Journal of Applied Sciences

ISSN 1812-5654

science alert

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Journal of Applied Sciences 13 (17): 3459-3464, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.3459.3464

Technological Competency-environment Fit and New Product Development Performance: An Empirical Study of Small and Medium–size Enterprises

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Abstract: Adaptation to fierce competition and dynamic environment through innovation is of major concern for all firms. Although studies have emphasized the importance of fit between technology competency and environmental factors on new product development, the empirical examination of this field has been some what scarce. Based on a survey of cross-industry sample of 336 manufacturing SMEs in China, the study adopts multiple regression analysis to find that technology competency and external environment interactively impact NPD performance. Theoretically, it empirically examines how a firm' organizational resources/capabilities and environmental contexts jointly create NPD performance. Specifically, the efficiency of internal technology competency would be deteriorated in dynamic environment and strengthened in highly competitive intensity. It is recommended that SMEs should rely more external partners or modes to acquire knowledge in technological turbulent environment. However while the market becomes more fierce, building the technological competency internally would be a feasible solution to maintain the competitive advantages.

Key words: Technological competency, environmental turbulence, competitive intensity, new product development

INTRODUCTION

Resource-based view argues that successful new products emerge from a combination of the firm's existing capabilities, skills and resources (Prahalad and Hamel, 1990). Prior research has identified technology competency as a means to deal with the uncertainty of the external environment which is very important to new product development (Song and Parry, 1997). Weiss and Heide (1993) also point out that innovation represents the most effective means to deal with the turbulence in external environments. On the other hand, various external environment a firm faced would neutralize or dissipate the comparative advantage of a resource (Reed and DeFillippi, 1990). As a result, a capability that was once an asset may become a liability if it is not appropriate for the product development project (Reed and DeFillippi, 1990). Based on the discussion above, it is claimed that an appropriate fit between the environmental factors and technology competency can lead to a better new product development performance. However, such interaction effect between external environment and technology competency on new product development has received scant empirical study, except (Droge *et al*., 2008).

To fill this gap in the literature, this study examines whether the fit between technology competency and environmental characteristics exist. In other words, how does the interaction effect of firm's external environments and technological competency impact NPD performance? And does such interaction mechanism vary under different environmental characteristics? The environment in which a firms competes in is not under managerial control. However, understanding how the interaction of environment and technological competency could allow managers to adapt to varying environmental conditions. It helps to improve the odds of new product success. In so doing, the paper puts a special focus on small and medium-sized manufacturing firms in China.

THEORY AND HYPOTHESES

Moderating role of environmental turbulence: The development of technological competence, including previous knowledge and resource bases of the firm, is an accumulative process which has path dependence (Teece *et al*., 1997; Ethiraj *et al*., 2005; Zollo and Winter, 2002). However, rapid, discontinuous changes in customer needs and technological ''know how'', may obsolete a firm's technology and market knowledge accumulated from past NPD process (Li *et al*., 2010), or even will prevent enterprise from their attempts for further development. Song and Montoya-Weiss (2001) also suggested that dynamic environment leads to disrupt the synergies between the organization's accumulated experiences with existing competences and the problem solving for the new product. These incumbents are

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reluctant to adopt the new technology because it is competence-destroying which will wipe out their considerable investments and organizational routines (Tushman and Anderson, 1986). And organizational inertia seems to retard the development of innovations that destroy existing competencies (Gatignon *et al*., 2002). In addition, developing products in a highly turbulent environment may be challenging because the market or technology may shift rapidly and unpredictably during the development time window (Buganza *et al*., 2004) which demands continuous and expensive project adaptation. In such an environment, it is difficult to obtain accurate and timely information on customer preferences, the actions of competitors and technological discontinuities.

Finally, divergence in customer preferences and technologies requires a higher level of product customization which higher level of technical resources required for the NPD project (Wong, 2002). In volatile markets, success of NPD relies more on creating new knowledge than on the ability to reconfigure and harness existing knowledge (Herrmann *et al*., 2007). Therefore, the sufficiency of available technical resources is more likely to be adversely affected (Wong, 2002). Additionally, firms have to develop products fast enough to keep pace with rapid technology enhancement and increase the rate of introduction of new, upgraded products (Chen *et al*., 2005). Such speedy product innovation will be significantly reduced odds of success, due to the skip of certain NPD process.

Hypothesis 1: The positive effect of technological competence on NPD performance will be weaker in higher turbulent environment.

Moderating role of competitive intensity: The other widely accepted characteristic is competitiveness within the market (Bowman and Gatignon, 1995). The number of competitors, industry concentration, entry barriers and competitive reactions from incumbents are essential factors that have proved to be germane to the success of a new product's launch strategy. Just following the arguments of Barney (2001) and Priem and Butler (2001), the value of technology competency would be determined by the intensity of competitive environment within which a firm competes.

When the competition intensifies, firms are likely to focus more on resource conservation and on the pursuit of economic advantages and profits (Dobni and Luffman, 2003). As tangible business profits and market share are major corporate targets to survive, the relative importance of current customer needs, competitive pricing and costs are emphasized (Dobni and Luffman, 2003; Srivastava *et al*., 2001).

However, as market competition is becoming harsher, firms have to be more aggressive in discovering customer wants and offering more customer value to satisfy their wants. The literature suggests that firms need to engage in a greater level of innovative activities, such as innovate in both products and processes, exploration and find novel ways to compete and strategic renewal as environmental hostility intensifies (Zahra, 1993; Zahra and Covin, 1995). Under this circumstance, firms can no more depend on their existing systems, instead they have to adapt by engaging in risk-taking and proactive activities to break out of price and promotion wars (Auh and Menguc, 2005).

In short term, although firms have to counter its competitors with promotions, price-cutting and copycat products, returns delivered would be undercut by further competitive behavior (Auh and Menguc, 2005). Many firms have responded to these growing pressures by relying more on their technology resources and competency to pursue new product development activities.

Hypothesis 2: The positive effect of technological competence on NPD performance will be stronger for firms in high competitive intensity than for firms in low competitive intensity.

METHODS

Sample and data collection: Questionnaire survey research method was adopted to collect data from the small and medium sized manufacturing firms in Zhejiang province. A total of 500 firms were approached and 374 questionnaires were returned (response rate: 74.8%). Thirty-eight questionnaires were eliminated due to substantial missing data on key construct items, resulting in 336 valid questionnaires left for analysis.

The sample firms are in a wide dispersion of industries. They are: Textile (13.1%), Common machines manufacturing (11.6%), chemical industry (14.24%), metal products and non-metal mineral products (12.21%), Metal products (10.1%), Traffic equipment manufacturing (8.9%), Special equipment manufacturing (8.3%) and electric equipment and parts manufacturing (7.7%) which are the six highest responding sectors. In addition, the sample was composed of companies with annual sales ranging from RMB 1.46 million to RMB 5.87 billion. The number of employees ranged from 14 to 8000, with an average of 411.

Construct measures: Perceptual measures are widely adopted in organizational research as a substitute. Seven point Likert-scales were adopted to estimate the survey variables which respondents were asked to rate the degree to which they agreed with the following statements (ranging from 1 = 'strongly disagree' to 7 = 'strongly agree'). The paper generated multi-item scales based on previous related research and field interviews with senior managers.

Technological competence was measured using a set of scale items draw from several sources of previous literature (Guan and Ma, 2003; Jeong *et al*., 2006). Based on extensive interviews with academic scholars and executives, the measure for technological competence reflects the extent to which the firms build and leverage sophisticated technologies, abundance of R and D personnel and rapidity of integration of external new technologies.

Questions of environmental turbulence were mainly adapted from Jaworski and Kohli (1993) and Moorman and Miner (1997). Two questions were asked regarding market turbulence and two regarding technology turbulence. Technology turbulence refers to the change associated with new product technologies and market turbulence reflected the speed of change in customer demand and their preferences in the industry (Tsai and Huang, 2008). Competitive intensity was measured in terms of three indicators adapted from the work of Jaworski and Kohli (1993), reflecting the nature of interfirm rivalry within the firm's target market.

For new product development performance, measures were adopted from the work of prior studies (Kim and Atuahene-Gima, 2010) which reflect the efficiency and profitability of new product development, including the length of development cycles, sales of new products, profitability, market share and success rate of new products. For each of multi-item constructs, The study averaged the items to create the scores for the constructs.

Four sets of controls have been taken into account. Firstly, firm size is controlled because of its potential impact on new product introductions and access to external sources. Previous research suggests that the larger the firm, the greater NPD performance (Huq and Toyama, 2006). Thus, The study measure firm size as the logarithm of number of fulltime employees. Secondly, firm age is measured by the number of years elapsed after founding until the year 2008. According to Deeds and Hill (1996) argument, established companies were engaged in more frequent new product introductions. Thirdly, industry effects are taken into account as a result of cross-industry approach.

Measurement properties: As single sources of information can bring spurious relationships among the variables and as this study collected data via the same method (self-report scales), it need to test for common method variance. Thus, The study conducted a Harman's one factor analysis using the principal component method with Varimax rotation. Four distinct factors were extracted with eigenvalues greater than 1 and the variance explained was 69.4%. As no single factor emerged, nor did one factor account for most of the variance (only 24.7%), a potential risk for common method bias was reduced.

It conducted a confirmatory factor analysis in LISREL 8.70 to assess the composite reliability, convergent and discriminant validity. The measurement model produced the following fit statistics: χ^2 = 384.33, df =129, p = 0.000, χ^2/df = 2.98, Goodness of Fit Index (GFI) = 0.89, Comparative Fit Index (CFI) = 0.97, Normed Fit Index (NFI)= 0.96, Incremental Fit Index (IFI)= 0.97 and Root Mean Square Error of Approximation (RMSEA) = 0.077. Taken collectively, these indices suggest an acceptance degree of model fit, even though the Chi-square index is significant. The composite reliability of each factor is from 0.78 to 0.94 (higher than 0.7), thus satisfying Nunnally (1978) criteria. The results show that all items loadings are significant on their corresponding latent construct. Convergent validity is achieved.

To assess discriminant validity between the constructs, The study compare the square root of the AVE (bold figures on the diagonal in Table 1) with correlations among the constructs indicates that each construct is more closely related to its own measures than to those of other constructs and discriminated validity is therefore supported.

Finally, in order to assess the criterion validity of the perceptual measures of NPD performance, we correlated it with less perceptual measures-the ratio of new product output value which was also included in the survey. The result shows that they are highly correlated (correlation = 0.33, $p<0.001$). Unfortunately, managers are often unwilling to provide actual performance numbers. Thus, missing data prevented us from using this less perceptual data in further analyses.

RESULTS

The means, standard deviations and correlations for all of the survey variables are provided in Table 1. To test the hypotheses, The study used hierarchical moderated regression analysis to assess the hypotheses.

Table 1: Correlation analysis of key variables

Variables	Mean	s.d.	1	2	3	4	5
No. of employee	426.090	626.040					
Firm age	12.950	8.260	0.200**				
Technological competence[a]	5.470	1.010	0.024	0.052	0.713		
Competitive intensity[a]	5.660	0.800	0.004	0.061	0.267**	0.712	
Environmental turbulence[a]	5.010	0.850	-0.016	-0.037	0.445**	0.412**	0.471
NPD performance[a]	5.439	1.046	0.042	0.085	0.724**	0.191**	0.404**

*p<0.05, **p<0.01 (two-tailed); N = 310, [a]The diagonal entries represent the average variance extracted by the construct

Table 2: Results of regression analysis

Variables	Model 1	Model 2	Model 3	Model 4	VIF
Constant	5.437	5.460	5.509	5.525	
Machinery	0.000	-0.051	-0.006	-0.045	5.775
Electronics	0.030	-0.050	0.008	-0.038	3.130
Textile	-0.094	-0.118	-0.105	-0.118	2.940
Chemicals/pharmaceuticals	-0.305	-0.323	-0.365	-0.369	1.936
Other industry	-0.049	-0.103	-0.059	-0.098	4.983
Firm agea	0.005	0.003	0.008	0.007	1.193
Ln_No. of employeea	0.079+	0.079+	0.064	0.071+	1.256
Technological competence[a]	0.692***	0.738***	0.655***	0.660***	1.435
Competitive intensity[a]	-0.060	0.006		-0.004	1.369
Environmental turbulence[a]	0.155**	0.000	0.183**	0.169**	1.617
Technological competencea×Competitive intensity[a]		0.107*		0.147**	1.259
Technological competencea×environmental turbulencea			-0.150**	-0.195***	1.315
R2	0.565	0.562	0.577	0.588	
R2 adjusted	0.551	0.547	0.563	0.572	
ΔR2		0.007*	0.013*	0.023***	
Sig. F Change		0.034	0.002	0.000	

+p<0.1, *p<0.05, **p<0.01, ***p<0.001 (two-tailed). [a]Variables mean centered. Unstandardized coeficients with standard errors in parentheses

Following Venkatraman (1989), it mean-centered the independent variables prior to the formation of interaction terms to minimize the effects of any multicollinearity among the variables comprising interaction terms. Variables in each regression model have a Variance Inflation Factor (VIF) well below the threshold of ten, indicating no significant multiconllinearity problems. Data were analyzed using SPSS14.0.

Table 2 presents results of the regression analysis. Model 1 tests the effects of the control variables on NPD performance. Firm size (measured by number of employees) has a significant positive relationship with the NPD performance. It entered the two-way interaction terms to test the hypotheses. Hypothesis 1 stipulates a negative effect on NPD performance of the interaction between environmental turbulence and technological competency. As shown in models 3 and 4, the interactive effect of environmental turbulence and technological competence on both performance measures is negative and statistically significant (model 4: $\beta = -0.195$, $p<0.001$). Thus, Hypothesis 1 received support. Next, Hypothesis 2 predicts a positive effect of the interaction of competitive intensity and technological competency on NPD performance. The results in models 2 and 4 show that the interaction between competitive intensity and technological competence indeed has a statistically significant and positive effect on NPD performance (model 4: $\beta = 0.147$, $p<0.01$). Thus, Hypothesis 2 was supported.

DISCUSSION AND CONCLUSION

New products are important weapons for firms in today's competitive marketplace. This and previous studies demonstrated the role of internal R and D on overall new product development performance by essential configuration of technological resource and competency. However, doing business in a rapidly changing and hostile environment complicates the strategic decisions of firms. In other words, whether and when to exploit their technological resource to launch a new product can be challenging in such environment. To deepen understanding of this fit mechanism, this study examines the interaction effects of technology competency and external environment on NPD performance in the context of manufacturing SMEs in China.

Theoretical implications: This study has several theoretical implications. First, this study theoretically and empirically examines the effect of fit between technology competency and environmental factors on NPD performance, thereby filling a research gap about how a firm' organizational resources/capabilities and environmental contexts jointly create NPD performance.

Second, Exploiting technology competency internally in turbulent environment would weaken firm's NPD performance. Prior studies show that perceived environmental uncertainty can accelerate product

development. However, the study shows the efficiency of internal technology competency would deteriorate in dynamic environment. Firms facing highly uncertain markets have a hard time figuring out what the market is, who the competitors are and what the end customer regards as added value in the product. This finding supported the argument of Vandenbosch and Clift (2002) that turbulent environments during the NPD project require development processes that are flexible and able to respond to new knowledge as the project evolves. In such circumstances, firms, especially for the SMEs, should emphasize external alliance or other sourcing modes for accessing the new and heterogeneous knowledge during the NPD process.

Finally, it finds that the employ of internal technology competency in competitive market would enhance firm's NPD performance. The study extend Cooper and Kleinschmidt (1994) allegation of competitive intensity being a two-edged sword, by combining Priem and Butler (2001) thoughts that "value of a firm's resources must be understood in the specific market context within which a firm is operating". While competitive pressures increasing but not too intensive, firms are still able to depend on their marketing activities and managerial adaptation by engaging in price wars (Ramaswamy *et al*., 1994), reducing cost. To some extent, the value of firm's technology resource/competency is not much emphasized due to the existence of other alternatives. As the market competition intensifies, it heightens the need of innovation to differentiate and make more profit margins. As indicated by PearceII (2002), when a company is facing intense competitive pressures, bringing products to market faster is often one of the few options a firm can choose to differentiate its offering.

However, this study has its limitations. The sample was limited to a single respondent and geographically to one region. The design also limits the generalizability of the results; Research in the future should attempt to extend the sample to multiple regions and include multiple respondents from each firm.

ACKNOWLEDGMENT

This study was supported by IDRC of Zhejiang University (104044-001), Philosophy and Social Science Research Program of Zhejiang Province (12JCGL04YB) and Teacher Research Funding of ZUCC (J-13037).

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