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MARKETING AND TECHNOLOGY RESOURCE COMPLEMENTARITY: AN ANALYSIS OF THEIR INTERACTION EFFECT IN TWO ENVIRONMENTAL CONTEXTS

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The dynamic capabilities perspective posits that a firm can leverage the performance impact of existing resources through resource configuration, complementarity, and integration, but little empirical research addresses these issues. We investigate the effects on performance of marketing capabilities, technological capabilities, and their complementarity (interaction), and whether these effects are moderated by low vs. high technological turbulence. Results from SEM two-group analyses (with controls) show that both main effects positively impact performance in both environmental contexts. However, (1) their interaction effect is significant only in the high-turbulence environment; (2) the marketing-related main effect is lower in the high-turbulence environment; and (3) the main effects of technology-related capabilities are the same in both environments. Our research suggests that the synergistic performance impact of complementary capabilities can be substantive in particular environmental contexts: while synergistic rents cannot always be obtained, it is possible to leverage existing resources through complementarity.

INTRODUCTION

The relationships between resources (or capabilities) and firm performance have attracted much research interest, but we still know relatively little about why some firms successfully use their capabilities while others do not (Helfat, 2000). The extant literature suggests that superior performance can come from resource uniqueness (e.g., Barney, 1991), from reconfiguration and integration of existing resources (e.g., Eisenhardt and Martin, 2000; Teece, Pisano, and Shuen, 1997), and/or from the ability to respond appropriately to the surrounding environment (e.g., Mintzberg, 1987; Pfeffer and Salancik, 1978; Tan and Litschert, 1994). Our study aims to contribute to this literature by focusing on two issues that are relatively neglected: (1) the performance impact of the *interaction of capabilities* (in addition to main effects); and (2) the *differential* impact of capabilities and their interaction in different environments. The former addresses whether complementary capabilities have synergistic effects, while

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the latter specifies environmental conditions under which both main and synergistic effects can be expected. Specifically, we investigate the relationships to performance of marketing-related capabilities, technology-related capabilities, and their interaction in two environmental contexts: high vs. low technological turbulence. We tap performance by considering profit, sales, and ROI relative to objectives.

Technological-related capabilities have been shown to enable firms to achieve superior performance (e.g., Clark and Fujimoto, 1991; Pisano, 1994). Likewise, marketing-related capabilities have been established as important resources for market-driven organizations (Day, 1990, 1994). The focus of this paper goes beyond the impact of these main effects; rather, we scrutinize the relatively unknown and under-researched impact of their joint presence (their interaction) under different environmental conditions. Thus our first broad goal is to contribute to the literature by enabling an evaluation of complementarity in capabilities through our modeling of interaction. However, the analysis of *construct* interaction effects is still in its infancy (Jaccard and Wan, 1996), and thus to accomplish this goal we use a little-used methodology to model interaction constructs in structural equation modeling (SEM). We hope that these methodological aspects will encourage more interest in *construct* interaction effect analysis.

Our second broad goal is to examine the moderation of technological turbulence (a form of environmental uncertainty) on the relationships to performance of both main and interaction effects. Various degrees of technological turbulence, with associated rates of product or process obsolescence and new product introduction, characterize the current competitive environment of high-tech industries. Surprisingly, little research empirically tests whether, for example, the performance impact of technology-related capabilities is greater in high as compared to low technologically turbulent environments. We address these issues in the following research question: Is performance affected *differentially* by each individual capability (the marketing or technology capabilities main effects) and/or by their joint presence (the interaction of these capabilities), depending on the level of this technological turbulence?

We begin our paper with the development of main effects, interaction effect, and moderation hypotheses, and then test them using new product commercialization joint ventures (JVs) as a setting. New product commercialization is not only crucial for the materialization of technology-related capabilities (Page, 1993), but is also the stage in the new product development process where the interaction between technology-related capabilities and marketing-related capabilities is most likely to occur. We used joint ventures because they are 'firms' born of strategic alliances whose very purpose may be providing firms with access to complementary assets (Harrison *et al.*, 2001; Kogut, 1988). This allows us to focus on relatively narrow firm capabilities in a context hospitable for the empirical testing of our hypotheses.

RESOURCES, CAPABILITIES, AND PERFORMANCE

In the following sections, we develop six hypotheses that, *as a set*, specify different relationships to performance of marketing-related capabilities, technology-related capabilities, and their interaction. Differences are hypothesized to be engendered by technological turbulence. Our model also specifies three control variables: market growth, relative costs, and industry. Grounded in the resource-based view, the model's hypotheses are summarized in Figure 1.

Resource-based theory: A brief summary

Resource-based theory views a firm as a unique bundle of tangible and intangible resources and emphasizes the protection of firm core competencies comprising these resources. Several authors (Barney, 1991; Day and Wensley, 1988; Prahalad and Hamel, 1990; Wernerfelt, 1984) have expanded the seminal work of Penrose (1959). Resources include all assets, capabilities, organizational processes, firm attributes, information, and so on controlled by a firm and enabling the firm to conceive of and implement strategies that improve efficiency and effectiveness (Barney, 1991). Firm competitive advantage is rooted in resources that are valuable and inimitable, and the firm's survival largely depends on how it creates new resources, develops existing ones, and protects its core competencies (Day and Wensley, 1988).

The resource-base view of the firm is not restricted solely to examining internal resources, however. Several authors recognize that many

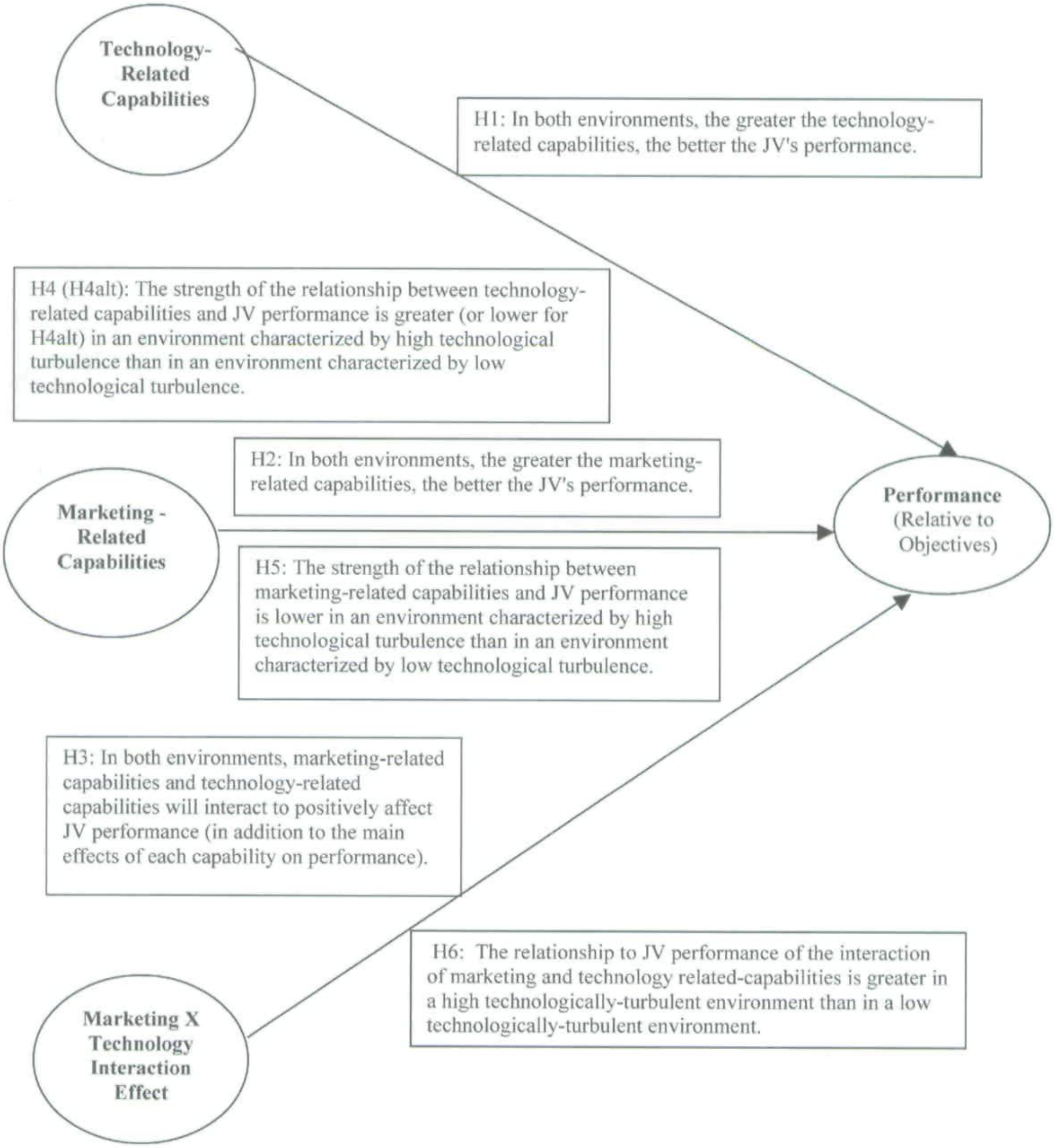


Figure 1. Theoretical model of marketing and technology resource complementarity in the two environmental contexts

essential resources and capabilities lie outside the firm's boundaries (Doz and Hamel, 1998). Grant (1991), for example, stated that when internal resources are unavailable, outsourcing should be considered, and Das and Teng claim that by joining forces with other firms a firm can gain 'otherwise unavailable competitive advantages and values' (Das and Teng, 2000: 36). Integration of tangible or intangible resources from participating firms provides a joint venture or alliance with strategic rents that are achieved not necessarily because it has better or more resources, but rather because the venture's distinctive competence involves making better use of *joint* resources (Penrose, 1959).

Marketing vs. technology-related capabilities: Two key resources

There are many ways to define 'capabilities.' Collectively, capabilities are defined as complex bundles of skills and accumulated knowledge, exercised through organizational processes, that enable firms or joint ventures to coordinate activities and make use of the asset (Day, 1994). In this research, we focus on marketing-related capabilities vs. technology-related capabilities in joint ventures (JVs). Although established through cooperation between firms, a JV is considered a separate legal entity or a 'firm' in its own right (Murray and Siehl, 1989; Park and Ungson, 1997). Therefore, technology and marketing-related capabilities are regarded as 'firm'-level traits. Marketing-related capabilities are those that provide links with customers; they enable JVs to compete by predicting changes in customer preferences as well as creating and managing durable relationships with customers and channel members (Day, 1994). Technology-related capabilities are those that develop and produce technology; these enable response to the rapidly changing technological environment (Wind and Mahajan, 1997). Thus both capabilities are idiosyncratic resources that can provide competitive advantage (Barney, 1991; Peteraf, 1993; Wernerfelt, 1984). Therefore, according to the resource-based perspective, Hypotheses 1 and 2 are hypothesized. Neither is new, but both are necessary for model completeness.

Hypothesis 1: The greater the technology-related capabilities, the better the JV's performance.

Hypothesis 2: The greater the marketing-related capabilities, the better the JV's performance.

Joint ventures are not only an effective means to share complex capabilities among the venture partners (Kogut, 1988; Mowery, Oxley, and Silverman, 1996), but also an attractive vehicle for enhancing firm capabilities (Madhok, 1997). Capabilities can be divided into complementary and supplementary capabilities: complementary capabilities are those that combine effectively with those the firm already has, whereas supplementary resources are those that serve the same functions as the ones the firm already has (Wernerfelt, 1984). Integrating marketing capabilities and technological capabilities should lead to better performance because it is a complementary rather than supplementary combination. Such integration reconfigures competencies, reduces the resource deficiency, and generates new applications from those resources (Kogut and Zander, 1992; Teece *et al.*, 1997; Woodcock, Beamish, and Makino, 1994). Complementary resource combinations will also contribute to the JV's balance of power: balance is crucial for JV success (Bucklin and Sengupta, 1993; Heide, 1994) and stems from the equal resource dependence of both parties (Emerson, 1962; Gaski, 1984). Therefore it is hypothesized that:

Hypothesis 3: Marketing-related capabilities and technology-related capabilities will interact to positively affect the JV's performance (in addition to the main effects of each capability on performance).

The moderating effect of low vs. high technological turbulence in the environment

Consideration of the environment is important to the analysis of firm resources and performance since different environments imply different valuations of resources (Penrose, 1959). In particular, JVs are often chosen *in order to* respond to the continuing global *technologically turbulent* environment (Achrol, 1991; Collis, 1991). Such JVs usually seek to enhance strategic advantage by leveraging critical capabilities (such as technology-related and marketing-related capabilities) and by improving flexibility in response to technological change (Achrol, 1991). According to the dynamic capabilities model, and more broadly the resource-based view, uncertain and turbulent environments help firms achieve competitive advantages *because* uncertain turbulent environments increase causal ambiguity and, as a consequence, the ability to imitate resources or combinations of resources decreases (e.g., Eisenhardt and Martin, 2000; Lippman and Rumelt, 1982; Noda and Collis, 2001). In highly turbulent environments, the JV can deploy resources from each participant in order to respond to changing conditions; thus, the way the JV uses resources and the joint capabilities to be developed will not be static. This is difficult for competitors to imitate in a timely fashion. On the other hand, when the environment is relatively unchanging and predictable, competitors can see clearly which resources and combinations of resources are valuable to the business, and these can be imitated because time is not of the essence.

Consider first technology-related capabilities. A highly technologically turbulent environment is characterized by a short cycle of technological innovation and obsolescence. In high turbulence, technology-related capabilities (such as innovation) should enable a JV to shape or react to these environmental conditions (Kotabe and Swan, 1995). For example, the timely introduction of new products to replace obsolete products may become crucial to firm success (Wind and Mahajan, 1997). Therefore, the relationship between *technology*-related capabilities and performance in a high technologically turbulent environment should be greater than this relationship in a low-turbulence environment (i.e., the betas will not be the same).

It can, however, also be counter-argued that embedded technological capabilities may lead to incumbent inertia when the environment becomes technologically turbulent (Lieberman and Montgomery, 1988). Deeply embedded knowledge and skill sets can actually create problems if firms fail to fill the gap between current technological environmental requirements and their core technological capabilities, thus creating core rigidities (Leonard-Barton, 1992). Technological changes can therefore either enhance or destroy the existing firms' technological competencies (Tushman and Anderson, 1986). We address this paradox by proposing both Hypothesis 4 and 4alt:

Hypothesis 4: The strength of the relationship (i.e., the beta) between technology-related capabilities and performance is greater (Hypothesis 4alt: lower) in an environment characterized by high technological turbulence than in an environment characterized by low technological turbulence.

Next, consider marketing-related capabilities, which enable JVs to gain and use market intelligence about exogenous market factors that influence current and future customer needs. In the high technologically turbulent environment, the role of *marketing*-related capabilities in generating performance may be downplayed, particularly in the situation where the whole industry is affected by rapid technological change. In such a situation, the importance of close relationships with customers or among supply chain members may decrease, whereas the importance of new product introduction increases. Customers may not be able to help firms innovate (although they can be used to test products), and thus technology-related capabilities must assume a dominant role in performance responsibilities. Therefore, we hypothesize:

Hypothesis 5: The strength of the relationship (i.e., the beta) between marketing-related capabilities and performance is lower in an environment characterized by high technological turbulence than in an environment characterized by low technological turbulence.

In a high technologically turbulent environment, JV partners will not be able to predict future changes. In such a situation, diversity in capabilities should provide JVs with more diversified ideas, which should lead to better risk management and higher success. As such, the effect on performance of the complementarity of marketing-related and technology-related capabilities should be greater in a high (vs. low) technologically turbulent environment. Therefore, we propose:

Hypothesis 6: The relationship to JV performance of the interaction of marketing and technology-related capabilities is greater in a high technologically turbulent environment than in a low technologically turbulent environment.

METHOD: SAMPLE AND MEASUREMENT

Sample and procedure

We tested our hypotheses using survey data. The initial sampling frame was obtained from a commercial listing of U.S. joint ventures formed between 1990 and 1997. After eliminating firms for which the questionnaire was inappropriate, the overall frame had 971 JVs. In administering the mail survey, we followed the modified total survey design method (Dillman, 1978), and obtained 466 usable responses (response rate = 48%). A comparison of the responses from two mailings revealed no systematic differences in the study variables.

The respondents consisted of 79 presidents; 214 vice-presidents of marketing or directors for marketing operations; 187 vice-presidents of R&D or manufacturing; and 61 others. Informant tenure levels with the JV averaged 6 years. The average number of employees in the JVs was 792, with a range of 57–1650 (this is an indicator of JV size). The industries represented were: Chemicals and Related Products; Electronic and Electrical Equipment; Pharmaceutical, Drugs, and Medicines; Industrial Machinery and Equipment; Telecommunications Equipment; Semiconductors and Computer Related Products; Instruments and Related Products.

Measurement of key model constructs

Before collecting data, we conducted four in-depth case studies to validate measures. Table 1 presents the wording and scale points of key model variables. Cumulative normal probability plots demonstrated that each of these measures was normally distributed. Appendix 1 contains the complete correlation matrix.

Respondents were required to rate the marketing-related capabilities and technology-related capabilities of the JV. The *marketing-related* capabilities, focusing on market sensing and external linking capabilities, were developed from Day (1994). The *technology-related* capabilities, focusing on technology development, new product development, and manufacturing processes, were also drawn from Day (1994). In addition to these two latent independent constructs, we also have the following independent variables as controls: (1) *market growth*, the average annual growth rate in percentage of total sales in the JV's principal served market segment over the past 3 years; (2) *relative costs*, the JV's average total operating costs in relation to those of its largest competitor in its principal served market segment; and (3) *industry* (six dummy variables representing seven industry groups).

Finally, the dependent construct *performance* relative to profit, sales, and ROI objectives was measured on 11-point scales anchored 'low'/'high.' Using perceived performance scales relative to objectives permits comparisons across firms and

Table 1. Measurement items and response formats

Construct and response format	Measurement items
Marketing-related capabilities (MKT)	
Please evaluate how well or poorly you believe this joint venture performs the specific activities or possesses the specific capabilities relative to your major competitors. (11-point scale with anchors: 0 = Much worse than your major competitors; 10 = Much better than your major competitors) (adapted from Day, 1994)	Customer-linking capabilities (i.e., creating and managing durable customer relationships) Market-sensing capabilities (predicting changes in customer preferences) Channel-bonding capabilities (creating durable relationship with channel members such as wholesalers, retailers)
Technology-related capabilities (TECH)	
Please evaluate how well or poorly you believe this joint venture performs the specific activities or possesses the specific capabilities relative to your major competitors. (11-point scale with anchors: 0 = Much worse than your major competitors; 10 = Much better than your major competitors) (from Day, 1994)	Technology development capabilities Manufacturing processes New product development capabilities
Technologically-turbulent environment	
Please indicate the degree to which you agree or disagree with the following statement regarding this joint venture (11-point scale with anchors: 0 = strongly disagree; 10 = strongly agree)	The technology in our industry is changing rapidly Technological changes provide big opportunities in our industry It is very difficult to forecast where the technology in our industry will be in the next 2–3 years Technological developments in our industry are rather minor (R)
Overall performance	
Please rate the extent to which this joint venture (JV) has achieved the following outcomes. (11-point scale with anchors: 0 = low; 10 = high)	Overall profit margin relative to the JV's objective Overall sales relative to the JV's objective Overall ROI relative to the JV's objective

contexts (such as across particular industries, cultures, time horizons, economic conditions, and expectations of parent firms). The managers in the case studies preferred subjective to objective measures because the latter are often confidential. The literature shows that subjective scales are widely used and that there are high correlations between subjective and objective firm performance measures. Finally, note that performance objectives are determined with capabilities in mind, and thus measuring actual performance *relative to objectives* creates a potential bias against finding significant effects.

Classification of high vs. low technological turbulence

Perceived technological turbulence refers to the state of technology in the industry, the rate of change in technology, and the JV's inability to accurately forecast the changes in the technology (Downey and Slocum, 1975; Milliken, 1987). JVs were classified in two steps. First, three researchers assessed the technological environments by labeling as 'high' those with the following characteristics: strong network externalities (Xie and Sirbu, 1995); high uncertainty; rapid changes in industry technology standards; short technology life cycles (less than 2 years); and faster development cycle time (less than 1 year for typical new products). Majority rule resolved disputes. This classification scheme is consistent with Song and Montoya-Weiss (2001). Second, we calculated the sample mean for the composite score of the perceived technological turbulence scales (Table 1). Based on this mean score, JVs were sorted into 'high' or 'low.' For a JV to be included in the final usable sample ($n = 466$), it had to have the same classification from both methods (19 JVs were dropped due to mismatch). The result was 249 JVs in the high and 217 JVs in the low technological turbulence group.

Equivalence of measurement across high vs. low groups

The equivalence of measurement across groups was assessed by the set of hierarchical tests as outlined by Bollen (1989) and summarized in Table 2. The initial model (Model 1), without constraints across groups, provided a baseline chi-square. The results showed a good model fit ($\chi^2_{(16)} = 35.99$;

Table 2. Analysis of the measurement model across environmental groups

(A) Two-group analyses: tests for equivalence of measurement and discriminant validity

Measurement model	Goodness of fit	Test of hypotheses
Model M1: Baseline model	$\chi^2_{(16)} = 35.99$, $p = 0.00$	
Model M2: Factor loadings modeled invariant	$\chi^2_{(20)} = 43.64$, $p = 0.00$	Test for loading invariance Model 2-Model 1: $\Delta\chi^2_{(4)} = 7.65$, n.s. at 0.05
Model M3: Factor loadings *and* error variance modelled invariant	$\chi^2_{(26)} = 59.36$, $p = 0.00$	Test for invariance Model 3-Model 2: $\Delta\chi^2_{(6)} = 15.72$, sig. at $p < 0.05$
Model M4: Factor loadings invariant *and* correlation between marketing-related and technology-related capabilities set to 1	$\chi^2_{(22)} = 58.31$, $p = 0.00$	Test for discriminant validity Model 4-Model 2: $\Delta\chi^2_{(2)} = 14.67$, sig. at $p < 0.05$

(B) Measurement model with factor loadings constrained equal across groups

Measurement model (constraints equal)	Unstandardized solution (t-value in parentheses)	Common metric completely standardized solution
(MKT) λ_{11}	1.00	0.84
(MKT) λ_{12}	1.03** (11.65)	0.80
(MKT) λ_{13}	0.48** (9.94)	0.52
(TECH) λ_{21}	1.00	0.82
(TECH) λ_{22}	1.02** (16.39)	0.80
(TECH) λ_{23}	1.02** (16.36)	0.78

** Significant at $p < 0.01$

RMSEA = 0.07). The second step (Table 2A) was to constrain the factor loadings equal: the non-significant difference in chi-square between this model (Model 2) and the baseline model (Model 1) indicated that the factor loadings were invariant ($\Delta\chi^2_{(4)} = 7.65$, n.s. at $p < 0.05$). Third, we tested the equality of the error variances of the latent variables (Bagozzi and Edwards, 1998). A significant decrease in chi-square between Model 2 and Model 3 ($\Delta\chi^2_{(6)} = 15.72$, $p < 0.05$) indicated different error variances. Thus the measurement model was λ loading invariant only. This λ invariant model (Model 2) was used in subsequent analyses.

An examination of the loadings of Model 2 (Table 2B) indicated that a substantial amount of variance was captured by the latent constructs: all loadings were highly significant and only one standardized loading was below 0.7, showing strong convergent validity. The test of discriminant validity (Table 2A, Model 4) involved comparing chi-square values of models that either free or constrain the correlation between constructs to 1. The decrease in chi-square was significant ($\Delta\chi^2_{(2)} = 14.67$, significant at $p < 0.05$), supporting discriminant validity.

METHOD: INTERACTION EFFECT ESTIMATION IN SEM

Our approach to interaction effect analysis using SEM, outlined below and detailed in Appendix 2 is in line with that first suggested by Kenny and Judd (1984). It involves first centering the raw scores. The measurement equations of F_M (marketing-related capabilities) and F_T (technology-related capabilities) are, in deviate form:

$$M_i = \lambda_{Mi} F_M + e_{Mi} \tag{1}$$

and

$$T_i = \lambda_{Ti} F_T + e_{Ti} \tag{2}$$

Then the variance of an interaction latent construct is as follows (*constraint #1*):

$$\begin{aligned}\mathrm{Var}(F_M F_T) &= \mathrm{Cov}(F_M F_T, F_M F_T)\\ &= \mathrm{Var}(F_M)\mathrm{Var}(F_T) + \mathrm{Cov}(F_M, F_T)^2\end{aligned} \tag{3}$$

The second step is to establish the path coefficients (i.e., λ) and the error variances (i.e., e_{MiTj}) for the interaction. Therefore *constraint #2*, defining the path coefficients (λ) between interaction construct ($F_M F_T$) and its multiplicative indicators (MT), is:

$$\lambda_{MiTj} = \lambda_{Mi}\lambda_{Tj} \tag{4}$$

with errors of the product indicators as:

$$e_{MiTj} = (\lambda_{Mi} F_M e_{Tj}) + (\lambda_{Tj} F_T e_{Mi}) + e_{Mi} e_{Tj} \tag{5}$$

The residual variances of interaction indicators are:

$$\begin{aligned}\mathrm{Var}(e_{MiTj}) &= \lambda^2_{Mi}\mathrm{Var}(F_M e_{Tj})\\ &\quad + \lambda^2_{Tj}\mathrm{Var}(F_T e_{Mi}) + \mathrm{Var}(e_{Mi} e_{Tj})\end{aligned} \tag{6}$$

and *constraint #3*, defining the residual variances of interaction indicators, is:

$$\begin{aligned}\mathrm{Var}(e_{MiTj}) &= \lambda^2_{Mi}\mathrm{Var}(F_M)\mathrm{Var}(e_{Tj})\\ &\quad + \lambda^2_{Tj}\mathrm{Var}(F_T)\mathrm{Var}(e_{Mi}) + \mathrm{Var}(e_{Mi})\mathrm{Var}(e_{Tj})\end{aligned} \tag{7}$$

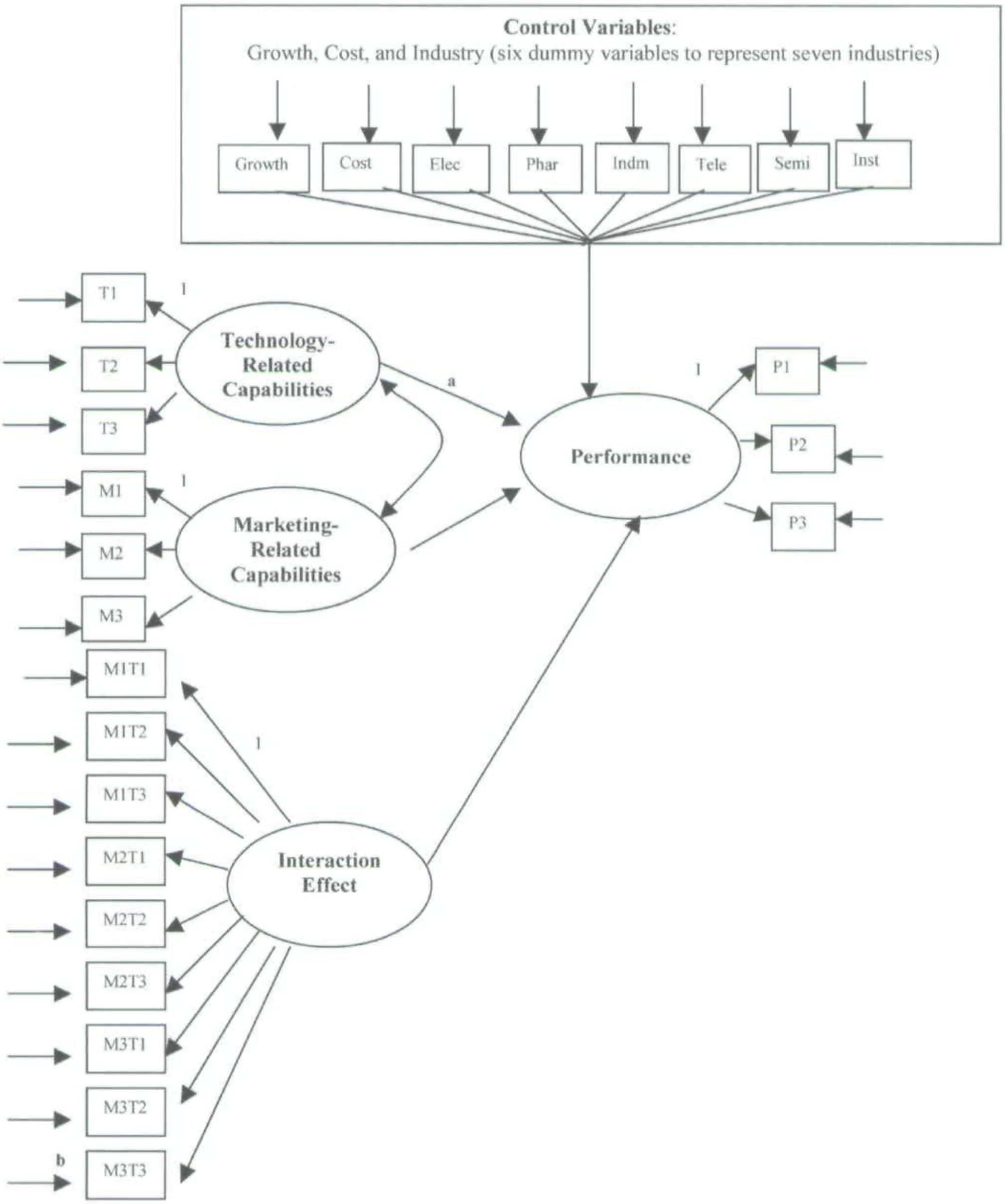
From Equations 6 and 7 it can be shown that all paths between error terms of multiplicative indicators must be freed *except* where there is no variance sharing. This set of fixed paths establishes *constraint #4* (described in detail in Appendix 2). The final step is to establish the covariances between the interaction and the other latent constructs: these are zero for normally distributed and mean centered variables (see Appendix 2). Therefore the final *constraint #5* is:

$$\phi_{FM.FMFT} = \phi_{FT.FMFT} = 0 \tag{8}$$

The five constraints outlined above show that a given multiplicative indicator is a function of the measurement error of the component parts of the interaction term. An analysis strategy not taking into account this complex function will cause poor model fit and erroneous results. SEM results from analysis of interaction *without* these constraints (available from the authors) substantially depart from results *with* these constraints (reported below). Furthermore, the results depart from those of regression procedures such as OLS (demonstrated below and in Table 4).

RESULTS

The results reported are from the LISREL model shown in Figure 2. We used invariant factor loadings, justified by the measurement tests. Also,



[a] We let technological capabilities and marketing capabilities covary.

[b] Some paths between the errors of the product terms (constraint #4) are not shown in this figure.

Figure 2. LISREL model of marketing and technology resource complementarity (with control variables) in two environmental contexts

based on constraint #2, the factor loadings of the interaction construct are functions of the factor loadings of the main latent constructs.

SEM analyses and hypothesis testing

We first tested the equality of the control variables' effects across groups. When these paths were constrained equal, chi-square did not change significantly from the baseline Model 1 (Table 3). Thus the effects of control variables were not statistically different across two groups.

The SEM results in Table 4 from the baseline model showed that the paths to performance from marketing-related capabilities and technology-related capabilities were highly significant in both low and high technologically turbulent environments (low: $\gamma_{TEC\to PERF} = 0.53$, $t = 6.58$; $\gamma_{MKT\to PERF} = 0.61$, $t = 8.39$; high: $\gamma_{TEC\to PERF} = 0.59$, $t = 9.64$; $\gamma_{MKT\to PERF} = 0.29$, $t = 4.58$). However, the path from the interaction effect to performance was significant only in the high technologically turbulent environment (low: $\gamma_{INX\to PERF} = -0.03$, $t = -0.84$, n.s.; high: $\gamma_{INX\to PERF} = 0.10$, $t = 4.16$). These results thus provide support for Hypotheses 1 and 2 and partial support for Hypothesis 3.

Next, we tested the hypotheses that the path coefficients to performance from marketing-related capabilities, technology-related capabilities as well as the interaction effect are different across the

Table 3. Two-group analysis: hypotheses testing

Structural model	Goodness of fit	Test of hypotheses
Model 1: Baseline model (factor loadings invariant)	$\chi^2_{(582)} = 1567.19$, $p = 0.00$	Test for Hypotheses 1, 2, 3
Model 2: Factor loadings *and* path coefficients between control variables and performance invariant	$\chi^2_{(590)} = 1575.21$, $p = 0.00$	Test for equalities across groups of the control variables on performance Model 2-Model 1: $\Delta\chi^2_{(8)} = 8.02$, n.s. at 0.05
Model 3: Factor loadings *and* path coefficients $\gamma_{MKT\to PER}$, $\gamma_{TEC\to PER}$, and $\gamma_{INX\to PER}$ invariant	$\chi^2_{(585)} = 1587.03$, $p = 0.00$	Model 3-Model 1: $\Delta\chi^2_{(3)} = 19.84$, sig. at $p < 0.05$
Model 4: Factor loadings *and* path coefficient $\gamma_{TEC\to PER}$ invariant	$\chi^2_{(583)} = 1567.46$, $p = 0.00$	Test for Hypotheses 4/4alt Model 4-Model 1: $\Delta\chi^2_{(1)} = 0.27$, n.s. at 0.05
Model 5: Factor loadings *and* path coefficient $\gamma_{MKT\to PER}$ invariant	$\chi^2_{(583)} = 1578.79$, $p = 0.00$	Test for Hypotheses 5 Model 5-Model 1: $\Delta\chi^2_{(1)} = 11.60$, sig. at $p < 0.05$
Model 6: Factor loadings *and* path coefficient $\gamma_{INX\to PER}$ invariant	$\chi^2_{(583)} = 1576.23$, $p = 0.00$	Test for Hypotheses 6 Model 6-Model 1: $\Delta\chi^2_{(1)} = 9.04$, sig. at $p < 0.05$

Table 4. Results of OLS vs. structural equation model analysis with control variables

Path coefficients (t-value in parentheses)	OLS		SEM		Δ Result
	Low tech. turbulence	High tech. turbulence	Low tech. turbulence	High tech. turbulence	Test of high vs. low
$\gamma_{TEC\to PERF}$	0.52*(2.69)	0.04 (0.28)	0.53*(6.58)	0.59*(9.64)	Invariant
$\gamma_{MKT\to PERF}$	0.57*(3.20)	−0.13 (−0.85)	0.61*(8.39)	0.29*(4.58)	Significantly different
$\gamma_{INX\to PERF}$	−0.02 (−0.36)	0.08*(3.27)	−0.03 (−0.84)	0.10*(4.16)	Significantly different
Control variables					
$\gamma_{GROWTH\to PERF}$	0.00 (1.00)	0.01*(2.52)	0.00 (0.92)	0.01*(2.68)	Invariant
$\gamma_{COST\to PERF}$	0.09 (0.97)	0.01 (0.13)	0.05 (0.49)	0.02 (0.20)	Invariant
$\gamma_{ELEC\to PERF}$	−0.50 (−0.73)	0.05 (0.07)	−0.48 (−1.14)	0.06 (0.13)	Invariant
$\gamma_{PHAR\to PERF}$	−0.76 (−1.19)	0.74 (1.19)	−0.54 (−1.32)	0.89*(2.12)	Invariant
$\gamma_{INDM\to PERF}$	−0.23 (−0.36)	0.90 (1.34)	−0.01 (−0.01)	1.06*(2.36)	Invariant
$\gamma_{TELE\to PERF}$	0.63 (0.97)	0.73 (1.22)	0.67 (1.56)	0.84*(2.23)	Invariant
$\gamma_{SEMI\to PERF}$	0.23 (0.35)	0.20 (0.33)	0.41 (0.93)	0.28 (0.70)	Invariant
$\gamma_{INST\to PERF}$	−0.06 (−0.10)	0.31 (0.60)	0.06 (0.17)	0.35 (1.07)	Invariant

* Significant at $p < 0.05$

two environments (Model 3 in Table 3). The result ($\Delta\chi^2_{(3)} = 19.84$, $p < 0.05$) demonstrated differences, and additional tests identified which paths differed. The first test was to assess the invariance of $\gamma_{TEC \rightarrow PERF}$ by constraining the path to be equal across groups (Model 4, Table 3). $\gamma_{TEC \rightarrow PERF}$ tested equal across groups ($\Delta\chi^2_{(1)} = 0.27$, n.s. at 0.05) and this supported neither Hypothesis 4 nor Hypothesis 4alt (Model 4 in Table 3). The second test was for invariance of the path from marketing-related capabilities to performance. The significant difference in chi-square supported Hypothesis 5 in that $\gamma_{MKT \rightarrow PERF}$ in the high technologically turbulent environment was significantly lower than $\gamma_{MKT \rightarrow PERF}$ in the low technologically turbulent environment ($\Delta\chi^2_{(1)} = 11.60$, $p < 0.05$). Finally, the test of invariance of the path coefficient from the interaction to performance (Model 6 in Table 3) showed a significant difference in chi-square ($\Delta\chi^2_{(1)} = 9.04$, $p < 0.05$), supporting Hypothesis 6 that the interaction effect in high turbulence was greater than the one under low turbulence.

In addition, Table 4 compares our SEM results with the results from ordinary least square (OLS) regression. Our purpose is to demonstrate that OLS results can lead to substantively different conclusions. For OLS analysis, we took the mean of the indicators of each construct (thus there is no 'measurement model' as in SEM; e.g., measurement error is not explicitly modeled) and the ordinary multiplicative interaction. The results from OLS differ from SEM analysis. For example, in the high technologically turbulent environment, neither main effect is significant in OLS. OLS estimates, being conditional on other model variables, changed in the high tech turbulence group because of the significance of the interaction in this group. All beta estimates will differ across SEM and OLS because OLS does not account for psychometric properties of the measurement model (both constructs and interaction).

The strength of the interaction effect and its interpretation

The strength of the interaction effect is reflected in the difference between the squared multiple correlation (similar to R^2 in OLS) of models without vs. with interaction (Jaccard and Wan, 1996). The latter was modeled by fixing the value of the path coefficient between the interaction effect latent variable and performance to zero. However, given that only the interaction effect in the high technologically turbulent environment was significant, the effect in the low technologically turbulent environment was not examined. In the high technologically turbulent environment, the square multiple correlations without and with the interaction were 0.42 and 0.51 respectively. This means that marketing-related and technology-related capabilities together accounted for 42 percent of variance in performance, while the interaction effect accounts for 9 percent. However, this is a somewhat crude index.

When an interaction effect is statistically significant, it should be further analyzed and interpreted as a conditional effect on the main effects (Jaccard, Turrisi, and Wan, 1990). Specifically, the effect of marketing-related capabilities on performance, at a given level of technology-related capabilities is: $b_{MKT \text{ at } Vtec} = \gamma_{MKT \rightarrow PERF} + \gamma_{INX \rightarrow PERF} \cdot V_{tec}$; where V_{tec} is a specific value of technology-related capabilities and γ are path coefficients as discussed above (similarly: $b_{TEC \text{ at } Vmkt} = \gamma_{TEC \rightarrow PERF} + \gamma_{INX \rightarrow PERF} \cdot V_{mkt}$). When assuming mean deviate form (as in this study), the mean of V is of course zero. For instance, in the high technologically turbulent environment, an increase of marketing-related capabilities by one unit was estimated to increase performance by 0.29 units, given that the JV has an average level of technology-related capabilities. That is: $b_{MKT \text{ at } Vtec} = \gamma_{MKT \rightarrow PERF} + \gamma_{INX \rightarrow PERF} \cdot V_{tec} = \gamma_{MKT \rightarrow PERF} + \gamma_{INX \rightarrow PERF}(0) = 0.29 + 0.10(0) = 0.29$.

When the values of the exogenous constructs are not at their means, V can be obtained (in a standard deviation form) from the square root of the variances. The variances of latent technological capability and marketing capability constructs are, respectively, 4.54 ($t = 10.06$) and 6.14 ($t = 8.50$) in the low technologically turbulent environment and 7.13 ($t = 11.61$) and 6.45 ($t = 9.52$) in the high technologically turbulent environment. For example, when the level of technology-related capabilities is 'high' (such as one estimated deviation above its sample mean), the effect of marketing-related capabilities on performance (in the high technologically turbulent environment) can be calculated as follows: $b_{MKT \text{ at } Vtec} = \gamma_{MKT \rightarrow PERF} + \gamma_{INX \rightarrow PERF} \cdot V_{tec} = \gamma_{MKT \rightarrow PERF} + \gamma_{INX \rightarrow PERF}\sqrt{\phi_{tec}} = 0.29 + 0.10(\sqrt{7.13}) = 0.56$. For every unit that marketing-related capability increases, performance increases by 0.56 units. This is an incremental increase of 0.27 units when compared to the value when technological capabilities are at the mean.

Using the same calculations, the effects of technology-related capabilities and marketing-related capabilities on performance in a low technologically turbulent environment will always be 0.53 and 0.61 units, since the latent interaction construct is not statistically significant. In the high technologically turbulent environment, (1) the effects of technology-related capabilities are 0.84, 0.59, and 0.34 units, when the marketing-related capabilities are high, at their means, and low respectively and (2) the effects of marketing-related capabilities are 0.56, 0.29, and 0.02 units, when the technology-related capabilities are high, at their means, and low respectively.

DISCUSSION

This research provided a contextually robust test of dynamic capabilities and, more generally, resource-based theory, in the joint venture arena. We modeled the effects on performance (profit, sales, and ROI relative to objectives) of (1) marketing-related capabilities, (2) technology-related capabilities, and (3) their interaction effect. The appropriate *constrained* structural equation model was used to test the hypotheses. Although our approach does not answer the question as to which *specific* levels of investment in resources (i.e., capabilities) is best, it *does* set the basis for synergy proposition testing in a field that claims synergy through complementarity but has not shown it empirically. In addition, the *moderating* effect of technological turbulence (low vs. high) was incorporated in the theoretical model. Overall, our model provides the foundation for straightforward but powerful managerial and theoretical guidelines without the possibly misleading oversimplifications and without compromising the richness of the contextual setting.

The main effects of marketing-related and technology-related capabilities

Results from two-group analysis showed that both marketing-related capabilities and technology-related capabilities were positively related to performance. These capabilities are the *resources* of the JV, and, consistent with resource-based theory, resources have positive performance impact. From a managerial point of view, the results confirm that JV performance can be enhanced by utilizing the right marketing and technology capabilities effectively.

The main effects of marketing-related and technology-related capabilities on performance were positive regardless of technological turbulence. For technology-related capabilities, the strengths of the relationships to performance were *equal* (i.e., this path was not moderated by technological turbulence). We had expected a difference in the slopes, but this was not the case. For marketing-related capabilities, the relationships were *not* the same in both contexts: the strength of the relationship (i.e., the slope) was greater in the low technologically turbulent environment (however, even in high turbulence, this main effect was positive; i.e., it was *not* nil).

For managers, the implication is clear: careful management of capability deployment (i.e., resource deployment) according to environmental conditions is essential for maximum performance. In our research, the performance impact of deploying marketing-related capabilities was greater in a low technologically turbulent environment, while the performance impact of deploying technology-related capabilities was the same across *this particular* environmental characteristic. In low turbulence, the performance effects of marketing-related and of technology-related capabilities were very similar; but with high turbulence, the effects of marketing-related capabilities (0.29) were not at all similar to the effects of technology-related capabilities (0.59). In general, managers and researchers frequently fail to take into account the moderation effects of environmental contexts, such as technological turbulence as moderator.

The interaction of marketing-related capabilities and technology-related capabilities

Resource-based theory claims that complementary resources may enjoy synergistic performance impact, but this is rarely empirically tested. Thus we modeled the interaction's effect on performance in addition to the main effects. We expected a positive interaction effect in both groups and a greater beta in the high technologically turbulent environment, but the effect was significant *only* in the high-turbulence environment. Clearly, resource combinations do not always lead to synergistic performance impact and managers should avoid overinvesting in contexts where resources cannot be leveraged through configuration, complementarity and/or integration. In terms of resource-based theory, synergistic rents cannot always be obtained.

Overall, the following picture emerges. In low technologically turbulent environments, marketing-related capabilities (beta = 0.61) and technology-related capabilities (beta = 0.53) had similar main effects and there was no interaction. In high technologically turbulent environments, the technology-related capabilities → performance beta (0.59) was greater than the marketing-related capabilities → performance beta (0.29), but in addition there was a significant interaction effect (beta = 0.10). The main effect of marketing-related capabilities on performance appeared to decrease as the environment becomes more technologically turbulent, while (1) the effect of technology-related capabilities remained unchanged and (2) the interaction effect increased. However, it should be noted that when an interaction effect is significant the path coefficients represent the conditional effects of one capability *when the other capability is at its mean.* Thus, in high turbulence, the impact of marketing-related capabilities on performance *increased with the level of technology-related capabilities* and the impact of technology-related capabilities on performance *increased with the level of marketing-related capabilities.*

Overall, for high technologically turbulent environments, our results showed that the more the capability in one area (i.e., marketing-related or technology-related), the higher the impact on performance of one more unit of the other capability. Searching for such synergies and extracting synergistic rents is, of course, an important managerial concern. But it is also an important theoretical concern in resource-based theory, which has long claimed the possibility of synergy through complementarities. Our research demonstrates empirically such synergy for JVs operating in high technologically turbulent environments. The results also support the dynamic capabilities view's contention that in high-velocity markets the outcomes of dynamic capabilities are particularly unpredictable (Eisenhardt and Martin, 2000). This unpredictability may be attributable to the interaction effect being significant only in the high turbulent environment. Future research should determine whether other capabilities have similar performance impact profiles (i.e., characterized by synergistic interaction) and under what environmental conditions.

CONCLUSION

The value of our analyses is to show that resources (i.e., marketing-related capabilities and technology-related capabilities) and combinations of resources (i.e., the interaction of capabilities) produce different performance results when the context varies (i.e., high vs. low technologically turbulent). Often researchers posit linear main effects with no interactions for independent, orthogonal variables under a broad scope of conditions. However valid as a first approximation, the loss of realism is severe. At times, the results will be very misleading and managers who implement accordingly will have counter-productive performance results. In this study, complex conditions (i.e., moderation) and non-independent effects of exogenous, yet controllable, firm inputs are modeled. In addition: (1) three control variables were incorporated for their possible impact on the core relationships; and (2) performance was measured relative to objectives, which means that *a priori* capabilities are factored in. Both of these characteristics of the analysis procedure serve to ensure rigorous testing of the hypotheses. This realism comes at the price of a more complex computational load, yet simple but powerful insights are available to managers as a result. Lack of contextual variation often leads to results so general that the conclusions are meaningless for managerial purposes and misleading for theory testing and development purposes.

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APPENDIX 1: CORRELATION MATRIX

Explanatory variables		$M1$	$M2$	$M3$	$T1$	$T2$	$T3$	$P1$	$P2$	$P3$	Growth	Cost	Elec	Phar	Indm	Tele	Semi	Inst
	SD	3.06	3.51	2.31	2.80	2.88	2.93	3.20	2.89	3.05	42.36	1.62	0.29	0.34	0.32	0.38	0.35	0.43
Customer linking ($M1$)	3.22	***	0.70	0.46	0.02	0.05	0.05	0.22	0.16	0.20	0.04	0.01	−0.03	−0.03	0.01	−0.04	0.11	−0.01
Marketing sensing ($M2$)	3.29	0.64	***	0.40	0.00	−0.02	0.00	0.22	0.20	0.20	0.08	−0.01	−0.07	0.04	−0.02	−0.10	0.04	0.07
Channel bonding ($M3$)	2.65	0.42	0.46	***	0.16	0.17	0.17	0.43	0.33	0.40	0.07	0.05	0.02	−0.00	−0.00	−0.05	0.04	0.03
Technology development ($T1$)	2.53	−0.15	−0.08	0.07	***	0.65	0.69	0.39	0.38	0.39	0.02	0.06	−0.02	−0.07	−0.09	0.04	0.08	0.06
Manufacturing process ($T2$)	2.72	−0.17	−0.08	0.04	0.66	***	0.69	0.32	0.29	0.32	0.10	0.03	−0.01	−0.08	−0.04	0.04	0.03	0.04
New product development ($T3$)	2.71	−0.13	0.07	0.14	0.55	0.52	***	0.45	0.39	0.47	0.14	0.03	0.03	−0.05	−0.09	0.02	0.04	0.05
Profit margin ($P1$)	3.03	0.15	0.42	0.34	0.17	0.22	0.41	***	0.75	0.80	0.17	0.03	0.00	0.01	−0.03	−0.04	0.03	0.03
Overall sales ($P2$)	2.88	0.26	0.47	0.39	0.20	0.29	0.33	0.76	***	0.82	0.20	0.01	−0.06	0.03	0.02	0.07	−0.02	−0.01
Overall return on investment ($P3$)	2.92	0.22	0.46	0.39	0.17	0.21	0.36	0.78	0.85	***	0.18	0.05	−0.04	0.06	0.00	0.02	0.02	−0.00
Growth	45.93	0.01	0.15	−0.04	−0.09	−0.01	−0.02	0.00	0.08	0.03	***	0.05	0.07	0.12	−0.10	−0.01	−0.06	0.00
Cost	1.67	0.03	0.03	0.04	0.02	−0.08	−0.04	0.10	−0.00	0.02	−0.08	***	0.06	−0.06	0.04	−0.10	0.06	−0.03
Elec	0.35	0.06	0.04	0.07	0.10	−0.02	0.08	0.04	0.07	−0.06	−0.08	−0.10	***	−0.13	−0.11	−0.15	−0.13	−0.18
Phar	0.36	0.03	0.00	0.13	0.01	0.11	−0.12	−0.06	−0.04	−0.08	−0.02	0.10	−0.17	***	−0.14	−0.18	−0.16	−0.22
Indm	0.35	0.11	0.02	0.05	−0.00	−0.05	0.04	−0.01	0.00	0.06	−0.02	0.02	−0.17	−0.17	***	−0.16	−0.15	−0.20
Tele	0.35	0.04	0.04	0.00	−0.05	0.04	0.00	0.12	0.11	0.09	−0.04	−0.10	−0.16	−0.17	−0.16	***	−0.19	−0.26
Semi	0.33	−0.03	−0.06	0.18	0.00	−0.01	0.00	0.04	0.07	0.01	0.09	0.07	−0.15	−0.16	−0.15	−0.15	***	−0.23
Inst	0.40	0.08	−0.02	−0.07	−0.10	−0.10	−0.10	−0.03	−0.05	0.00	0.11	0.02	−0.21	−0.21	−0.21	−0.20	−0.19	***

Notes:

Variable means are zero (i.e., variables are mean-centered).

Underlined correlations are significant at $p < 0.05$ (2-tailed).

M, marketing-related capabilities; T, technology-related capabilities; P, Performance.

Below the diagonal are correlations for the low technologically turbulent environment ($n = 217$).

Above the diagonal are correlations for the high technologically turbulent environment ($n = 249$).

APPENDIX 2: SEM ANALYSIS OF INTERACTION EFFECTS

There have been several approaches to interaction effect analysis using SEM. The Kenny and Judd (1984), Jaccard and Wan (1995), and Ping (1995) approaches are based on the same assumptions, namely that the linear latent constructs and measurement errors of their indicators are normally distributed and have means of zero. The Ping (1995) approach, analogous to two-step estimation, can be seen as an approximation of the Kenny–Judd method because the first step is to analyze the model without the interaction indicators. The parameters from this first analysis are then used for calculating the parameters of the interaction variables, which are then specified as fixed parameters in the subsequent analyses. The second approach involves adding additional latent constructs to account for loadings and error variances of the interaction indicators (Hayduk, 1987). This approach, however, can become impractical when the model consists of several latent interaction constructs and multiplicative indicators. The final approach is also based on the Kenny–Judd model, but it includes constant intercept terms in the model (Joreskog and Yang, 1996). However, this latter approach requires elaborate and complex equations to specify the constraints.

The approach used in our study is in line with that of Kenny and Judd (1984). Our approach involves first centering the raw scores and thus simplifying many of the mathematical relations between variables and rendering the effects of several of the constraints negligible (Jaccard and Wan, 1996). Consequently, this method enables us to incorporate all the multiplicative indicators of the interaction effect into the model. The equations of the measurement models of latent independent constructs, F_{M} (marketing-related capabilities) and F_{T} (technology-related capabilities) are, in deviate form:

$$M_i = \lambda_{Mi} F_M + e_{Mi} \quad (1)$$

$$T_i = \lambda_{Ti} F_T + e_{Ti} \quad (2)$$

The first step in establishing the theoretical constraints for interaction effect estimation is to define the variance for the latent interaction construct ($F_M F_T$). According to the previously noted assumptions (Kenny and Judd, 1984), the variance of an interaction latent construct is as follows:

$$\begin{aligned} \mathrm{Var}(F_M F_T) &= \mathrm{Cov}(F_M F_T, F_M F_T) \\ &= \mathrm{Var}(F_M)\mathrm{Var}(F_T) + \mathrm{Cov}(F_M, F_T)^2 \quad (3) \end{aligned}$$

Equation 3, specifying the variance for the latent interaction construct, is *constraint #1*.

The second step is to establish the path coefficients between latent interaction construct and its multiplicative indicators (i.e., λ) as well as to establish the error variances (i.e., e_{MiTj}) for the indicators. From Equations 1 and 2, we see that $M_i T_j = (\lambda_{Mi} F_M + e_{Mi})(\lambda_{Tj} F_T + e_{Tj}) = (\lambda_{Mi}\lambda_{Tj} F_M F_T) + (\lambda_{Mi} F_M e_{Tj}) + (\lambda_{Tj} F_T e_{Mi}) + e_{Mi} e_{Tj} = (\lambda_{MiTj} F_M F_T) + e_{MiTj}$. Therefore *constraint #2*, defining the path coefficients (λ) between latent interaction construct ($F_M F_T$) and its multiplicative indicators (*MT*), is:

$$\lambda_{MiTj} = \lambda_{Mi}\lambda_{Tj} \quad (4)$$

With errors of the product indicators as:

$$e_{MiTj} = (\lambda_{Mi} F_M e_{Tj}) + (\lambda_{Tj} F_T e_{Mi}) + e_{Mi} e_{Tj} \quad (5)$$

Therefore the residual variances of product indicators are:

$$\begin{aligned} \mathrm{Var}(e_{MiTj}) &= \lambda^2{}_{Mi}\mathrm{Var}(F_M e_{Tj}) \\ &\quad + \lambda^2{}_{Tj}\mathrm{Var}(F_T e_{Mi}) + \mathrm{Var}(e_{Mi} e_{Tj}) \quad (6) \end{aligned}$$

And since F_M and e_{Tj}, F_T and e_{Mi}, as well as e_{Mi} and e_{Tj}, are each assumed to be uncorrelated, *constraint #3*, defining the residual variances of product indicators, is:

$$\begin{aligned} \mathrm{Var}(e_{MiTj}) &= \lambda^2{}_{Mi}\mathrm{Var}(F_M)\mathrm{Var}(e_{Tj}) \\ &\quad + \lambda^2{}_{Tj}\mathrm{Var}(F_T)\mathrm{Var}(e_{Mi}) + \mathrm{Var}(e_{Mi})\mathrm{Var}(e_{Tj}) \end{aligned} \quad (7)$$

Equation 6 shows that the residual variances of product indicators, e_{MiTj}, is composed of three components, namely $\lambda^2{}_{Mi}\mathrm{Var}(F_M e_{Tj})$, $\lambda^2{}_{Tj}\mathrm{Var}(F_T e_{Mi})$ and $\mathrm{Var}(e_{Mi} e_{Tj})$. These components form the basis of one set of non-linear equality constraints, which necessitates constraint #3 (Equation 7). Constraint #3 also indicates that $e_{Mi} e_{Tj}$ may share the same variance components among themselves, which may result in correlated errors between these $e_{Mi} e_{Tj}$. For example, $e_{M2} e_{T3}$ and

$e_{M3}e_{T3}$ share Var(e_{T3}). Therefore all the paths between error terms of multiplicative indicators must be freed *except* where there is no variance sharing. For our analysis, the matrix below shows 0 = Fixed Path (the two multiplicative error terms are not allowed to covary) and 1 = Free Path (the two multiplicative error terms are allowed to covary). This set of fixed paths establishes *constraint #4*.

	e_{M1T1}	e_{M1T2}	e_{M1T3}	e_{M2T1}	e_{M2T2}	e_{M2T3}	e_{M3T1}	e_{M3T2}	e_{M3T3}
e_{M1T1}	1								
e_{M1T2}	1	1							
e_{M1T3}	1	1	1						
e_{M2T1}	1	0	0	1					
e_{M2T2}	0	1	0	1	1				
e_{M2T3}	0	0	1	1	1	1			
e_{M3T1}	1	0	0	1	0	0	1		
e_{M3T2}	0	1	0	0	1	0	1	1	
e_{M3T3}	0	0	1	0	0	1	1	1	1

The final step is to establish the covariance between the latent interaction construct and other latent constructs. It has been shown that when variables are normally distributed and mean centered, the covariance of each with the latent interaction construct is zero (Kendall and Straut, 1958; Kenny and Judd, 1984). This is because $E[\mathrm{Cov}(F_M F_T, F_T)] = E(F_M F_T F_T) - E(F_M F_T)\, E(F_T)$. Since all odd moments are zero, then $E(F_M F_T F_T)$ equals 0 and since all mean centered variables have expected values of zero, then $E(F_T)$ also equals 0. Then $E[\mathrm{Cov}(F_M F_T, F_T)]$ is 0 and similarly $E[\mathrm{Cov}(F_M F_T, F_M)]$ is 0. It follows that the correlations between the marketing-related capabilities construct and the latent interaction construct, as well as between the technology-related capabilities construct and the latent interaction construct, are zero. Therefore the final *constraint #5* is:

$$\phi_{FM.FMFT} = \phi_{FT.FMFT} = 0 \qquad (8)$$