, and resist to, the new knowledge created by another department because it calls into question its existing knowledge and skills (Carlile 2002; Menon, Thompson and Choi 2006). Cross-functional collaboration is a social process in which individuals from different departments develop integrating devices which allow them to overcome language barriers, reconcile differences in meanings, and align objectives (Gupta, Raj and Wilemon 1986); in other words, cross-functional collaboration helps reduce the practical and political barriers to cross-functional learning. A central tenet of market orientation theory is that market knowledge is generated cross-functionally (Kohli and Jaworski 1990). Hence, other things been equal, we expect a positive association between cross-functional collaboration and the depth and breadth of a firm’s market knowledge.

Although cross-functional collaboration my be beneficial in engendering broad and deep market knowledge, the effects of its interactions with search processes on these knowledge dimensions are not straightforward. This is because the same ability of cross-functional collaboration to reconcile differentiated systems of functional learning within the organization may actually stifle or enhance deep and broad market knowledge depending on whether the search process is proximal or distal. We draw on a role-theoretical perspective to posit a moderating effect of cross-functional collaboration on market knowledge dimensions depending on the type of information search processes used by the firm.

Proximal search. Role theory essentially presumes that behaviors follow the expectations - in terms of norms, beliefs or attitudes - individuals develop about their social relationships (Biddle 1986). Role theory also predicts that expectations will be associated with consensus (i.e., agreement among the expectations held by various persons) and conformity (i.e., compliance to some pattern of behavior). We argue that when cross-functional collaboration in a firm is high, the stronger expectations for cooperative relationships among subunits will more likely drive them to overcome the aforementioned language, interpretative and political barriers by seeking *convergence* and reinforcement of the existing knowledge on which such collaboration was established in the past (March 1991). On the contrary, when cross-functional collaboration is low, weak expectations towards cooperative relationships will more easily lead different departments to *diverge*, emphasizing differences in perspectives, openly discuss and challenge others' interpretations (Moorman 1995), strive more to influence others' subunits knowledge and resist to others' attempts to transform their own knowledge (Carlile 2002).

When firms undertake proximal search, the different departments are very familiar with the information environment. The role theory arguments imply that under high cross-functional collaboration conditions, different functions become even more efficient in refining existing knowledge because familiar information will fit very easily with effective communication patterns and shared interpretive schemes previously applied to the same kind of information domain. Also, proximal search strategies coupled with high-degrees of cross-functional collaboration may loop into phenomena such as "groupthink", when the strong alignment of goals and perspectives among single individuals and departments impede creativity (Madhavan and Grover 1998). On the contrary, under low cross-functional collaboration, different functional departments will engage in more disagreement and negotiation over the content, interpretation and consequences of the new information searched, as these behaviors will not be contrasting with the expected relationship rules; this, in turn, will enhance the chances to re-interpret prior knowledge and apply it diversely from the past and outside current activities (Carlile 2002). Functional departments will engage in more disagreement over the content, interpretation and consequences of the new information searched, enhancing the re-interpretation of prior knowledge and applying it diversely from the past and outside current activities (Schulz 2001). Hence:

H_{3a}: The positive association between proximal search and market knowledge depth is stronger when cross-functional collaboration is higher rather than low.

H_{3b}: The positive association between proximal search and market knowledge breadth is weaker when cross-functional collaboration is high rather than low.

Distal Search. When firms undertake distal search, the different departments are not familiar with the new information environment (Schulz 2001). Because of the novelty and heterogeneity of the new information search environment, distal search will stimulate more debate, confrontation and disagreement among individuals and functional units over the meaning, usefulness and consequences of the new information. When cross-functional collaboration is high, the level of cooperation may prevent the surfacing of such necessary level of conflict and debate, resulting in a little new insight on how to use the new distal information both within and outside the context of prior knowledge (Pelled, Eisenhardt and Xin 1999). We posit that this might lead to unproductive process of distal search, weakening the link between distal search and both depth and breadth of market knowledge. Conversely, under low cross-functional collaboration, different individuals and functional units will be more effective in envisaging new ways to deploy distal information, because they are less constrained by problems of communication, shared interpretation and political consequences typically associated with highly cooperative environments (Carlile 2002). Hence:

H_{4a}: The positive association between distal search and market knowledge depth is weaker when cross-functional collaboration is higher rather than low.

H_{4b}: The positive association between distal search and market knowledge breadth is weaker when cross-functional collaboration is higher rather than low.

Market Knowledge and Performance: Moderating Role of Technology Knowledge

At the heart of market orientation literature is the claim that knowledge about customers and competitors has a positive impact on organizational performance (Kohli and Jaworski 1990; Narver and Slater 1990). Drawing on more than 15 years of empirical studies, recent meta-analytic works have confirmed the existence of such a relationship (Kirca, Jayachandran and Bearden 2005; Rodriguez Cano, Carillat and Jaramillo 2004). Broad and deep market knowledge are associated to superior capability to sense and respond to market opportunities (Day 1994a; Kohli and Jaworski 1990) and to establish effective relationships with customers and suppliers (Day 1994a) in that they allow firms to connect customers with product designs and to develop effective marketing strategies to present their products in the marketplace (Moorman and Rust 1999). Knowledge about customers and competitors enhances firms' proficiency in product innovation, which is an antecedent of organizational success (Han, Kim and Srivastava 1998; Henard and Szimansky 2001). Beyond that, increasing levels of breadth and depth of market knowledge create interfirm ambiguity which surrounds the linkage between the focal firm's market knowledge and performance, protecting the firm's competitive advantage from imitation by rivals (De Luca and Atuahene-Gima 2007; Reed and DeFilippi 1990; King 2007).

Although the above arguments on the direct effects of market knowledge dimensions on organizational performance are sound, they are limited to the consideration of market knowledge in isolation from other types of knowledge possessed by the firm. For a long time, the marketing literature has indicated the need to consider technological knowledge as a major moderator of the link between marketing capabilities and performance (e.g., Capon and Glazer 1987; Dougherty 1992; Dutta, Narasimhan and Rajiv 1999; Moorman and Slotegraaf 1999). The interplay of market knowledge with other types of knowledge (e.g., operations knowledge) was shown to be important but to a significantly less extent than the interplay between market and technological knowledge (Dutta, Narasimhan and Rajiv 1999; Olson et al. 2001). To date however, few, if any, studies have examined how the different dimensions of market and technology knowledge interact to affect firm performance. We address this issue next.

Based on Prabhu, Chandy and Ellis (2005), we define *technological knowledge breadth* as the range and variety of technological domains, within and outside its industry, over which the firm has knowledge; and *technological knowledge depth* as the level of intricacy and sophistication of the firm's knowledge and understanding of technology. Technological knowledge breadth and depth represent, respectively, the horizontal and vertical dimensions of the firm's internal technological knowledge (Prabhu, Chandy and Ellis 2005).

In the literature on individual skills the labels A-shaped and T-shaped capabilities have been used to represent special combinations of knowledge dimensions held by an individual (Madhavan and Grover 1998). A-shaped skills describe people with the unique ability to integrate in their heads two different disciplines, in each of which they have some depth of expertise (Madhavan and Grover 1998); T-shaped skills describe people who have deep knowledge of one discipline (e.g., ceramic materials engineering) but also broad knowledge about how their discipline interacts with other knowledge domains (e.g., polymer processing) (Iansiti 1993). Borrowing from this literature, in this study we propose an extension of these ideas from individual to the firm level. We first describe four ideal combinations of market and technology knowledge dimensions within a firm and then hypothsize how firm performance can vary across these combinations.

We label as *Z-shaped* a combination of broad market knowledge with broad technological knowledge (each represented by the horizontal segments). Firms falling in this category possess an extensive set of knowledge elements about customers and competitors types and factors which describe them, and a wide-ranging set of knowledge elements across diverse technological domains. As symbolized by the diagonal line linking the two knowledge bases, in this situation firms have the potential to draw non-straightforward connections *across* multiple market and technological realms, work with a very broad set of feasible combinations of customer needs and new products' features (Dougherty 1992) and combine knowledge in a more creative and complex manner (e.g., Kogut and Zander 1992). For example, von Hippel, Thomke and Sonnack (1999) describe how 3M's Medical-Surgical Market Division successfully developed several innovations by combining broad market knowledge from the lead-user process with a broad array of in-house technologies, which ensured efficient technical feasibility of the new concepts.

We label as *H-shaped* a combination of deep market knowledge and deep technological knowledge (each represented by the vertical bars). As symbolized by the horizontal segment linking the two vertical bars, these firms have the potential to connect the two knowledge domains in such a way that the sophistication of technological knowledge can match the opportunities offered by deep market knowledge, and vice versa. For example, as reported by Zahra and Covin (1991), when faced with fierce competition, some US textile firms like Burlington Industries leveraged their cutting edge knowledge of the production technology and market needs' evolution in their industry, to develop high margin, unique products targeted at selected premium customer segments.

Consistent with the individual skills literature (e.g., Iansiti 1993; Madhavan and Grover 1998), we label as T-shaped the combinations of broad knowledge (represented by the horizontal segment) in one domain with deep knowledge in the other (represented by the vertical segment). A T^m*-shaped* combination describes firms with a broad market knowledge coupled with very deep technology knowledge. These firms have a thorough exposure to market opportunities, but can find it difficult to fully exploit this potential as far as their market sensing ability drives them too far from their technological skills. For example, Dell's innovative build-to-order model allowed the company to accumulate a broad knowledge of the PC market (i.e., from individual consumers to megacorporations); however, to increase efficiency, the company developed deeper and deeper technological knowledge of its current operations and did not invest in new technological platforms required for sustaining innovation. As a result, to respond to growing competitive pressure, Dell opted for pushing its customization model in a broader set of markets (i.e., TVs, printers), obtaining only modest results (Business Week 2007).

Lastly, we label as *T ^{t}-shaped* a combination of broad technological knowledge and deep market knowledge. These firms can be brilliant at developing new or improved products based on their knowledge of different technologies and proactiveness toward technological change, but can find it difficult to champion them within the firm (e.g., Christensen and Bower 1996) and to connect them to customers (Day 1994a; Moorman and Rust 1999), because they lack the market knowledge outside the sphere of their current operations. For example, as reported by Norman (1998), Xerox's PARC first developed breakthrough innovations such as the mouse and the graphical user interface operating system; however, the company was unable to get those innovations into the market because its market knowledge was very deeply focused on the copy-machines customers, but lacked the breath of market knowledge required to take advantage of technological process, and eventually ceded their commercial exploitation to other firms.

The interplay between market and technological knowledge increases performance when it extends the set of feasible configurations of attributes that a firm can operationalize in its new product innovations (Dougherty 1992, p. 79). When new market knowledge elements are created, the set of feasible configurations of attributes is expanded only if there is one or more technological knowledge element which can be matched with the new market knowledge. Thus, the number of new configurations a firm can obtain by investing in new market knowledge at a given time (i.e., its returns on market knowledge), will depend on the dimension of market knowledge which is extended (i.e., depth or breadth) and on the characteristics of the existing technological knowledge base. The examples discussed above, such as Dell and Xerox, provide cases in which a mismatch between the increase in one marketing knowledge dimension and the characteristics of the technological knowledge base attenuates the impact of the former on performance. We propose that when firms increase the breadth of their market knowledge, their benefits will be higher if the technological knowledge base is also broad, as the number of new feasible product innovation opportunities will be greater than under deep technological knowledge. Similarly, we propose that when firms increase market knowledge along the depth dimension, their performance benefits will be higher if the technological knowledge base is also very deep, as the number of new feasible product innovation opportunities will be greater than under broad technological knowledge.

H_{5a}: The positive association between market knowledge breadth and organizational performance will be stronger under broad technological knowledge (*Z-shaped* combination) than under deep technological knowledge (T^{m}*-shaped* combination).

H_{5b}: The positive association between market knowledge depth and organizational performance will be stronger under deep technological knowledge (*H-shaped* combination) than under broad technological knowledge (T^{t}*-shaped* combination).

Research Methods

Sample and Data Collection

This study is set in China, which is a suitable context for studying market knowledge for at least two important reasons. First, the extreme complexity and dynamism of this transitional environment, coupled with the high heterogeneity among market segments and competitive strategies, make market knowledge rather than technological supremacy the key factor for succeeding in many industries in China. Also, the more advanced stage of development of its market, especially in the huge and fast-growing middle segment, makes China a real-life laboratory in which local and multinational firms compete on experimenting and learning about the market, in order to re-deploy such knowledge in other large emerging markets, such as India and Brazil.

The instrument was prepared in English and then translated into Chinese. It was checked for accuracy following the conventional back-translation process. We pretested the instrument with 25 managers who had at least 3 years business experience in China. The purposes were to examine the face validity and appropriateness of the items, and assess informants understanding of the survey questions. The test led to modifications that improved the questionnaire. The sampling frame included 750 firms selected randomly from a mailing list of 2500 high technology firms provided by a local business intelligence consulting firm. Like previous studies in China (Li and Atuahene-Gima 2001), we collected the data on-site. An interviewer scheduled appointments with the marketing manager/director as a first informant who then nominated a second knowledgeable informant. The interviewer presented the key informants with the survey questionnaire, and collected the questionnaire upon completion. We motivated respondents by offering a summary of the research results and a free workshop on the research findings - information that would be meaningless to them in the absence of accurate data.

We received 363 usable questionnaires for a response rate of 48%. The responses represent different industries, such as electronics and information technology (21.9 %), computers and software (28.4 %), telecommunications (8.2 %), integrated optical, mechanical and electric products (5.7 %), chemical, pharmaceutical and biotechnology (13.4 %), new energy and material (6.4 %) and others (16.0%). We compared a sample of 50 participating firms with a sample of non-participating firms for which we had data on sales, R&D expense and number of employees. ANOVA tests indicated no significant differences between the two groups on number of employees (F = 1.01), sales in the most recent year (F = 0.89) and R&D expenditure as percentage of sales (F = 0.98).

Ninety percent of the first informants were from marketing and sales, 6% product development managers and 4% CEOs/general managers. These informants had a mean industry experience of 8.18 years and mean firm experience of 4.77 years. Seventy-three percent of the second informants were product development director/managers, 11% CEOs/general managers, 9% marketing/sales, and 7% from R&D. These informants had mean industry experience of 7.76 years and mean firm experience of 4.55 years. We also examined the quality of the informants by asking them to indicate on a 10-point scale their degree of knowledge of (1 = “not at all knowledgeable,” 10 “extremely knowledgeable”) and involvement in (1 = “no involvement,” 10 “very high involvement”) product innovation issues in the firm, a field which critically involves both marketing and technological knowledge. The means of the two items for the first and second informants were 7.55, 7.40 and 8.00, 7.78, respectively. ANOVA tests did not indicate differences in the scores of the multiple items measures across different informants' positions ($F \leq 1.81$), so we pooled the data for subsequent analyses.

Measures

The Appendix contains information about the specific items used for our measures. We measured the breadth and depth of market knowledge based on the work of Zahra, Ireland and Hitt (2000). We measured *market knowledge breadth* with four items by asking respondents, for example, to evaluate their firms' market knowledge on a continuum from "limited" to "wide-ranging". We measured *market knowledge depth* with four items, asking, for example, to evaluate their firms' customer knowledge on a continuum from "basic" to "advanced". To measure the breadth and depth of technological knowledge we developed two multiple items scales based on the work of Srinivasan, Lilien and Rangaswamy (2002) and Prabhu, Chandy and Ellis (2005). To measure t*echnological knowledge breadth* we used three items, which assessed the degree to which relative to major competitors, the firm possesses a broad and thorough technological knowledge and is at the forefront to detecting changes in technology directions likely to affect its activities. We measured *technological knowledge depth* with three items, assessing the degree to which a firm's knowledge about technology is sophisticated, complex and specialized relative to its major competitors. We used different question and scale format to aid clarity and differentiation in measuring these knowledge categories, thus avoiding method bias that could work against discriminant validity of the two central constructs. This follows on the recommendations of Podsakoff et al. (2003, p. 888) that "still another way to diminish method biases is to use different scale endpoints and formats for the predictor and criterion measures. This reduces method biases caused by commonalities in scale endpoints and anchoring effects." For this reason, we also assessed all the items on a 5-point scale, except organizational performance, which was measured on a 7-point scale.

Based on the work by Li and Atuahene-Gima (2001), we measured *organizational performance* with a six items scale, assessing multiple aspects of the firm's performance compared to its major competitors. We measured proximal and distal information search based on the work of Atuahene-Gima (2005). To measure *proximal search* we used a four items scale, assessing the degree to which a firm searches and integrates new information which builds on its current activities and operational skills. To measure *distal search* we used four items, assessing the degree to which a firm searches and integrates information from outside the domain of its current activities and operational skills. We measured *cross-functional collaboration* with a five items scale drawn from the work of Li and Calantone (1998), which asked the informant, for instance, to rate the extent to which different functional units cooperate in establishing goals and priorities for the firms' strategies and product innovation.

Control variables. We also employed control variables to control for potential confounds. Specifically, we included *firm size*, measured as the logarithm of the number of employees and two dummy-coded variables representing aggregations of similar industry settings (*Industry 1* = electronics, IT, computers & software; telecommunications; *Industry 2* = integrated optical mechanical & electric products; chemical, pharmaceutical & biotech; new energy & materials). We also controlled for *market uncertainty* and *technological uncertainty* (Jaworski and Kohli 1993) and for *discretionary environment*, defined as the extent to which the environment is dynamic and munificent (Goll and Rasheed 1997).

Also, the type of business strategy can affect the type of information search adopted, the dimensions of knowledge firms emphasize and, ultimately, their performance. To include these factors, we also controlled for strategy type, which we operationalized using the self-typing paragraph approach commonly used in strategic management and marketing research (Slater and Olson 2000). In this study, 39% of informants characterized their businesses as Prospectors, 22% as Analyzers, 33% as Defenders (low-cost or differentiated) and 6% as Reactors. We used the

Reactors as baseline group and created three dummy-coded variables to control for the other three strategy types.

Reliability and Validity of Measures

We followed different steps to assess the reliability and validity of our multi-items measures. First, we assessed the need to treat the two informants groups with a multi-group analysis. Following Steenkamp and Baumgartner (1998) we estimated three confirmatory factor analysis (CFA) models, using Lisrel 8.7. The first model imposed equality of indicators' covariances and means between the two groups and yielded these results: χ^2=1,062.85 with 989 degrees of freedom; comparative fit-index (CFI) = .99; parsimony normed fit index (PNFI) = .51; CAIC = 8,494.96; a second model, imposing equality of means only, yielded these results: χ^2=22.36 with 43 degrees of freedom; CFI = 1.00; PNFI = .02; CAIC = 14,703.93; a third model, imposing equality of covariances only, yielded these results: χ^2=1,040.49 with 946 degrees of freedom; CFI = .99; PNFI = .49; CAIC = 8,800.63. As these statistics suggested, multi-group analysis between our two informants groups was not necessary as the first model fits the data better than the second and third.

As a further evidence of consistency between the two informants, we computed the interrater agreement index (r_{wg}) for each item (James, Demaree and Wolf 1984).This index ranges from -1 to 1, indicating minimum and maximum agreement respectively, for constructs measured on the 5-point scale, and for -1.25 to 1 for construct measured on a 7-point scale. The lowest r_{wg} index for the whole set of items was .81, indication of a high level of agreement between the two informants.

Given these results we averaged the items scores from the two informants for all the remaining analyses to reduce the potential for common method variance. On these indicators, we ran a CFA to test for the multi-items scales measurement model. This model performed reasonably well (χ^2/df = 1,484.54/805 = 1.84; global fit index [GFI] = .83; CFI = .91; non-normed fit index [NNFI] = .91; root mean square error of approximation [RMSEA] = .05). As evidence of convergent validity, each item had a significant factor loading on its theorized latent construct ($t \geq 8.49$), and each construct had acceptable values of average variance extracted (AVE) and composite reliability (CR) (See Table 1). Based on Fornell and Larcker (1981), we tested for discriminant validity of the constructs by examining if each correlation between two latent variables was smaller then the square root of both their AVEs. For some constructs (i.e. cross-functional collaboration), the square root of AVE was very close to the highest correlation between constructs. In such cases, following Bagozzi, Yi and Philips (1991) we examined whether for each pair of constructs a one-factor model fitted the data better than the hypothesized two-factor model. In all cases the χ^2 of the constrained one-factor model was significantly greater than the χ^2 for the unconstrained two-factor model, suggesting discriminant validity. For the subsequent analyses we used the items' averaged scores as constructs' indicators.

INSERT TABLE 1 HERE

Hypothesis Testing and Results

We tested our hypotheses following a three-step hierarchical regression model (Aiken and West 1991). In the first step we entered the control variables; in the second step, the main effects of both predictors and moderators, and in the third step the hypothesized interaction effects. All variables involving in the interactions were mean-centered to avoid excessive multicollinearity. Variance inflation factors (VIF) for main effects and interaction terms ranged between 1.25 and 3, indicating no major concern. The estimated models for the antecedents and consequences of market knowledge dimensions were specified as follows:

$$MKB/MKD = \alpha_1 + \beta_1 SIZE + \beta_2 IND1 + \beta_3 IND2 + \beta_4 TECHUN + \beta_5 MKTUN + \beta_6 DISCRENV + \beta_7 PRO + \beta_8 ANA + \beta_9 DEF + \beta_{10} PROX + \beta_{11} DIST + \beta_{12} CFC + \beta_{13}\, PROX*CFC + \beta_{14}\, DIST*CFC + \varepsilon_1$$

$$PERF = \alpha_2 + \beta_{15} SIZE + \beta_{16} IND1 + \beta_{17} IND2 + \beta_{18} TECHUN + \beta_{19} MKTUN + \beta_{20} DISCRENV + \beta_{21} PRO + \beta_{22} ANA + \beta_{23} DEF + \beta_{24} MKB + \beta_{25} MKD + \beta_{26} TKB + \beta_{27} TKD + \beta_{28} MKB*TKB + \beta_{29} MKB*TKD + \beta_{30} MKD*TKB + \beta_{31} MKD*TKD + \varepsilon_2,$$

Where:
SIZE = Firm'size; IND1 = Industry dummy 2; IND2 = Industry dummy 2; TECHUN = Technology uncertainty; MKTUN = market uncertainty; DISCRENV = discretionary environment; PRO = Prospector; ANA = Analyzer; DEF = Defender; PROX = Proximal search; DIST = distal search; CFC = cross-functional collaboration; PERF = organizational performance; MKB = market knowledge breadth; MKD = market knowledge depth; TKB = technology knowledge breadth; TKD = technology knowledge depth

Table 2 reports results on the relationships between information search and market knowledge dimensions and on the moderating role of cross-functional collaboration (H_1-H_4). In all cases, adding a new block of variables yielded a significant increase in R^2 ($p<.05$ or $p<.10$ in Model 6). Therefore, we comment on our results based on the full models, including control variables, main effects and the relevant interaction effects.

INSERT TABLE 2 HERE

Market knowledge breadth. As shown in Table 2 (Model 3), proximal search is positively related to market knowledge breadth (β = .20, $p<.01$), and cross-functional collaboration negatively moderates such relationship (β = -.10, $p<.10$). Also, our results confirm that distal information search is positively related market knowledge breadth (β = .08, $p<.05$), and that cross-functional collaboration negatively moderates such relationship (β = -.09, $p<.10$). Also, the main effect of cross-functional collaboration is positive (β = .13, $p<.05$), as expected. Overall, H_1,H_{3a} and H_{3b} are supported.

Market knowledge depth. As shown in Table 2 (Model 6), proximal information search is positively associated with market knowledge depth (β = .29, $p<.01$), and cross-functional collaboration positively moderates such relationship (β = .14, $p<.05$). Distal search is not directly related to market knowledge depth (β = .02, $p>.10$), but this relationship is negatively moderated by cross-functional collaboration (β = -.10, $p<.10$). Also, the main effect of cross-functional collaboration is positive (β = .15, $p<.05$), as expected. Overall, H_{4a} and H_{4b} are supported while H_2 is not.

To understand the interaction effects described by H_3 and H_4 more clearly, we computed the simple slopes of the effects of information search strategies on market knowledge dimensions at low (1 SD below the mean) and high (1 SD above the mean) levels of cross-functional collaboration and plotted them in Figure 2. Panel 2a shows that the effect of proximal search on market knowledge breadth is stronger when cross-functional collaboration is low (β= .26, t= 3.90) than when it is high (β=.14, t=2.095); Panel 2b shows that the effect of distal search on market knowledge breadth is positive and significant when cross-functional collaboration is low (β= .14, t=2.17), but non-significant when it is high (β= .02, t=.38). Panel 2c shows that the effect of proximal search on market knowledge depth is stronger for high levels of cross-functional collaboration (β= .38, t=6.11), than for low ones (β=.21, t=3.30); finally, panel 2d shows that the effect of distal search on market knowledge depth is stronger for low levels of cross-functional collaboration (β=.08, t=1.47), than for high ones (β= -.04, t=-.69), although none of them is statistically significant (p>.10).

INSERT FIGURE 1 HERE

Organizational performance. The findings reported in Table 3 (Model 3) confirm a positive effect of market knowledge breadth (β = .35, p<.01) and market knowledge depth (β = .27, p<.01) on organizational performance. The effect of market knowledge breadth on organizational performance is positively moderated by technological knowledge breadth (β =.40, p<.01), whereas it is negatively moderated by technological knowledge depth (β =-.20, p<.10). Also, the effect of market knowledge depth on organizational performance is not significantly moderated by the degree of technological knowledge depth (β = .02, p>.10), whereas is negatively moderated by technological knowledge breadth (β = -.55, p<.01).

To test for H_5 we computed the simple slopes for the four combinations of market and technology knowledge dimensions and plotted them in Figure 3, following the procedure outlined by Aiken and West (1991). As shown in Panel 3a, the simple slope for the effect of market knowledge breadth under high levels of technological knowledge breadth (Z-shaped combination: β = .61, t = 4.33) is higher than the simple slope for the effect of market knowledge breadth under high levels of technology knowledge depth (T^m-shaped combination: β = .22, t = 1.64). As shown in Panel 3b, the simple slope for the effect of market knowledge depth under high levels of technological knowledge depth (H-shaped combination: β = .28, t = 2.24) is higher than the simple slope for the effect of market knowledge depth under high levels of technology knowledge breadth (T^t-shaped combination: β = -.09, t= -.59). Taken together, these results lend considerable support for H_{5a} and H_{5b}.

INSERT FIGURE 3 HERE

Control variables. Among the control variables, size is positively related to organizational performance (β =.11, p<.01). Discretionary environment positively affects both market knowledge breadth (β = .27, p<.01), and market knowledge depth (β = .31, p<.01), suggesting that when the environment is growing and dynamic firms accumulate greater amounts of knowledge about customers and competitors. Among the strategy types, prospector strategy is the most positively related to market knowledge breadth (β = .34, p<.01), and is also positively related to organizational performance (β= .45, p<.05); analyzer strategy is positively related to and performance (β = .79, p<.01); and defenders strategy is positively related to market knowledge breadth (β =.21, p<.10), negatively related to market knowledge depth (β =-.22, p<.10) and positively related to performance (β = .55, p<.05).

Additional findings and post-hoc analyses

The rationale between H_{5a} was that the effect of market knowledge breadth on organizational performance was more synergic with technological knowledge breadth than depth; similarly, H_{5b} advanced that the effect of market knowledge depth on performance was more synergic with technological knowledge depth than breadth. For this reason we focused on the four possible "high-high" combinations between market knowledge and technological knowledge breadth and depth. Here we also discuss the effects of market knowledge dimensions under *low* levels of technological knowledge breadth and depth, which can usefully complement the results of the study hypotheses previously reported.

Overall, market knowledge breadth is positively related to organizational performance. At low levels of technological knowledge breadth this effect becomes non-significant (β=.09, p>.10); on the contrary, at low levels of technological knowledge depth the effect of market knowledge breadth on performance is strengthened (β=.48, p<.01). These findings indicate that investments in market knowledge breadth are redundant for firms with a limited technological knowledge breadth, but are particularly rewarding for firms with a limited technological knowledge depth.

Market knowledge depth is positively related to organizational performance. At low levels of technological breadth this effect becomes stronger (β=.62, $p<.01$) and remains virtually the same across low and high levels of technological knowledge depth. These findings indicate that investments in market knowledge depth are especially rewarding for firms with lack breadth of knowledge in the technology domain.

Results concerning the main effects of market and technological dimensions on organizational performance indicate that all the dimensions but technological knowledge depth are positively related to organizational performance. Although the main effects of technological knowledge dimensions were included to enable proper partialling of their products with market knowledge dimensions (Irwin and McClelland 2001), the absence of technological knowledge depth's effect on performance was unexpected.

For this reason, we conducted a post-hoc analysis including the squared term of technological knowledge depth, in order to account for a non-linear relationship between this variable and performance. To this aim, we specified a first post-hoc model as follows:

$$PERF = \alpha_3 + \beta_{32}SIZE + \beta_{33}IND1 + \beta_{34}IND2 + \beta_{35}TECHUN + \beta_{36}MKTUN + \beta_{37}DISCRENV + \beta_{38}PRO + \beta_{39}ANA + \beta_{40}DEF + \beta_{41}MKB + \beta_{42}MKD + \beta_{43}TKB + \beta_{44}TKD + \beta_{45}TKD^2 + \varepsilon_3$$

As shown in Table 3 (Post-hoc 1), we found a significant negative coefficient for the squared term (β = -.13, $p<.05$), indicating an inverted U-shaped relationship. We then specified a second post-hoc model, including the interactions between the two market knowledge dimensions and the squared term of technology knowledge, as follows:

$$PERF = \quad = \alpha_4 + \beta_{46}IND1 + \beta_{47}IND2 + \beta_{48}TECHUN + \beta_{49}MKTUN + \beta_{50}DISCRENV + \beta_{51}PRO + \beta_{52}ANA + \beta_{53}DEF + \beta_{54}MKB + \beta_{55}MKD + \beta_{56}TKB + \beta_{57}TKD + \beta_{58}TKD^2 + \beta_{59}MKB*TKB + \beta_{60}MKB*TKD + \beta_{61}MKD*TKB + \beta_{62}MKD*TKD + \beta_{63}MKB*TKD^2 + \beta_{64}MKD*TKD^2 + \varepsilon_4$$

INSERT TABLE 3 HERE

Results in Table 3 (post-hoc model 2) show significant interactions between the squared term of technological knowledge depth and the breadth ($\beta = -.41$, $p<.01$) and depth ($\beta = .47$, $p<.01$) of market knowledge. Such findings are consistent with H_5 but depict a more complex picture of how market knowledge dimensions interact with market knowledge depth. Figure 4 reports the plots of the interactions between the squared term of technology knowledge depth and the two dimensions of market knowledge. Specifically, the positive effect of market knowledge breadth on performance is stronger when the level of technological knowledge depth is low or intermediate rather than high (panel 4a); and the effect of market knowledge depth on performance is positive for high and low levels of technology knowledge depth but not significant for intermediate levels (panel 4b).

INSERT FIGURE 4 HERE

DISCUSSION

The purpose of this article was to investigate antecedents and consequences of market knowledge dimensions. As for the antecedents, we found that search types have more complex relations with market knowledge dimensions than prior research would suggest. Proximal search has a direct, positive effect on market knowledge depth, but also a direct, positive effect on market knowledge breadth. Moreover, distal search has a direct, positive effect on market knowledge breadth, and a marginal positive effect on market knowledge depth under low cross-functional collaboration. These results suggest that the transformation of market information into deep and broad knowledge of customers and competitors can occur through different routes. Adopting a specific search process does not imply an either-or situation in terms of market knowledge outcomes. On the contrary, searching for information in the neighborhood of own market domain or searching distantly from it, would lead a firm to deepen and broaden its market knowledge, depending on the specific ways this information is interpreted and used.

Our results indicate also that cross-functional collaboration plays a critical role in the process of transforming market information into market knowledge. The results suggest that cross-functional collaboration helps deepening existing market knowledge when market-based learning stems from proximal search. In a collaborative organizational environment managerial mental models converge toward homogeneous interpretations of market information and allow the firm to obtain a more detailed knowledge of its customers and competitors. However, our findings show that cross-functional collaboration negatively moderates the relation between proximal search and market knowledge depth and distal search and market knowledge breadth. These results suggest that, on the one hand, a very collaborative environment reduces the possibility to learn vicariously from competitors, to recombine existing knowledge elements in novel ways, to adopt unorthodox interpretation of familiar information, in order to transform familiar information in broader market knowledge. On the other hand, cross-functional collaboration reduces also the chance to develop more detailed knowledge structures of the market and to learn through cross-industry benchmarking and brokering, so to use information collected through a distal search to generate a deeper knowledge of existing markets. A possible explanation for these findings may be gleaned by recent literature on cross-functional relationships contending that, in an effective team, collaboration should be complemented by internal competition that fosters open discussion among members, divergent interpretations of information, and the challenging of long-held representations of the market (Luo, Slotegraaf and Pan 2006; Sethi, Smith and Park 2001).

As for the consequences of market knowledge, we found that both depth and breadth have a direct, positive effect on organizational performance. These results confirm a major tenet of market-based learning theory, that is, continuous learning about actual and potential customers and competitors improves organizational performance (Day 1994a; Sinkula 1994; Slater and Narver 1995). However, we unearthed differential effects of market knowledge dimensions on organizational performance corresponding to different combinations among the firm's market and technological knowledge dimensions. When market knowledge is broad, its positive effect on organizational performance is stronger in case of a corresponding broad technological knowledge - that is, a *Z-shaped* combination - whereas the effect is attenuated by a very deep technological knowledge – that is, a T^m*-shaped* combination. When market knowledge is deep, its positive effect on organizational performance is stronger in case of very limited or very high technological knowledge depth – that is, an *H-shaped* combination. On the contrary, the positive effect is reduced by a high technological knowledge breadth – a T^t*-shaped* combination.

Taking the picture as a whole, our findings suggest a positive *mirroring effect* of knowledge dimensions on performance. That is, when broad market knowledge is mirrored by an equivalent technological knowledge in an *Z-shaped* combination, or, when deep market knowledge is mirrored by deep technological knowledge in an *H-shaped* combination, positive effects of market knowledge on performance are strengthened. When this mirroring effect is not in place – with the T^m*-shaped* and T^t*-shaped* combinations – the positive effects on performance are attenuated. In fact, in a T^m*-shaped* situation a firm has a broad knowledge of customer needs and preferences, and of competitors' strategies to meet them; however, there is a limited return on the good feedbacks coming from the market because the technological knowledge is strongly focused on some technical areas. Along with this, in a T^t*-shaped* situation a firm has the potential to satisfy needs of several market segments because of its broad technological knowledge, but it actually has limited chance to obtain a large return because its deep market knowledge is focused on a limited part of the potential customer base. Recent research by Danneels (2007) demonstrates this pathology with a case study in which a firm having significant technology prowess was unable to leverage this because its focus on current customer space limited the development a broadened view of the market or what he calls 'marketing competence'.

The only interaction that deviates from this picture is the one between market knowledge depth when market knowledge is very deep and technological knowledge is not deep at all. Also in this case the effect on organizational performance is positive. Hence, our findings suggest a sort of *substitution effect*, whereby a firm with a very deep knowledge of actual customers and competitors can make the most of this knowledge also in case the technological within-field knowledge it possesses lacks depth. These results are in sharp contrast with prior research that examines the interaction between market and technological knowledge in an omnibus fashion without attention to the different dimensions of each knowledge type.

Theoretical contributions

Our study contributes to the marketing literature in four main respects. First, we contribute to literature on market knowledge dimensions, by investigating their antecedents and consequences. Prior research on the topic highlighted how breadth and depth of market knowledge are the most salient dimensions in affecting important organizational outcomes such as new product development performance (De Luca and Atuahene-Gima 2007). We improve knowledge in this field by advancing that information search types have different effects on specific dimensions: searching in the neighborhood of existing knowledge domain or distantly from it may yield differential impacts on market knowledge depth and breadth.

Second, we contribute to market-based learning theory substantially. Prior research on organizational learning (Huber 1991; Levitt and March 1998; March 1991; Walsh 1995) and market-based learning (Day 1994b; Sinkula 1994; Slater and Narver 1995) highlighted that information acquisition is the first step of organizational learning. Moreover, this literature underlined that searching locally leads to deeper knowledge and searching distantly leads to broader knowledge. We enrich this theory by indicating two novel routes whereby information can be transformed into market knowledge, so to detail two routes to market knowledge depth and two routes to market knowledge breadth (Figure 5). A firm may *refine* the knowledge of its current market domain by searching for information from actual customers and competitors and by adopting familiar interpretation models. Moreover, a firm may *integrate* its current market knowledge and learn new ways to serve its market segments by searching for information across market segments and industry boundaries, benchmarking firms not competing in its market and by building more abstract knowledge structures of its served market. Further, a firm may *extend* its knowledge to new customers and competitors by searching in the same domain, and learning vicariously from competitors that adopt unconventional market strategies or recombining information in novel ways, or adopting unorthodox interpretations of that information. Finally, a firm may achieve a *really new* market knowledge that changes the boundaries of its competitive arena and redefines its dominant logic (Prahalad and Bettis 1996), by searching for information outside its current market boundaries and develop a broad knowledge of new market segments and competitors.

INSERT FIGURE 5 HERE

Third, this study contributes to literature on cross-functional collaboration, by showing that it can affect the transformation of market information in market knowledge in different ways. In keeping with recent literature on the topic (Luo, Slotegraaf and Pan 2006; Sethi, Smith and Park 2001), our findings confirm that cross-functional collaboration fosters the convergence of different functional groups toward homogenous interpretations of information and representations of the market. Homogeneity has a positive effect when the firm aims at refining its existing knowledge, but it attenuates the positive effect of information search when novel information is intended to lead to broad market knowledge and when novel interpretations of familiar information is needed to deepen existing market knowledge. In these cases, challenging long-held assumptions about customers and competitors and bringing different perspectives in the discussion are beneficial, so that a less collaborative organizational environment may be more encouraging. In this respect, our results point to a potential *dark-side of cross-functional collaboration*, in that collaboration appears to thwart the less straightforward patterns of conversion of information search into market knowledge dimensions, and in particular to prevent the conversion of information search into market knowledge breadth.

Finally, we contribute to the literature on market and technological knowledge complementarity. Prior research demonstrated that the interaction between marketing and technological capabilities can enhance organizational performance (Dutta, Narasivam and Rajiv, 1999; Griffin and Hauser 1996; Moorman and Slotegraaf 1999). We offer new insight to this stream of research by detailing how different knowledge dimensions can interplay effectively. Our findings suggest that simply combining market and technological knowledge is not enough if the aim of the firm is to improve its performance. We described four different combinations of knowledge dimensions (Figure 6) and suggested that a knowledge profile characterized by symmetry between knowledge dimensions may enhance organizational performance, whereas asymmetrical profiles are associated with lower performance. Hence, we advance that knowledge *specialization* (deep market and technological knowledge) and knowledge *diversification* (broad market and technological knowledge) may be more effective in improving organizational performance. On the contrary, market-knowledge *overexposure* (broad market knowledge and deep technological knowledge) and technology-knowledge *overstretching* (deep market knowledge and broad technological knowledge) may reduce performance.

INSERT FIGURE 6 HERE

Implications for management

This study has several implications also for managers who have to deal with issues related to market knowledge development and use. First, we offer insights to managers who intend to generate new market knowledge. If the goal is to deepen the knowledge of served markets, we recommend managers to use data collection tools to gather information on different industries and learn from best practices in those industries, and use that information to gain a more sophisticated representation of their own served market segments (e.g. Iacobucci and Nordhielm 2000). If, on the contrary, the goal is to broaden the market knowledge, a our findings would suggest to focus on actual competitors that adopt unconventional market strategies so to learn from their exploratory behaviors; another option would be to use managerial tools to challenge long-held interpretations of familiar information so to come up with new knowledge of different market segments (e.g. Berstell and Nitterhouse 1997).

Second, when generating new market knowledge, we recommend managers to take into account the different possible consequences of a high degree of collaboration among different units of their organization. In fact, our findings suggest that a highly collaborative environment may reduce the effectiveness of the information search strategy by raising barriers to unorthodox interpretations of that information and converging on same perspectives about customers' preferences and behaviors. Managers may find useful to stimulate a certain level of competition among organizational units in order to challenge homogenous representations of served markets and to use familiar information to get fresh insights on new market segments.

Third, marketing managers share a strong view that having deep and broad knowledge of the market is beneficial to designing a firm's offer apt to meet customer's needs and to building a strong competitive advantage. However, we recommend managers to carefully evaluate the characteristics of the firm knowledge profile. In fact, knowledge profiles characterized by highly diversified market and technological knowledge bases - *Z-shaped* - or a very specialized profile - *H-shaped* - may be superior to profiles where market knowledge is over-exposed - T^m*-shaped* - or technological knowledge is over-stretched - T^t*-shaped*. For example, when designing and implementing education programs, recruiting plans, consultancy projects, and other initiatives on knowledge management, a concerted view of market and technological knowledge dimensions can help marketing and top managers to direct their investments towards more rewarding options and avoid unbalanced, sub-optimal combinations between the two knowledge areas.

Limitations and Future Research Directions

This study inevitably brings a number of limitations that should be born in mind while interpreting its findings. First, we used cross-sectional data which make it difficult to infer causal links from observed empirical relationships, and are subject to common method variance. Despite this, there are a number of characteristics of our research which attenuate the two problems. Concerning causality, our theoretical model is consistent with the three principal markings of causality discussed by marketing scholars (Rindfleish et al. 2007). In fact, beyond the statistical covariation between independent and dependent variables, our hypotheses about the direct effects are consistent with the temporal ordering between causes and effects (antecedents conceptually comes before consequences), and are coherent with respect to widely-held theoretical expectations and the broader pattern of nomological relationships with other relevant variables. As for the common method variance problem, we took different steps in the research design to limit its impact on the set of relationships among the study variables, namely the use of multiple informants, averaged scores and different response framings. In addition, we conducted a post-hoc analysis by including the common method factor in the measurement and structural equation model, and found no significant difference in the results.

Second, the generalizability of the results is limited because we used data from a sample of firms in China. Third, our study focused on information search as a means for knowledge acquisition, by distinguishing between local and distal search effects on market knowledge dimensions. Although information search is a prominent knowledge acquisition process, organizational learning literature suggests several other processes, such as for example experiential learning (Huber 1991). A more explicit consideration of such knowledge acquisition subconstructs, along with information search, would lead to a more comprehensive understanding of how market knowledge dimensions are shaped by firms' knowledge acquisition strategies.

Although we controlled for several factors which account for variance in growth, market power and technological skills of firms (e.g., firm size, environmental conditions, and strategy types), we did not include some potentially influential covariates, such as industry maturity (Eisenhardt and Tabrizi 1995) company age (Sinkula 1994) and R&D strength (Li and Calantone 1998) considered in previous studies. This might limit the definitive evaluation of the relative importance of the antecedents of market knowledge dimensions and organizational performance in the current study and offers a chance for future researchers to take steps in this direction. Finally, two of our scales, distal search and discretionary environment showed and AVE below .45, suggesting the need for further scale development. In addition to alleviating these limitations, there are at least two promising avenues for further research.

First, future research can improve the understanding of market knowledge acquisition by exploring these issues at lower-order levels of analysis than the organizational one we adopted in the present study. For example, while our study shows that cross-functional collaboration is both an antecedent of organizational market knowledge characteristics and a moderator of their link with information search types, future research at the group-level of analysis (e.g., product development teams, or departmental subgroups) can shed new light on how information search processes and inter-individual social relationships affect the dimensions of the group's knowledge base. Groups have been identified as the principal vehicle of learning in organizations (Edmondson 2002); yet, as recently noted in by Wilson, Goodman and Cronin (2007) in their review, "there currently is no integrated view of group-level learning". If the marketing field is to move toward a better understanding of market knowledge acquisition processes, this direction then appear highly fruitful for future studies.

A second promising avenue for future research is to develop the complex picture of complementarity among market and technology knowledge dimensions we have developed in this study from a contingency approach based on interaction analysis into a configurational approach. In our study we have found evidence supporting the differential value of market knowledge breadth and depth under different levels of corresponding technology knowledge dimensions. However, due to analytical and interpretational complexity, we restricted our analysis to two-way interactions between market and technological knowledge dimensions. A configurational approach will allow to overcome this limitation and to analyze more complex and non-linear relationships among multiple knowledge characteristics and firms' performance. Moreover, by means of its holistic nature, a configurational approach would allow for equifinality in knowledge configurations, whereby two or more configurations of knowledge dimensions and other organizational characteristics (i.e., integration mechanisms, resource endowments, strategy), can be equally conducive to high levels of performance even when confronted by the same environmental contingencies. In this concern, cluster analysis involving multiple dimensions of market and technological knowledge, profile deviation analysis or set-theoretic approaches (Fiss 2007) can represent promising methodological development of the line of inquiry taken on in this study.

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Figure 1

Conceptual Model

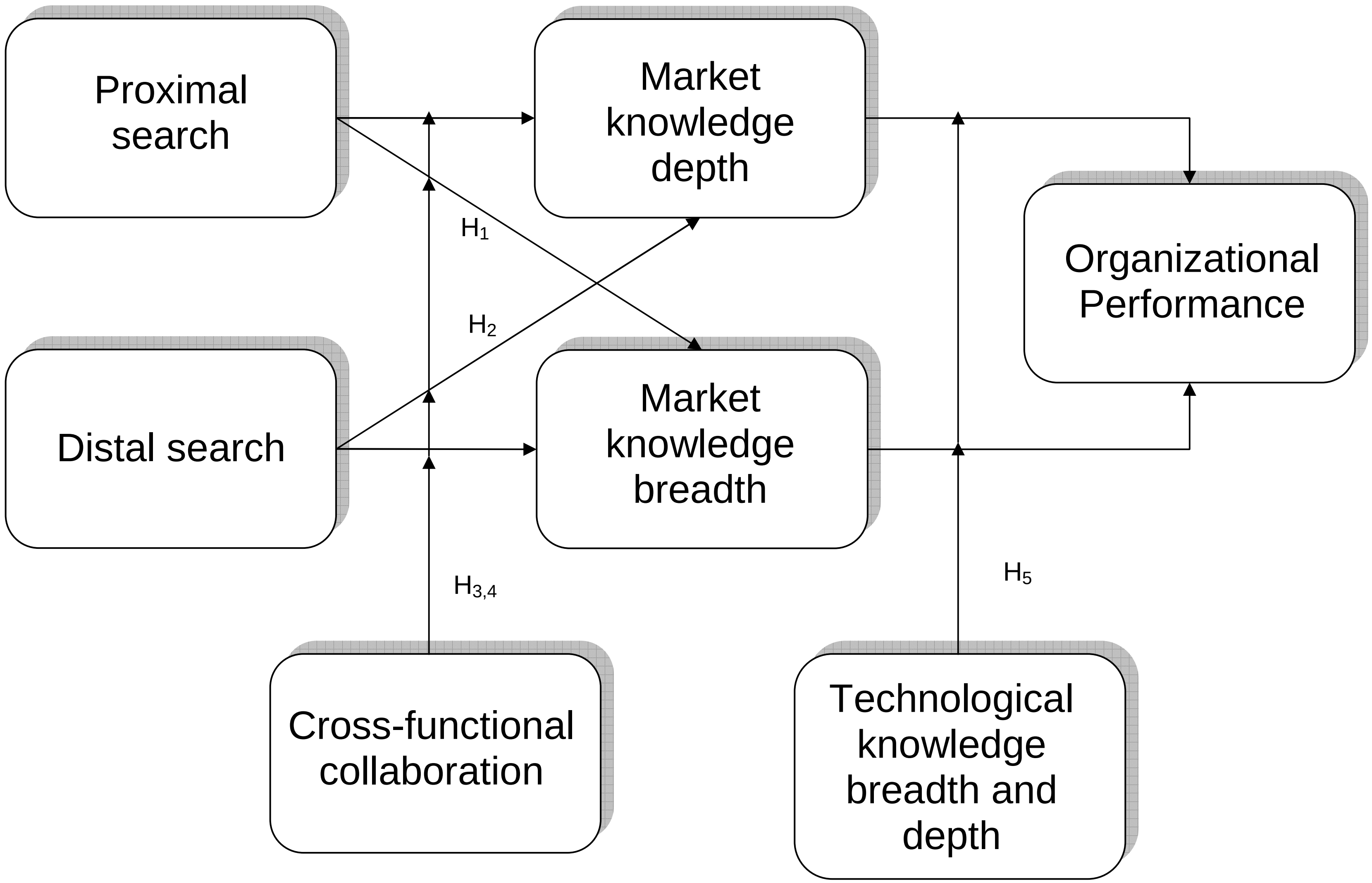
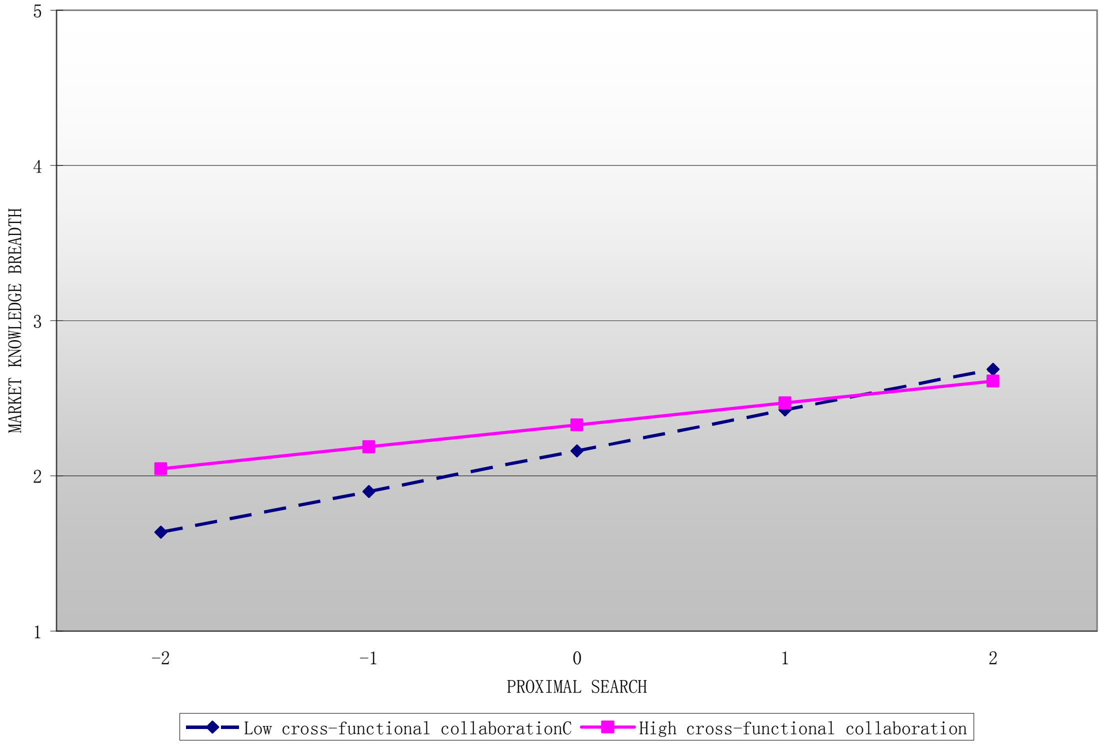
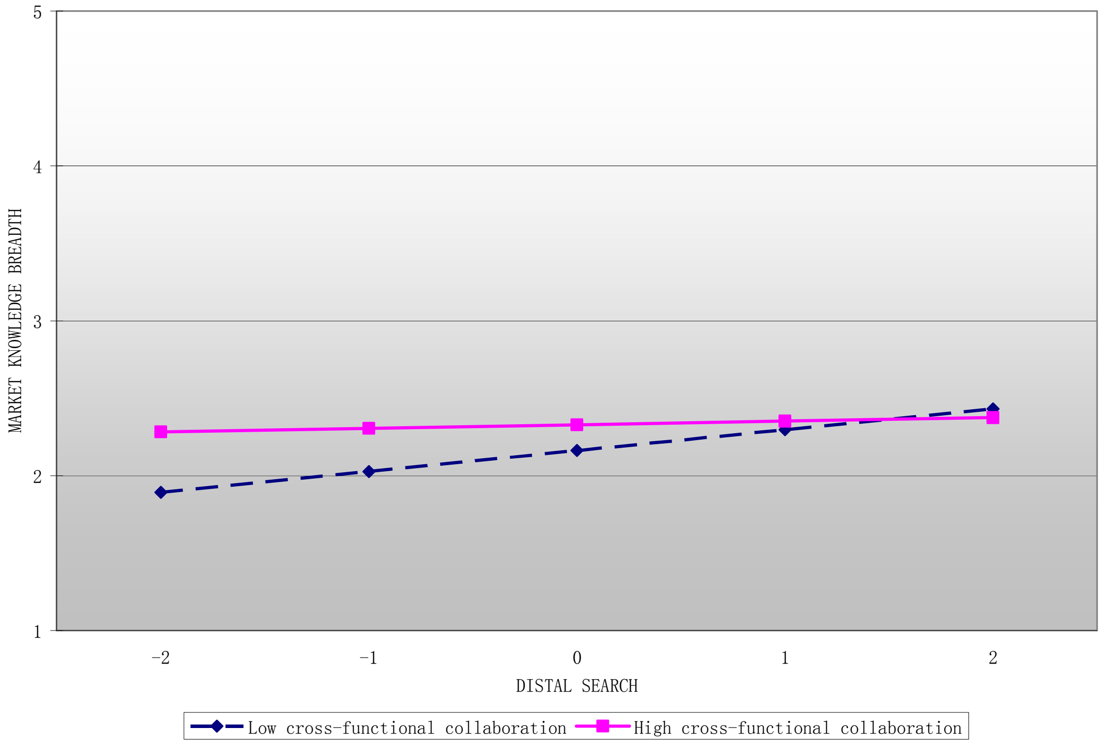


Figure 2
The moderating role of cross-functional collaboration
Panel 2a



Panel 2b



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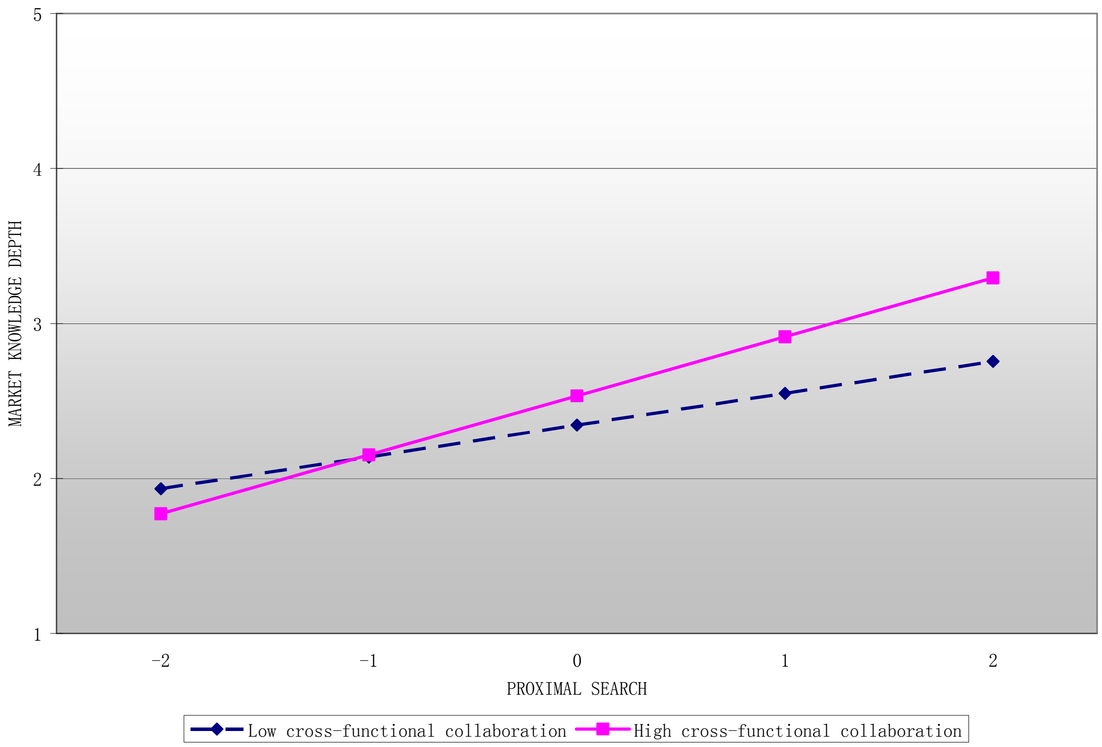


Panel 2d

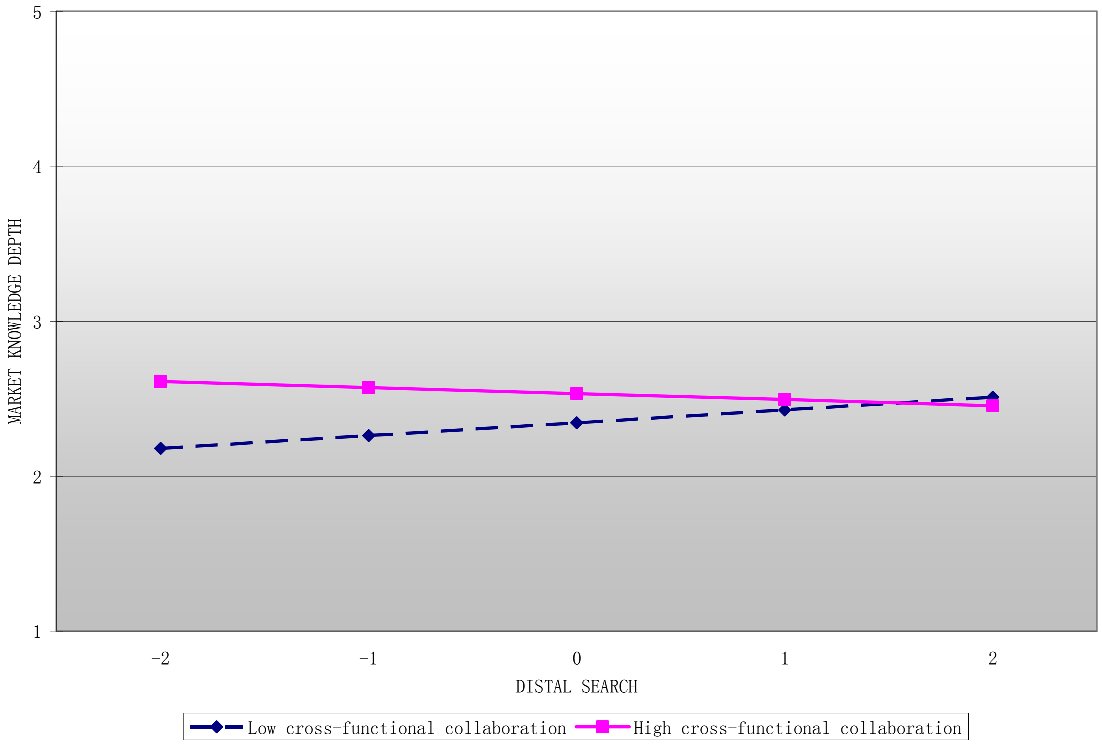
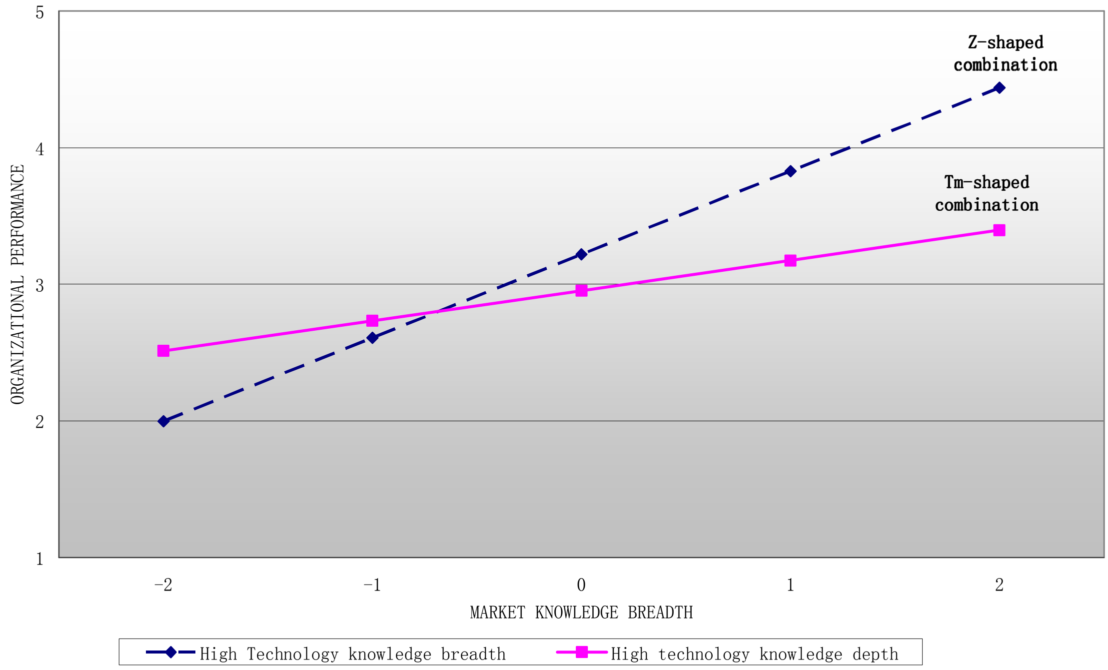


Figure 3

The moderating role of technological knowledge dimensions

Panel 3a



Panel 3b

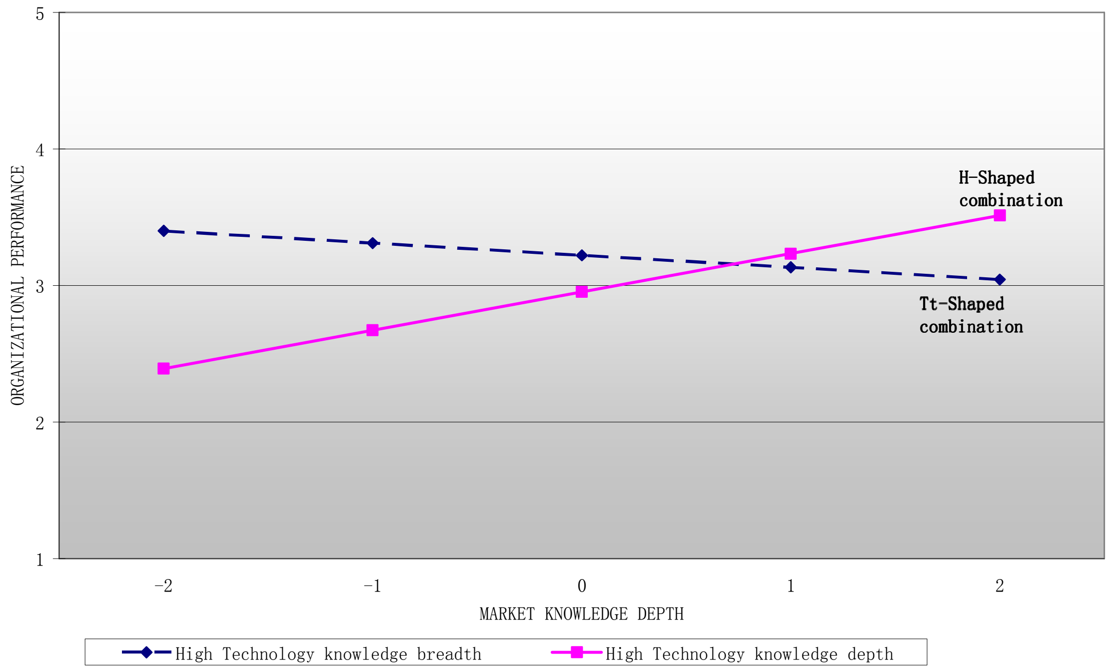
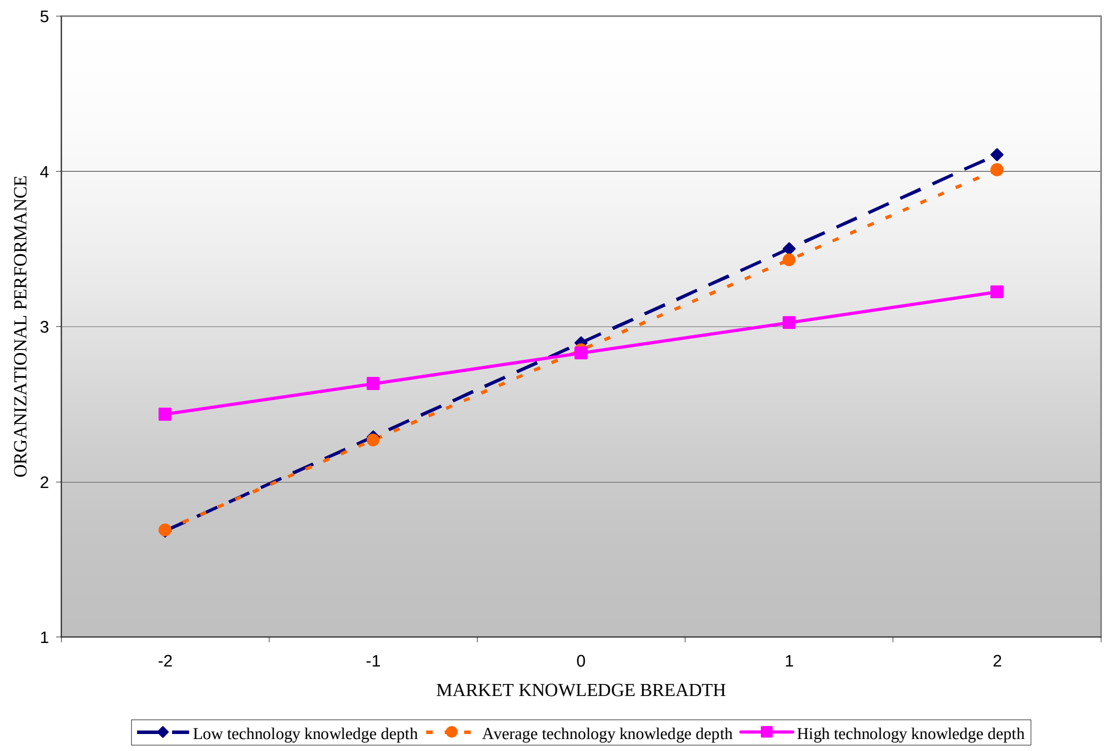


Figure 4
Post-hoc analysis interactions

Panel 4a



Panel 4b

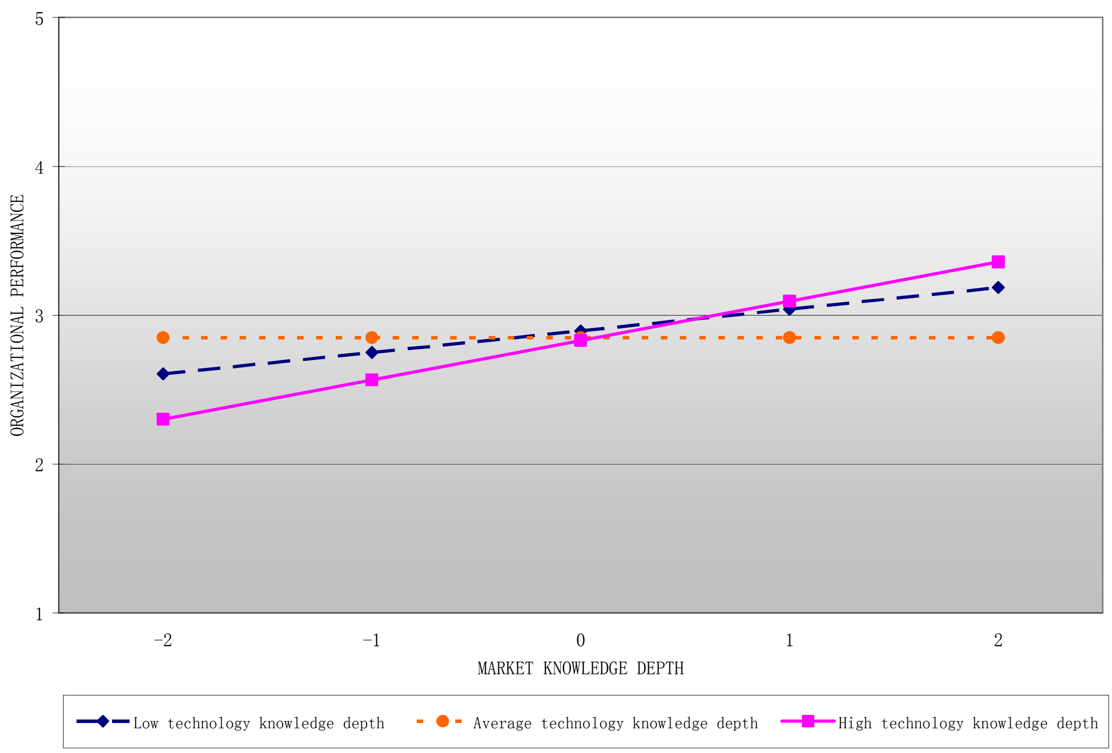


Figure 5

Different routes for market-based learning

Information search		Depth	Breadth
	Proximal	*Refinement of current marketing knowledge*	*Extension of current marketing knowledge*
	Distal	*Integration of current marketing knowledge*	*Creation of radically new marketing knowledge*

Market knowledge dimensions

Figure 6

Different knowledge profiles

Technological knowledge dimensions		Depth	Breadth
	Depth	*Knowledge specialization*	*Market knowledge over-exposure*
	Breadth	*Technological knowledge over-stretching*	*Knowledge diversification*

Market knowledge dimensions

Table 1.
Measures correlations and descriptive statistics

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Proximal Search	**.68**	.42	.55	.59	.59	.67	.55	.41	.13	.04	.54	N/A	N/A	N/A	N/A	N/A	N/A
2	Distal Search	.30	**.66**	.42	.34	.46	.48	.28	.24	.21	.37	.44	N/A	N/A	N/A	N/A	N/A	N/A
3	Market knowledge breadth	.43	.31	**.70**	.69	.53	.67	.45	.52	.22	.20	.62	N/A	N/A	N/A	N/A	N/A	N/A
4	Market knowledge depth	.48	.26	.55	**.72**	.51	.67	.52	.45	.18	.08	.63	N/A	N/A	N/A	N/A	N/A	N/A
5	Cross-functional collaboration	.48	.35	.43	.43	**.73**	.74	.42	.33	.14	.09	.56	N/A	N/A	N/A	N/A	N/A	N/A
6	Technological knowledge breadth	.50	.36	.51	.51	.58	**.69**	.65	.54	.26	.17	.64	N/A	N/A	N/A	N/A	N/A	N/A
7	Technological knowledge depth	.44	.24	.33	.43	.39	.49	**.68**	.30	.04	.03	.39	N/A	N/A	N/A	N/A	N/A	N/A
8	Organizational Performance	.35	.20	.46	.40	.31	.46	.25	**.85**	.23	.19	.43	N/A	N/A	N/A	N/A	N/A	N/A
9	Technological uncertainty	.10	.19	.17	.14	.11	.20	.02	.20	**.78**	.58	.32	N/A	N/A	N/A	N/A	N/A	N/A
10	Market uncertainty	.05	.32	.18	.08	.10	.15	.03	.17	.47	**.71**	.29	N/A	N/A	N/A	N/A	N/A	N/A
11	Discretional environment	.40	.34	.47	.50	.46	.48	.33	.36	.26	.26	**.66**	N/A	N/A	N/A	N/A	N/A	N/A
12	Firm's size	.07	-.04	.06	.12	-.01	-.02	.03	.16	-.02	.00	.07	N/A	N/A	N/A	N/A	N/A	N/A
13	Industry 1	.05	-.01	.09	.06	.01	.08	-.01	.12	.15	.10	.05	-.10	N/A	N/A	N/A	N/A	N/A
14	Industry 2	.00	.06	-.01	.03	.02	-.02	.09	-.11	-.06	-.10	.04	.08	-.57	N/A	N/A	N/A	N/A
15	Prospectors	.16	.16	.22	.17	.17	.18	.23	.08	-.03	-.04	.13	.09	-.04	.04	N/A	N/A	N/A
16	Analyzers	-.03	-.03	-.02	-.02	-.06	-.04	-.04	.08	.05	.08	.00	.03	.05	-.01	-.43	N/A	N/A
17	Defenders	-.09	-.15	-.12	-.15	-.04	-.08	-.15	-.06	.04	-.01	-.08	-.07	.02	-.05	-.56	-.37	N/A
	M	3.92	3.37	3.66	3.57	3.68	3.65	3.67	4.63	3.23	3.32	3.64	4.75	.59	.18	.39	.22	.33
	SD	.61	.67	.62	.60	.64	.65	.66	1.06	.81	.69	.61	1.5	.49	.39	.49	.42	.47
	# of items	4	4	4	4	5	3	3	6	3	3	4	N/A	N/A	N/A	N/A	N/A	N/A
	AVE	.46	.43	.49	.52	.54	.48	.47	.74	.61	.51	.43	N/A	N/A	N/A	N/A	N/A	N/A
	CR	.77	.75	.79	.81	.85	.73	.72	.93	.82	.75	.75	N/A	N/A	N/A	N/A	N/A	N/A

Notes: (i) AVE = average variance extracted; (ii) CR = composite reliability; (iii) diagonal elements = square root of AVE; (iv) above-diagonal elements = correlation among latent constructs (PHIs); (v) below-diagonal elements = correlation among average scales scores; (vi) N/A = not applicable.

Table 2.
Results of regression analysis: Antecedents of market knowledge dimensions

	Market Knowledge Breadth			Market Knowledge Depth		
Control variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Firm's size	-.00 (.02)	.00 (.02)	.00 (.02)	.03 (.02)*	.03 (.02)	.03 (.02)
Industry dummy 1	.07 (.07)	.07 (.07)	.07 (.07)	.11 (.07)	.10 (.06)	.08 (.06)
Industry dummy 2	-.01 (.09)	-.01 (.09)	.01 (.08)	.09 (.09)	.09 (.08)	.09 (.08)
Technology uncertainty	.03 (.04)	.03 (.04)	.02 (.04)	.02 (.04)	.02 (.04)	.01 (.04)
Market uncertainty	.05 (.05)	.04 (.05)	.03 (.05)	-.05 (.04)	-.04 (.04)	-.02 (.04)
Discretionary environment	.43 (.05)***	.26 (.05)***	.27 (.05)***	.50 (.05)***	.32 (.05)***	.31 (.05)***
Prospectors	.44 (.13)***	.35 (.13)***	.34 (.12)***	-.02 (.12)	-.13 (.11)	-.13 (.11)
Analyzers	.26 (.14)*	.23 (.13)*	.21 (.13)	-.13 (.13)	-.19 (.12)	-.18 (.12)
Defenders	.26 (.13)**	.29 (.13)*	.21 (.13)*	-.18 (.12)	-.23 (.12)**	-.22 (.11)*
Direct effects						
Proximal search		.21 (.05)***	.20 (.05)***		.28 (.05)***	.29 (.05)***
Distal search		.07 (.05)*	.08 (.05)**		.02 (.04)	.02 (.04)
Cross-functional collaboration		.14 (.05)**	.13 (.05)**		.16 (.05)***	.15 (.05)***
Moderating effects						
Proximal search × Cross-functional collaboration			-.10 (.07)*			.14 (.06)**
Distal search × Cross-functional collaboration			-.09 (.07)*			-.10 (.06)*
R^2	.28	.36	.37	.31	.43	.44
Adjusted R^2	.26	.34	.35	.29	.41	.42
ΔR^2		.08	.01		.12	.01
F-value	14.05***	15.52***	13.89***	16.45***	20.75***	18.37***
Incremental F		14.72***	3.02**		23.56***	2.76*
N	344	344	344	341	341	341

Notes: (i) * p<.10; ** p<.05; ***p<.01 (Two-tailed test for control variables; one-tailed test for directional hypothesis). (ii) We report unstandardized regression coefficients, with standard errors between brackets. (iii) Differences in sample size are due to outliers deletion.

Table 3
Results of regression analysis: Consequences of market knowledge dimensions

	Organizational Performance				
	Model 1	**Model 2**	**Model 3**	**Post-hoc 1**	**Post-hoc 2**
Control variables					
Firm's size	.10 (.03)***	.11 (.03)***	.11 (.03)***	.10 (.03)***	.12 (.03)***
Industry dummy 1	.14 (.13)	.07 (.11)	.08 (.11)	.06 (.11)	.08 (.11)
Industry dummy 2	-.22 (.16)	-.22 (.14)	-.23 (.14)*	-.24 (.14)	-.18 (.14)
Technology uncertainty	.13 (.07)*	.08 (.07)	.07 (.07)	.08 (.07)	.06 (.06)
Market uncertainty	.05 (.08)	.05 (.08)	.00 (.08)	.04 (.08)	.00 (.07)
Discretionary environment	.52 (.09)***	.07 (.09)	.12 (.09)	.09 (.09)	.16 (.09)*
Prospectors	.66 (.23)***	.43 (.21)**	.45 (.21)**	.44 (.21)**	.46 (.21)**
Analyzers	.81 (.24)***	.72 (.22)***	.79 (.22)***	.70 (.22)***	.78 (.22)***
Defenders	.58 (.23)**	.51 (.21)**	.55 (.21)***	.49 (.21)**	.53 (.21)**
Main effects					
Market knowledge breadth		.35 (.09)***	.35 (.09)***	.36 (.10)***	.58 (.12)***
Market knowledge depth		.21 (.10)**	.27 (.10)***	.21 (.10)**	.00 (.12)
Technological knowledge breadth		.45 (.09)***	.40 (.09)***	.46 (.09)***	.39 (.09)***
Technological knowledge depth		-.02 (.08)	.00 (.08)	-.06 (.08)	-.05 (.09)
Moderating effects					
Market knowledge breadth × Technological knowledge breadth			.40 (.15)***		.44 (.15)***
Market knowledge breadth × Technological knowledge depth			-.20 (.15)*		-.31 (.15)**
Market knowledge depth × technological knowledge breadth			-.55 (.17)***		-.60 (.17)***
Market knowledge depth × Technological knowledge depth			.02 (.14)		.09 (.15)
Post-hoc tests					
Technological knowledge depth^2				-.13 (.08)**	.03 (.09)
Market knowledge breadth × Technological knowledge depth^2					-.41 (.14)***
Market knowledge depth × Technological knowledge depth^2					.47 (.13)***
R^2	.22	.38	.41	.39	.44
Adjusted R^2	.20	.36	.38	.36	.40
ΔR^2		.16	.03		.05
F-value	10.54***	15.61***	13.34***	14.79***	12.61***
Incremental F		21.23***	4.09***		4.99***
N	344	344	344	344	344

Notes: (i) * p<.10; ** p<.05; ***p<.01 (Two-tailed test for control variables; one-tailed test for directional hypothesis). (ii) We report unstandardized regression coefficients, with standard errors between brackets. (iii) Differences in sample size are due to outliers deletion.

Appendix 1
Constructs and Measures

Construct and source	Item description	λ_x
Proximal search (Atuahene-Gima 2005)	In searching for market information and knowledge: • We tend to look for and integrate knowledge that builds on our current skills. • We search and use proven ideas that help to refine and improve on our current operations. • We are most concerned with learning that improves efficiency on our current activities. • We put emphasis on utilizing knowledge that tap into our experience and skills. • We search for ideas that are consistent with our current product/market experience.*	.63 .63 .70 .74
Distal search (Atuahene-Gima 2005)	In searching for market information and knowledge: • We search for ideas that can take the firm beyond its current product/market domain. • We search for information in new market domains far distant from our current operational domain. • We tend to search and integrate novel and varied information into our activity. • We tend to search and use information which helps us experiment in our strategic activities. • We search and use ideas that have no identifiable strategic direction.*	.64 .61 .80 .55
Market knowledge breadth (Zahra, Ireland and Hitt 2000)	*Compared to major competitors, our firm's knowledge of competitors' strategies is:* • narrow vs. broad • limited vs. wide-ranging *Compared to major competitors, our firm's knowledge of customers is:* • narrow vs. broad • limited vs. wide-ranging	.68 .67 .73 .72
Market knowledge depth (Zahra, Ireland and Hitt 2000)	*Compared to major competitors, our firm's knowledge of competitors' strategies is:* • shallow vs. deep • basic vs. advanced *Compared to major competitors, our firm's knowledge of customers is:* • shallow vs. deep • basic vs. advanced	.76 .71 .71 .72
Cross-functional collaboration (Li and Calantone 1998)	*In this organization, different departments:* • Cooperate fully in generating and screening new ideas for new products. • Fully cooperate in establishing goals and priority for our strategies. • Fully deploy all functional knowledge in our strategic activities. • Are adequately represented on project teams and other strategic activities. • Regularly communicate about the new product development projects.	.66 .74 .78 .73 .74

Construct and source	**Item description**	λ_x
Technological knowledge breadth	• We are often at the forefront in our industry in detecting various technology developments that potentially affect our business. • We actively seek broad intelligence on technology changes that affect our firm. • Our knowledge of technological changes is usually broad and thorough.	.68 .73 .66
Technological knowledge depth	• Relative to our major competitors we have very sophisticated knowledge about technological developments in our industry. • Our knowledge about technology developments in our industry is relatively more complex than our major competitors'. • Using the information we have about our technology requires the coordination of several people with specialized knowledge and skills.	.79 .72 .51
Organizational performance (Li and Atuahene-Gima 2001)	• Relative to your principle competitors, rate your firms' performance over the last three years on: • Return on sales • Profit growth • Return on assets • Sales growth • Market share growth • Cash flow from market operations • Overall firm reputation for performance.*	.84 .89 .88 .89 .81 .80
Technological uncertainty (Jaworski and Kohli 1993)	• It was very difficult to forecast technology developments in our industry. • Technology environment was highly uncertain. • Technological developments were highly unpredictable. • Technologically, our industry is a very complex environment.*	.67 .85 .82
Market uncertainty (Jaworski and Kohli 1993)	• Customer needs and product preferences changed quite rapidly. • Customer product demands and preferences were highly uncertain. • It was difficult to predict changes in customer needs and preferences.	.59 .80 .75
Discretionary environment (based on Goll and Rasheed 1997)	• New customer segments emerged frequently in our industry. • The market has grown quite rapidly. • We witnessed demand for our products from entirely new customers. • There have been major favorable technological developments in our industry. • Technological changes have provided big opportunities in our industry.*	.62 .62 .72 .67

Note: Factor loadings are completely standardized.
* Item dropped during measures' purification phase.