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Technological capabilities and firm performance: The case of small manufacturing firms in Japan

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Abstract The purpose of this study is to investigate the relationship between technological capabilities and firm performance. We divide technological capabilities into two types—*refinement capability*, which involves the improvement of the existing asset portfolio, and *reconfiguration capability*, which involves the restructuring of the asset portfolio through the integration of new assets. The results of an analysis of a sample of 302 small and medium-sized manufacturing firms in Japan suggest that refinement capability relates more positively to operational efficiency than does reconfiguration capability, and that reconfiguration capability relates more positively to strategic performance than does refinement capability. The results also suggest that firms with superior refinement capability tend to possess superior reconfiguration capability. Our findings show that both external and internal factors, such as technological volatility, inter-firm collaboration, and firm age and size, are significantly associated with the level of refinement and reconfiguration capabilities possessed by a firm.

Keywords Technological capabilities · Competitive advantage · Resource-based view · Dynamic capability

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Introduction

There is a growing body of literature on the means by which firms can develop a sustainable competitive advantage in rapidly changing and unpredictable environments (Karim & Mitchell, 2000; Teece et al., 1997; Eisenhardt & Martin, 2000). The resource-based view of the firm (RBV) sees a firm as a bundle of resources (Penrose, 1959; Wernerfelt, 1984; Peteraf, 1993; Conner, 1991; Barney, 1991; Bruton et al., 2007) and suggests that a firm's distinctive resources are the direct sources of its sustainable competitive advantage. The general premise of the RBV is that firms that upgrade their existing resources in a path-dependent manner are more likely to achieve superior performance. From a related but different perspective, the dynamic capability theory highlights a firm's capability to reconfigure its asset structure as being the key source of its sustainable competitive advantage (Eisenhardt & Martin, 2000; Teece et al., 1997; Mathews, 2002). The general premise of the dynamic capability theory is that firms that reconfigure their resources faster than their rivals to capture newly emerging market opportunities are more likely to achieve superior performance.

These two perspectives indicate that the capability to refine proprietary assets (refinement capability) and the capability to reconfigure the asset structure (reconfiguration capability) are the critical sources of a firm's competitive advantage. However, most firms are unable to simultaneously refine and reconfigure their existing asset structure, for two reasons. First, refinement and reconfiguration involve different—and often conflicting—strategic orientations. Second, firms have limited resources, and thus the choice between the two orientations has critical strategic implications. The aims of our study, therefore, were to examine critical strategic issues. Whether firms should focus on *refining* existing assets to build a stronger competitive position? Or, whether they should focus on *reconfiguring* their asset structure through the integration of new assets into the existing asset portfolio faster than their rivals? Although there are a growing number of studies that have investigated the impact of firm resources on performance, few have clearly differentiated between the effects of refinement and reconfiguration of the asset structure, and almost no studies have simultaneously examined the impact of these two strategies on performance.

In this study, we have assumed that refinement and reconfiguration capabilities have different associations with corporate performance. Building on the classification of organizational learning by March (1991), we argue that refinement capability facilitates *exploitation*, which involves the refinement of existing resources that are currently available and the improvement of the current (short-term) performance of existing routines, whereas reconfiguration capability facilitates *exploration*, which involves the acquisition of new knowledge and the improvement of future (long-term) performance through new routines. A failure to account for the distinct effects of the two types of capabilities on performance may mask the fact that a firm's choice of strategic action is endogenous to its expected outcome in both the short and the long term, which suggests that decision-makers should seek to understand how each capability results in different performance outcomes (Hamilton & Nickerson, 2003).

Another issue to be addressed is the interaction between refinement capability and reconfiguration capability. Recent strategic management studies have suggested that

the processes of refinement and reconfiguration are dynamically linked in a sequential and path-dependent manner (Eisenhardt & Martin, 2000). The management of the interaction between refinement capability and reconfiguration capability is therefore critical to the development of a sustainable competitive advantage. Although firms usually grow through the period of exploitation and exploration (Holmqvist, 2004), we have a poor understanding of how the two types of capabilities co-evolve and interact in the development of a sustainable competitive advantage by facilitating exploitation and exploration. This study fills this gap by systematically examining both the antecedents to and consequences of these two capabilities.

Theory

Building on the RBV perspective and the dynamic capability theory, we propose that firms need to engage in the strategic processes of refining and reconfiguring their existing asset structure to create and maintain a competitive advantage. The capability to refine the existing asset structure involves the efficient utilization and improvement of existing resources. In contrast, the capability to reconfigure the existing asset structure involves the redeployment of assets by integrating internal and external sources of technology to capture new market opportunities. In this study, we call the former capability *refinement capability* and the latter *reconfiguring capability*.

Relationship between refinement capability and corporate performance

The RBV assumes that a firm achieves a competitive advantage not only because it owns proprietary assets, but also because it possesses a superior ability to utilize and upgrade these assets (Penrose, 1959; Wernerfelt, 1984; Barney, 1991). Dierickx and Cool (1989: 1506) suggest that resources should be differentiated as either asset flows or asset stocks, and that "strategic asset stocks are accumulated by choosing appropriate time paths of flows over periods of time." Feedback effects, which amplify the heterogeneity among organizations (Levinthal & Myatt, 1994), have similar implications. The notion that underlies the concept of feedback effects is that the more resources a firm possesses, the more likely it is to be able to accumulate and upgrade knowledge than its rivals, and at a faster rate. Feedback effects have naturally self-reinforcing characteristics, in that a firm can acquire more resources if it has a large pool of resources to begin with. In this respect, some scholars argue that a firm's ability to utilize its assets and resources should be considered the primary source of its competitive advantage (Amit & Shoemaker, 1993).

Teece et al. (1997) suggest that a firm's technological assets evolve in a path-dependent manner. Path dependence describes a situation in which a firm builds on what it already knows, which means that what it chooses to do or know in the future depends on what it chose to do or knew in the past (Langlois, 1995). A firm accumulates resources as the result of the path-dependent processes of investment, learning, and decision-making that it adopts over time (Dierickx & Cool, 1989). For example, a firm's current research and development (R&D) activity is closely related

to its previous R&D activity (Nelson & Winter, 1982; Helfat, 1997). As a result of this path dependence, firms tend to confine themselves to a limited set of technological domains and lose flexibility in their ability to respond to environmental change (Levitt & March, 1988; Tushman & Anderson, 1986).

Refinement capability tends to enhance operational efficiency. As March pointed out, "the certainty, speed, proximity, and clarity of feedback ties exploitation to its consequences more quickly and more precisely than is the case with exploration" (1991: 73), because firms know and can predict their technological domains and existing products. Henderson and Cockburn (1994) found that a firm's previous or cumulative success increased the likelihood of its future success and explained a substantial portion of the variance in heterogeneity across firms. These arguments suggest that the refinement of existing resources and capabilities tends to enhance operational efficiency through path-dependent, incremental improvement. This leads us to set forth the following hypothesis.

Hypothesis 1 The greater a firm's refinement capability, the greater its ability to enhance its operational efficiency.

Relationship between reconfiguration capability and corporate performance

In a rapidly changing environment, firms must develop new technologies and change their asset structure to adapt to new environmental opportunities (Karim & Mitchell, 2000), because existing organizational practices and routines may reduce a firm's flexibility to adapt to new changes (Levitt & March, 1988). Scholars have therefore emphasized the importance of the firm's ability to integrate, reconfigure, gain, and release resources to match and even to create market change (Eisenhardt & Martin, 2000: 1107). This ability is often referred to as the "dynamic capability" of a firm (Teece et al., 1997; Eisenhardt & Martin, 2000; Henderson & Cockburn, 1994).

Dynamic capability represents the natural processes by which a firm creates a preferable circular system or routine, both through the deployment of capabilities in product markets and through the integration of various types of resources within the organization or with other organizations (Teece et al., 1997). The concept of dynamic capability is akin to the concept of combinative capability, which is defined as the ability to synthesize and apply current and acquired knowledge (Kogut & Zander, 1992), and also to the concept of architectural competence, which is defined as the ability to access new knowledge outside organizational boundaries and to integrate knowledge flexibly across the disciplinary and therapeutic class boundaries within the organization (Henderson & Cockburn, 1994).

Scholars of the RBV recognize that resources and capabilities have different effects on corporate performance. For example, Henderson and Cockburn (1994) studied the sources of competitive advantage in the pharmaceutical industry and differentiated component competence, which involves the local activities and knowledge that are required to solve day-to-day problems, from architectural competence, which involves the ability to use component competencies, integrate them effectively, and develop new competencies. They found that architectural competencies explained a significant portion of the variance in research productivity across firms.

The commonality among combinative capability, architectural competence, and dynamic capability is that a firm's sustainable advantage comes from its ability to reconfigure its asset structure through the integration of internal and external sources of technology to capture new market opportunities in changing environments. Unlike the refinement process, a firm that reconfigures its assets will wait many years before seeing a positive outcome (Teece et al., 1997), because the returns from the reconfiguration of new assets are often more distant in time and more variable than those derived from the refinement of existing assets (March, 1991). In support of this view, Isobe (2000) reported that small and medium-sized manufacturing firms took, on average, more than four years to successfully change their technological competences, and over five years to earn a profit from them. Thus, reconfiguration capability relates to long-term performance in areas such as new product development and technological innovation (Floyd & Lane, 2000), which we term "strategic performance."

Hypothesis 2 The greater a firm's reconfiguration capability, the greater its ability to enhance its strategic performance.

Relationship between refinement capability and reconfiguration capability

Cohen and Levinthal (1990) suggested that a firm's existing knowledge base (or previous related knowledge) plays a key role in its innovative activities. This knowledge base is referred to as *absorptive capacity*, which is defined as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990: 128). The notion that underlies absorptive capacity is that a firm's competence in the future depends on its existing level of technological assets and knowledge, which serve to simultaneously enhance and inhibit technological innovation (Leonard-Barton, 1992). Studying market entry strategies in the medical equipment industry in the United States, Mitchell (1989) observed the level of a firm's industry-specific capabilities to be significantly associated with the likelihood that the firm would effectively utilize its existing resources and exploit new technology within that industry. Similarly, Henderson and Cockburn (1994) found that a firm's previous or cumulative success increased the likelihood of its future success, which explained a substantial portion of the variance in heterogeneity across firms.

Some scholars have suggested that dynamic capabilities are the natural processes through which firms create a preferable circular system or routine with which they can identify valuable resources, deploy them in attractive product markets in which such resources would be most effectively utilized, and create new distinctive competencies or integrate internal and external resources (Teece et al., 1997; Winter, 1995). Firms usually accumulate and upgrade their distinctive resources and capabilities through an incremental process of refinement, which in turn enhances the chance of breakthrough innovation. Dierickx and Cool (1989) stressed that the amount and level of a firm's resources are the primary determinants of reconfiguration capability. In essence, these arguments suggest that the refinement of existing assets is a prerequisite to the successful reconfiguration of these assets in the development of a sustainable competitive advantage. We therefore expect firms

that have superior refinement capability to also have superior reconfiguration capability.

Hypothesis 3 The refinement capability of a firm is positively associated with its reconfiguration capability.

Data and methodology

The data that were used in this study were collected by a mail survey that was sent to the member firms of the Osaka Industrial Association. A questionnaire was separately mailed to each of the presidents of 917 small to medium-sized manufacturing firms in the association. Three hundred and seventeen questionnaires were returned, of which 302 were suitable for analysis, giving a response rate of 32.5%. Small to medium-sized firms were selected because they tend to have a relatively limited number of core products or technologies and their managers are therefore likely to have a good understanding of the firm's key technologies and their impact on the firm's core competencies, which would improve the accuracy of the responses.

Following the non-response bias detection method (Armstrong & Overton, 1977), we made comparisons between several key variables for the earlier and later respondents in our sample. We considered respondents who responded within two weeks of being sent the questionnaire to be "early respondents" (183) and the rest to be "late respondents" (119). The *t* tests showed no significant differences for any of the variables between the early and late respondent groups. We also examined the potential response bias that might stem from differences in firm size in terms of number of employees and industrial sector. As the Spearman's correlation and variance analysis showed no significant association between primary activities and firm performance, we concluded that neither industry difference nor firm size effects would bias the findings of the study.

We sent the same questionnaire to the technology or manufacturing managers of the responding firms, and 71 questionnaires were returned. These were then compared with the questionnaires that were initially returned by the presidents of the firms in terms of the variables representing refinement capability, reconfiguration capability, and firm performance. All of the variables were positively and significantly correlated, but only the data that were collected from the first respondents were used in the analysis.

In addition, to test for possible self-reporting bias in the measurement of performance, we examined whether the profitability of the selected firms in our sample (67 in total) as reported by the managers was significantly correlated with the profitability as reported in the *Nikkei Mijoujou Kigyo Soran 2000* (Directory of Non-listed Companies). There was a significant correlation (profitability $r=0.402$, $p<0.01$) between the profitability measures that were obtained from the two different sources of information, which indicates that the performance measures have a reasonable validity.

Because we could not use external subjective measures, we were obliged to rely on the self-reported assessments of the presidents of the firms that were surveyed.

We followed the approach of Podsakoff and Organs (1986) to assess the likelihood of common method variance being present in our data. If common method variance is present, then a confirmative factor analysis (CFA) that contains all of the constructs should yield a single method factor. The fit indexes for a single-factor model (AGFI= 0.61; CFI=0.57; RFI=0.48; RMR=0.11; and RMSEA=0.16) suggest a poor model fit, indicating that the data were not subject to common method bias to any significant extent. In addition, we assessed the discriminant validity of all of our measures by using two-factor CFA models that involved each possible pair of constructs. In all cases, the chi-square value of the unconstrained model was significantly less than that of the constrained model, which provides evidence of discriminant validity for all of our constructs, with $\Delta\chi^2$s falling within the range 17.33 to 190.74.

The overall measurement model employed 16 items to measure four exogenous and four endogenous constructs. The exogenous constructs, which were included as control variables, were firm size, age, inter-firm collaboration, and technological volatility. The endogenous constructs represent the two types of capabilities—refinement and reconfiguration—and the two performance constructs of operational efficiency and strategic performance. Details of the individual items that were used to measure each construct are presented in the Appendix.

Of the four exogenous constructs of firm size, age, inter-firm collaboration, and technological volatility, firm size and age were included because we assume that they represent certain aspects of refinement capability. Hannan and Freeman (1989: 72–73) suggested that well-established firms have two advantages—*reliability*, or the capacity to "produce collective products of a given quality repeatedly," and *accountability*, or the capacity to "account rationally for their actions," both of which favor the refinement, rather than the reconfiguration, of the asset structure of a firm.

Inter-firm collaboration, which is embedded in a firm's close interactions with its suppliers, customers, and particular institutions, often brings new resources and opportunities, and can thus serve as a significant source of competitive advantage for a firm (McEvily & Zaheer, 1999; Gulati, 1999; Phan & Peridis, 2000; Peng & Delios, 2006; Mathews, 2006). Many empirical studies have found positive relationships between inter-firm links, technological development, and firm performance (Powell et al., 1996; Henderson & Cockburn, 1994; Baum et al., 2000). For example, Powell et al. (1996: 119) argued that "inter-firm collaborations are not simply a means to compensate for the lack of internal skills, nor should they be viewed as a series of discrete transactions," and suggested that a firm can further develop and strengthen its internal competence through collaboration. Similarly, Tushman (1977) argued that collaboration tends to make partner firms more aware of outside opportunities, making them more flexible and innovative in dynamic environments. Consistent with these arguments, Powell et al. (1996) found that a knowledge creation process of external linkages in the form of inter-firm collaborations led to superior technological performance.

We added the technological volatility variable in the model because, according to the dynamic capability perspective, to develop a sustainable advantage in uncertain and unpredictable environments firms need to develop a stronger reconfiguration capability (Teece et al., 1997; Brown & Eisenhardt, 1997). The variable was therefore included to control for the possible effects of the uncertainty that arises from technological volatility on the development of reconfiguration capability.

The respondents were asked to report their responses to all of the questionnaire items, except for firm size and age, on a five-point Likert scale. To assess the internal reliability, we calculated the Cronbach's alpha for the items that loaded on each construct, and found that all of the items loaded above the 0.7 level, which is the cut-off point recommended by Nunnally (1978). Table 1 shows the descriptive statistics and internal reliability of the data.

The hypotheses were tested using the confirmatory factor analysis known as structural equation modeling. This method allowed us to identify the antecedents of both refinement capability and reconfiguration capability and their impact on the two performance variables. The model used in the analysis was estimated using LISREL, and is described in Figure 1.

Results

The overall fit of the model is excellent, as indicated in Table 2. The p value of the chi-square, which indicates the deviation of the variance–covariance matrix of the model, is insignificant at p=0.20, and the other indicators of fit (AGFI=0.92, CFI=0.99, RFI=0.95, RMR=0.041, and RMSEA=0.017) are all in the range that is considered to be indicative of an excellent overall fit of the model to the data.

The fit for the structural equations of the endogenous variables ranges from adequate to excellent for a cross-section of the data. The construct of reconfiguration capability fits particularly well, with R^2=0.72, thus demonstrating that the model captures this proposed phenomenon very well. R^2=0.56 for refinement capability, and R^2=0.50 for strategic performance, which are also very good results for cross-sectional data. Given that short-term performance is likely to be influenced by many

Table 1 Descriptive statistics: Correlation coefficients and Cronbach's alphas.

	Construct	1	2	3	4	5	6	7	Items	Cronbach's alpha
1	Firm size								1	–
2	Firm age	0.19**							1	–
3	Technological volatility	0.21**	0.08						3	0.72
4	Inter-firm collaboration	0.15**	0.05	0.28**					3	0.82
5	Refinement capability	0.32**	0.32**	0.22**	0.14**				2	0.81
6	Reconfiguration capability	0.26**	0.26**	0.71**	0.51**	0.46**			2	0.84
7	Operational efficiency	0.11*	0.11*	0.08	0.05	0.16**	0.16**		2	0.79
8	Strategic performance	0.21**	0.15**	0.52**	0.37**	0.40**	0.64**	0.14**	2	0.77

n=302
*p<0.05
**p<0.01

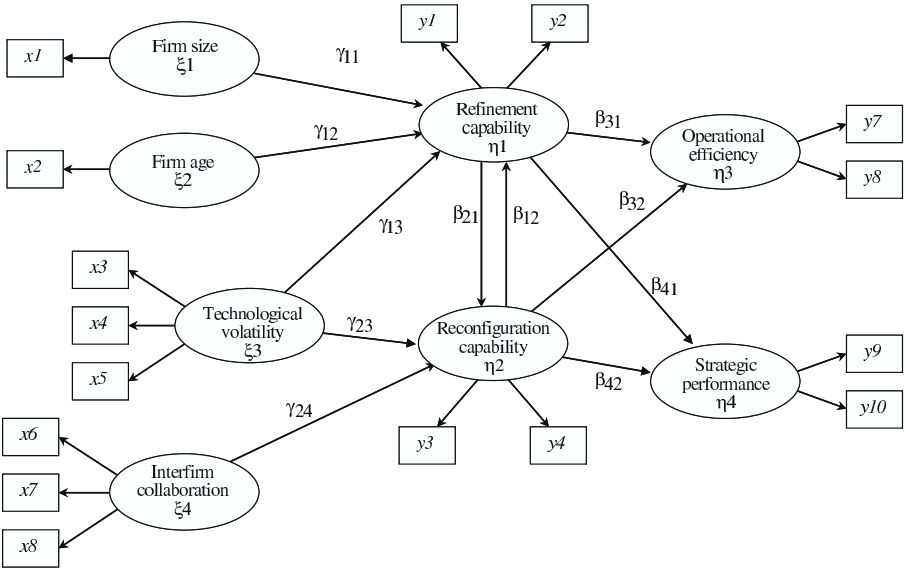

Figure 1 Paths between the latent variables

factors outside of the scope of our model, R^2=0.10 is adequate for operational efficiency.

The maximum likelihood estimates of these coefficients and their degree of significance are presented in Table 2. All of the regression coefficients in the structural equations are significant, except for β41 (refinement capability on strategic performance) and β32 (reconfiguration capability on operational efficien-

Table 2 LISREL results by maximum likelihood estimators.

Constructs	Refinement capability	Reconfiguration capability	Operational efficiency	Strategic performance
Firm size	γ11 0.23*			
Firm age	γ12 0.27**			
Technological volatility	γ13 −0.26*	γ23 0.26**		
Inter-firm collaboration		γ24 0.36**		
Refinement capability		β21 0.36**	β31 0.26*	β41 0.11
Reconfiguration capability	β12 0.24*		β32 −0.01	β42 0.86**
Adjusted R^2	0.56	0.72	0.10	0.50

n=302; chi-square=77.63, df=68 p=0.20; adjusted goodness of fit index (AGFI)=0.92; comparative fit index (CFI)=0.99; relative fit index (RFI)=0.95; root mean square residual (RMR)=0.041; root mean square error of approximation (RMSEA)=0.017.
*p<0.05
**p<0.01

cy). These results strongly support Hypotheses 1 and 2, which predict positive associations between refinement capability and operational efficiency (Hypothesis 1) and between reconfiguration capability and strategic performance (Hypothesis 2). Consistent with Hypothesis 3, we found refinement capability to have a positive and significant effect on reconfiguration capability at well above the 0.01 level.

The total standardized coefficients are presented in Table 3. The standardized coefficients reflect a measure of the relative importance of each predictor variable on the endogenous variables (Goldberger, 1964), indicating the "typical" variation in an endogenous variable that is associated with the "typical" variation in an independent variable, where "typical" is calibrated according to the sample standard deviations of all of the variables.

Our results show refinement capability to be the most important construct (0.28) for operational efficiency and reconfiguration capability (0.97) to be the most important construct for strategic performance, followed by refinement capability (0.45) and inter-firm collaboration (0.33). Although firm size and age are less important for both the performance variables, their effects are not trivial and are statistically supported. Refinement capability is most significantly linked with firm age (0.30), reconfiguration capability (0.26), and size (0.25). Inter-firm collaboration (0.39) and refinement capability (0.39) are by far the most important determinants of reconfiguration capability, followed by technological volatility (0.18). These results suggest that inter-firm collaboration plays a vital role in the enhancement of reconfiguration capability. In terms of the relationship between refinement capability and reconfiguration capability, our results show that the effects of refinement capability on reconfiguration capability (0.39) are 1.5 times greater than the effects of reconfiguration capability on refinement capability (0.26).

Discussion and conclusion

This study investigates the way in which refinement capability and reconfiguration capability independently and jointly influence the operational efficiency and strategic performance of firms. Our findings suggest that refinement capability has a greater positive impact on operational efficiency than does reconfiguration capability, and that reconfiguration capability has a greater positive impact on

Table 3 Standardized total effects of the exogenous and endogenous constructs.

	Refinement capability	Reconfiguration capability	Operational efficiency	Strategic performance
Firm size	0.25	0.09	0.06	0.10
Firm age	0.30	0.11	0.08	0.12
Technological volatility	−0.22	0.18	−0.06	0.13
Inter-firm collaboration	0.09	0.39	0.02	0.33
Refinement capability	0.09	0.39	0.28	0.45
Reconfiguration capability	0.26	0.09	0.06	0.97

All values greater than 0.09 are significant at the 0.01 level.

strategic performance than does refinement capability. These findings suggest that refinement capability contributes primarily to short-term improvement and superior operational performance, whereas reconfiguration capability mainly influences long-term improvement and superior strategic performance.

The results for the relationship between refinement and reconfiguration capabilities suggest that the effects of refinement capability on reconfiguration capability are greater than the effects of reconfiguration capability on refinement capability. A possible interpretation of this finding is that refinement capability and reconfiguration capability have different implications for a firm's asset configuration: whereas refinement capability may leverage resources for reconfiguration capability, reconfiguration capability may limit the availability of resources for refinement capability.

The results of our analyses also suggest that firm size and age are significantly and positively associated with a firm's refinement capability, which in turn enhances both the firm's operational efficiency and its strategic performance. Our results imply that, consistent with the evidence that has been found by previous studies (Rothaermel, 2001; Lane & Lubatkin, 1998; Lee et al., 2001), external learning through inter-firm collaboration has a stronger impact on reconfiguration capability than on refinement capability.

This study makes several contributions to the literature of organizational learning and strategic management. First, we have simultaneously examined the relationship between refinement capability and reconfiguration capability and their respective impact on performance, and show that they have different effects on firm performance. Specifically, our findings suggest that refinement capability enhances short-term operational efficiency, whereas reconfiguration capability enhances long-term strategic performance. The existing literature tends to ignore the effects of refinement capability and reconfiguration capability on performance, but our study demonstrates that the two capabilities should be treated separately in future research, and that their effects on different levels or kinds of performance merit further examination.

Second, we have examined the systematic relationships between refinement capability and reconfiguration capability. Makadok (2001: 391) suggested that understanding the relationship between "resource-picking" and "capability-building" mechanisms is one of the most important issues in strategy research. Our study partly addresses this issue. Our evidence suggests that a firm's refinement capability significantly enhances its reconfiguration capability, which in turn enhances its strategic performance, whereas a firm's refinement capability directly enhances its operational efficiency, yet has little impact on its strategic performance. These findings suggest that inter-firm collaboration, refinement capability, and reconfiguration capability work dynamically and complementarily in developing a competitive advantage for a firm. An important extension of this study would be to investigate how firms use inter-firm collaboration to manage the dynamic process of co-evolution between refinement capability and reconfiguration capability, and how they resolve the potential problems of expropriation (Hamel, 1991), competency traps (Levitt & March, 1988), and core rigidity (Leonard-Barton, 1992) that often arise in collaborative partnerships. This kind of research, however, requires in-depth, longitudinal case studies.

The third contribution of our study is its use of survey data. Previous studies of refinement and reconfiguration capability have been mostly conceptual. Although an increasing number of researchers have identified sources of competitive advantage and have investigated the relationship between resources and firm performance, most have measured both types of capabilities using proxies for technological competencies such as R&D expenditure, the number of patents, and the development of new products (Hitt & Ireland, 1985; Hitt et al., 1990). In contrast, our study directly measured refinement capability and reconfiguration capability through a survey of senior decision-makers in the sample firms.

Finally, this study is one of the few in the field of dynamic capability research to adopt a causal modeling method (structural equation modeling) for the analysis. We incorporated the effects of refinement capability and reconfiguration capability, firm age and size, technology volatility, and inter-firm collaboration into the model and examined the systematic associations among these variables. Unlike traditional regression models, the causal modeling method can help to elucidate the systematic associations between the antecedents to and consequences of refinement capability and reconfiguration capability.

This study has two implications for practitioners. First, our evidence suggests that the impact of refinement capability on operational efficiency is greater than that of reconfiguration capability, although reconfiguration capability has a greater impact on strategic performance, such as the development of new technological bases, than refinement capability. Our study suggests that both the refinement and reconfiguration of a firm's asset structure are critical to the achievement of superior performance in the short and long term. Although reconfiguration capability is not easy to develop, managers should recognize that the mere accumulation or refinement of assets does not guarantee a sustainable competitive advantage. In a rapidly changing environment, firms need to continuously search for new competence bases and reconfigure their existing portfolio of competences. Our evidence clearly shows that much of the variation in the strategic performance of firms is explained by the variation in their level of reconfiguration capability.

Second, our evidence suggests that inter-firm collaboration is a very effective means of enhancing reconfiguration capability. Although our sample includes only small to medium-sized firms, the evidence suggests that even small firms with limited resources should be able to develop a sustainable competitive advantage that is comparable to that of resource-rich large enterprises through the formation of collaborative relationships with other firms, and can thereby enhance their reconfiguration capability with new competence bases. Some firms may be reluctant to form alliances or other forms of collaboration with other firms because of the risk of expropriation of proprietary knowledge, but they should recognize that the key issue in inter-firm collaboration is not about how to avoid these risks, but about how to develop a good partnership through which to explore new competitive opportunities for both collaborating parties.

Despite its contributions, this study also has some potential limitations. We focus only on refinement capability and reconfiguration capability as key elements of competitive advantage, and other elements that affect performance, such as organizational culture, leadership, marketing competence, and other functional skills, are ignored. As superior performance is often based on a complex mix of

interrelated and organizationally embedded resources (Black & Boal, 1994), further in-depth investigation is necessary to gain a deeper understanding of the links between different sets of resources and their relative impacts on performance. The moderate R^2 for operational efficiency in our results suggests that further development of the performance model may also be helpful, although the very high R^2 for strategic performance suggests that the current model is sufficiently strong.

This study is cross-sectional in nature and says little about the dynamic process of a competitive strategy (Porter, 1991; Priem & Butler, 2001; Foss et al., 1995). Some scholars have recently proposed a new perspective that emphasizes the dynamic and evolutionary nature of technological competencies (Teece et al., 1997; Eisenhardt & Martin, 2000; Amit & Schoemaker, 1993). This perspective views a firm's distinctive competence as a "process" rather than a fixed asset and aims to explain the way in which a firm allocates resources for innovation over time, how it deploys its existing resources, and where it obtains new resources. However, because our study is cross-sectional, it does not capture the actual process of competence development.

Appendix Measurement items

Control variables

ξ1 Firm size
x1 Number of employees
ξ2 Firm age
x2 Age (year)
ξ3 Technological volatility
x3 Our technologies/products are substituted for new technologies/products (very unlikely–very likely).
x4 Our technologies become obsolete rapidly (very unlikely–very likely).
x5 Major technological innovations frequently appear in our industry (very unlikely–very likely).
ξ4 Inter-firm collaboration
x6 We aggressively participate in technological alliances (very unlikely–very likely).
x7 We obtain important product/market information from external sources (suppliers, customers, and alliance partners) rather than internal sources (internal search) (very unlikely–very likely).
x8 We frequently develop new products or services with customers (very unlikely–very likely).

Activity variables

η1 Refinement capability
y1 Our new technologies/products are highly related to existing technologies/products (very unlikely–very likely).
y2 We improve production processes and quality (very unlikely–very likely).
η2 Reconfiguration capability

y3 We always search for new and promising technologies (very unlikely–very likely).
y4 We integrate internal and external technologies (very unlikely–very likely).

Performance variables

η3 Operational efficiency
y5 Our profitability is higher than that of our major competitors (very low–very high).
y6 Our production process is more efficient than that of our major competitors (very unlikely–very likely).
η4 Strategic performance
y7 We develop more new technologies/products than our major competitors (very unlikely–very likely).
y8 The sources of our technological competence are significantly different than those of three years ago (very late–very early).

*Items with verbal anchors in parentheses had a 1–5 response scale.

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