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

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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

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 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 ($\alpha = .85$) 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, $\alpha = .90$), 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

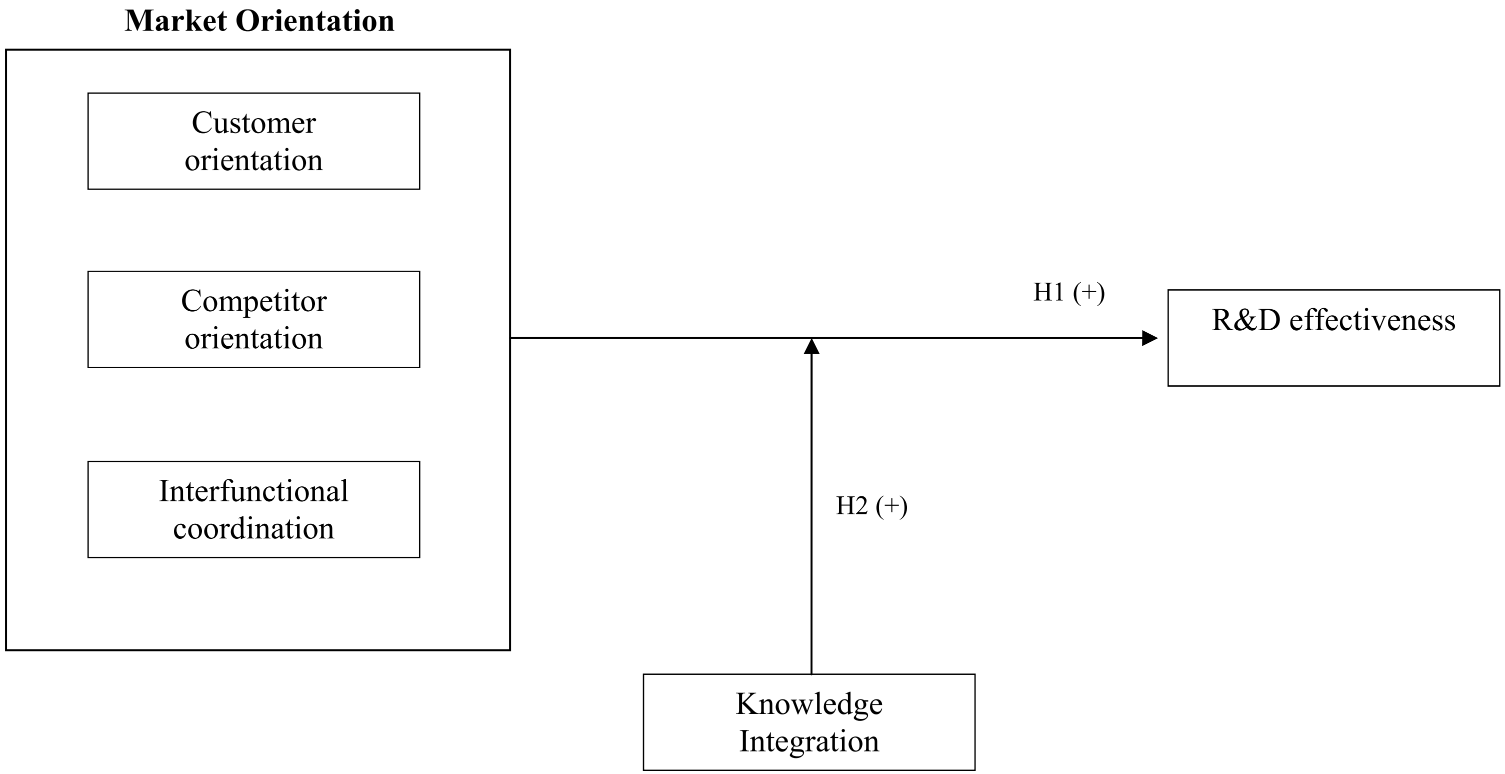

Table 1
Key Facts and Findings from In-depth Qualitative Analysis

	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.

	Empirical Setting		Innovation outcomes	
Author	**Category**	**Description**	**Category**	**Dependent Variable Domain**
Subramanian and Gopalakrishna (2001)	Mixed	Fast moving consumer goods, media and others.	NPMP	Managers' satisfaction with new product/service success.
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