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BALANCING VERTICAL INTEGRATION AND STRATEGIC OUTSOURCING: EFFECTS ON PRODUCT PORTFOLIO, PRODUCT SUCCESS, AND FIRM PERFORMANCE

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Most prior research has focused on vertical integration or *strategic outsourcing in isolation to examine their effects on important performance outcomes. In contrast, we focus on the simultaneous pursuit of vertical integration* and *strategic outsourcing. Our baseline proposition is that balancing vertical integration and strategic outsourcing in the pursuit of* taper integration *enriches a firm's product portfolio and product success, and in turn contributes to competitive advantage and thus to overall firm performance. We derive a set of detailed hypotheses, and test them on a unique and fine-grained panel of longitudinal data documenting over 3,500 product introductions in the global microcomputer industry. The results provide strong support for the notion that carefully balancing vertical integration and strategic outsourcing when organizing for innovation helps firms to achieve superior performance.* Copyright © 2006 John Wiley & Sons, Ltd.

A long and venerable tradition of cross-disciplinary scholarship is concerned with the boundaries of the firm (e.g., Coase, 1937; Thompson, 1967; Williamson, 1975; Galbraith, 1977). Determining the boundaries of the firm appears to be critical for firm performance, especially in high-technology industries (Teece, 1986, 1992; Bettis and Hitt, 1995; Hill and Rothaermel, 2003). Most of the extant research, however, examines the trade-offs between internalizing activities vs. sourcing them externally through market transactions (Walker and Weber, 1984; Jones and Hill, 1988; Leiblein, Reuer, and Dalsace, 2002) or through strategic alliances (Pisano, 1990; Folta, 1998; Steensma and Corley, 2001). While firms often trade off economizing on transaction costs vs. access to dispersed knowledge stocks and enhanced flexibility in making these important governance decisions, many firms are partially integrated *and* simultaneously outsource some activities (Harrigan, 1984; Afuah, 2001). We argue that these firms seek to identify the most effective balance in both organizing alternatives to leverage their benefits and mitigate their costs.

Following Harrigan's theoretical contribution, we label this organizing approach *taper integration*, which occurs 'when firms are backward or forward integrated but rely on outsiders for a portion of their supplies or distribution' (Harrigan 1984: 643). Thus, taper integration arises when a firm sources inputs externally from independent suppliers as well as internally within the boundaries of the firm, or disposes of its outputs through independent outlets in addition to company-owned distribution channels. Taper integration implies

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that some activities are pursued in a parallel manner, both in-house and through outsourcing. We argue that taper integration enhances a firm's product portfolio, new product success, and firm performance, in particular, if a firm effectively balances the two strategic components of taper integration, i.e., vertical integration and strategic outsourcing.

The benefits of pursuing *either* vertical integration *or* strategic alliances have been highlighted in numerous prior studies (e.g., Hill and Hoskisson, 1987; Jones and Hill, 1988; Kogut, 1988; Hagedoorn, 1993; Dyer, 1996; Dyer and Singh, 1998; Gulati, 1998; Stuart, 2000; Rothaermel, 2001; Ireland, Hitt, and Vaidyanath, 2002). In contrast, while the use of taper integration has been growing in prominence in a number of industries, little empirical research has examined the effects of this practice on firm outcomes. The dearth of empirical research is likely due to the methodological difficulty of capturing taper integration in a theoretically proximal fashion.

We undertake herein a first step towards closing the gap in our knowledge of the effects of taper integration. Our overarching hypothesis is that balancing vertical integration and strategic outsourcing in a prudent manner helps to optimize a firm's product portfolio and achieve product success. In so doing, it contributes to a firm's competitive advantage and thereby increases firm performance. To test this hypothesis, we examine the *joint effects* of simultaneously pursuing vertical integration *and* strategic outsourcing on a firm's product portfolio, new product success, and firm performance.

First, we suggest that vertical integration and strategic outsourcing interact to synergistically increase a firm's product portfolio. Building a portfolio of related products can contribute to a competitive advantage, particularly in highly dynamic markets (Brown and Eisenhardt, 1997). Next, we assess the individual effects of vertical integration and of strategic outsourcing on a firm's product portfolio, product success, and performance. Here, we suggest that these relationships resemble an inverted U-shape, reflecting the theoretical notion that vertical integration and strategic outsourcing should be balanced to achieve the desired firm-level outcomes.

To the extent that the products in the portfolio are at the cutting edge of technology and serve customer needs, they are likely to enjoy success in the marketplace. It is unlikely, however, that all products in a firm's portfolio will be successful, especially when there are a large number of them (Sanderson and Uzumeri, 1995). Firms must have the capability to manage a large number of products to target them for the appropriate market segments and to ensure their differentiation as perceived by the consumers. The difficulty of successfully accomplishing these tasks increases as the number of related products in the firm's portfolio grows, thereby enhancing the managerial challenges. This effect is likely to be particularly pronounced when firms face a high level of uncertainty, common in high-technology industries (Bettis and Hitt, 1995). We propose a synergistic interaction effect of vertical integration and strategic outsourcing on the size of a firm's product portfolio, while also suggesting that a moderate product portfolio size will have the strongest effect on subsequent new product success and firm performance.

The theoretical model presented herein makes a contribution by highlighting the performance-enhancing consequences of balancing two different organizational forms, vertical integration and strategic outsourcing, constituting taper integration. We draw on a longitudinal sample of firms in the global microcomputer industry to test the hypothesized relationships on an original panel dataset. In this research, we also make a methodological contribution by developing a unique and theoretically proximate measure of individual new product success, derived from a detailed analysis of over 3,500 product introductions. We conclude that successfully organizing for innovation can be accomplished through taper integration that balances the costs and benefits inherent in this hybrid organizational form to create product portfolios that enhance new product success and overall firm performance.

THEORY AND HYPOTHESES DEVELOPMENT

Taper integration and product portfolios

Firms must continuously develop and introduce new products to the marketplace to achieve and maintain a competitive advantage. New product introductions have the potential to create transitory advantages for firms, because they enable the firms to capture returns to innovation (Schumpeter, 1942). These advantages, however, are frequently short lived in dynamic industries (Bettis and Hitt, 1995; Bayus, Erickson, and Jacobson, 2003). As a result, firms often build portfolios of related products to deter entry through product proliferation, increasing their customer base, better serving customer needs, and maintaining strategic flexibility (Brander and Eaton, 1985; Hill, 1997). This in turn allows firms to respond rapidly to changes in the marketplace initiated by, for example, a competitor's introduction of new products (Brown and Eisenhardt, 1997). To build competitive product portfolios, firms increasingly attempt to combine the benefits from economizing on transaction costs through vertical integration (Williamson, 1975) with those derived through strategic outsourcing such as enhanced flexibility and access to a broader stock of knowledge external to the focal firm (Powell, Koput, and Smith-Doerr, 1996).

Firms vertically integrate to build entry barriers, facilitate investments in specialized assets, protect product quality, and improve scheduling and coordination (Williamson, 1975; Chandler, 1977; Harrigan, 1984). Vertical integration has the potential to enrich a firm's new product development because it provides the opportunity to integrate tacit knowledge with complementary assets across different value chain activities (Teece, 1986). In technologically advanced industries, where suppliers often control vitally important new technology, internalizing these technological capabilities affords control and assures access to the knowledge necessary to build a portfolio of products based on cutting-edge technology (Afuah, 2001).

While the determination of firm boundaries appears to be mediated by industry structure and firm capabilities (Argyres, 1996), a fundamental assumption of transaction cost economics is that firms can alter their boundaries based on managerial discretion (Williamson, 1975, 1985). One could argue, however, that this assumption may not hold in some industries. For example, in the microcomputer industry, the setting for this study, it may be considered an unlikely option for microcomputer manufacturers to integrate backwards into chips or forward into operating systems, because these value chain activities have been basically monopolized by Intel and Microsoft, respectively. While this example provides some evidence that the determination of firm boundaries is mediated by the existing industry structure, recent developments in microcomputing suggest that some firms have successfully integrated backwards into designing their own chips and are beginning to develop proprietary operating systems (Engardio and Einhorn, 2005). Nonetheless, backward and forward integration along the value chain clearly pose significantly differential strategic challenges. While integration into some value chain activities seems to be fairly effortless, integration into other activities can be quite difficult, the latter depending on the industry structure and the capabilities held by the integrating firm. Nonetheless, Leiblein and Miller (2003) found that internalization is likely under conditions of uncertainty regardless of the level of asset specificity. Therefore, vertical integration should facilitate new product development and thereby contribute to expanding the firm's product portfolio.

Because cutting-edge knowledge necessary for innovation tends to be widely dispersed across different firms, continual innovation in highly dynamic industries appears only possible if a firm reaches beyond its boundaries. This observation has prompted some to suggest that the locus of innovation might be found in a network of alliances rather than within individual firms, especially in high-technology industries (Powell *et al.*, 1996; Rothaermel and Deeds, 2004). Access to knowledge external to the firm, in addition to internal knowledge, enriches a firm's absorptive capacity (Cohen and Levinthal, 1990), and enables firms to avoid path dependence in the development of internal technological knowledge stocks (Collis, 1991; Lei, Hitt, and Bettis, 1996). Nicholls-Nixon and Woo (2003), for example, show that the ability to produce product innovations requires both internal and external R&D investments, leading firms to engage in a variety of strategic alliances. Integrating internal and external technological knowledge stocks allows a firm to build a larger and broader portfolio of related products in order to gain and maintain a competitive advantage or to achieve at least competitive parity.

These arguments suggest that under conditions of uncertainty prevalent in high-technology industries (Bettis and Hitt, 1995), firms tend to source some of the knowledge necessary for new product development through strategic alliances. In their inductive study of innovation in the computer industry, Brown and Eisenhardt (1997), found that firms using strategic alliances to probe and access cutting-edge knowledge external to the

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focal firm were more successful in their new product introductions. Similarly, others established that the sharing of knowledge across firm boundaries improves firm-level innovation when studying flat panel displays (Spencer, 2003), an important component in the microcomputer industry. Thus, when considering vertical integration and strategic outsourcing in isolation, prior research provides convincing evidence that *each* organizational form has the potential to expand a firm's product portfolio.

Herein, we argue that the *simultaneous* pursuit of vertical integration *and* strategic outsourcing allows for the integration of internal and external knowledge stocks to increase the number of products in the firm's product portfolio. Under conditions of uncertainty, firms can enrich their product portfolios by internalizing current valuable technological knowledge. At the same time, they must develop and maintain external sourcing relationships to gain access to new technical knowledge developed beyond the firm's boundaries (Cohen and Levinthal, 1990; Kotabe, Martin, and Domoto, 2003). Furthermore, the integration of currently valuable internal technical knowledge and new external technical knowledge can produce spillover effects that enable firms to profitably improve current products as well as to introduce additional related products in order to gain and maintain a competitive advantage.

Taper integration is thus a unique organizational form in which the simultaneous pursuit of vertical integration and strategic outsourcing has the potential to create synergy that facilitates development of new products to increase a firm's product portfolio. Taper integration enables a firm to economize on transaction costs, to obtain access to diverse sources of knowledge, to integrate tacit knowledge and complementary assets, and thereby to enhance its strategic flexibility. While this organizational form clearly increases the complexity of managerial tasks such as coordinating and scheduling, and also has non-trivial bureaucratic costs (Jones and Hill, 1988), a larger product portfolio is nevertheless a significant benefit. Thus, all else being equal, we suggest that firms with greater taper integration tend to have more products in their portfolio.

Hypothesis 1: The interaction between a firm's degree of vertical integration and level of strategic outsourcing has a positive effect on the number of related products in the firm's portfolio.

Balancing vertical integration and strategic outsourcing

The overarching hypothesis in this study is that balancing vertical integration and strategic outsourcing helps to optimize a firm's product portfolio and to improve product success, thereby contributing to a firm's competitive advantage and firm performance. Achieving balance implies that taper integration should be based on a somewhat equal emphasis on vertical integration and on strategic outsourcing. A balance in taper integration is achieved when a firm neither focuses too much on vertical integration nor on strategic outsourcing. This in turn implies that each organizing form in isolation should exhibit a curvilinear relationship on valuable firm-level outcomes. Thus, we hypothesize that the direct effects of each vertical integration and strategic outsourcing on a firm's product portfolio, product success, and firm performance are characterized by diminishing returns with the relationships resembling an inverted U-shaped function.

Extensive vertical integration can produce diminishing effects on firm-level outcomes for a number of reasons. Harrigan (1984), for example, highlights the disadvantages of extensive vertical integration such as increased managerial costs in coordinating integration over multiple stages of the value chain, the potential for either excess capacity or underutilization of resources because of unevenly balanced productivity across different value chain activities, technological obsolescence, strategic inflexibility, increased mobility and exit barriers, tight coupling to poor performing business units, lack of information and feedback from suppliers and distributors, among other problems. Thus, the greater the extent of vertical integration, the lower the degrees of strategic freedom and the greater the bureaucratic costs associated with it. When the loss in strategic flexibility and the increase in bureaucratic costs outweigh the benefits gained through vertical integration (Jones and Hill, 1988), diminishing returns result. These arguments suggest that the relationship between the degree of vertical integration and the firm-level outcomes of product portfolio, product success, and performance is inverted U-shaped.

Hypothesis 2: The effects of a firm's degree of vertical integration on the size of its product portfolio (2a), new product success (2b),

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and firm performance (2c) are characterized by diminishing returns such that the relationships resemble an inverted U-shape.

In a similar fashion, the extensive pursuit of strategic outsourcing through alliances can also exhibit diminishing returns on firm-level outcomes (Rothaermel, 2001). Several theoretical arguments support this relationship. First, firms frequently compete for the most promising outsourcing options, and thus enter them first. Based on the classical Ricardian rent model, this leaves only less productive alliance options as firms engage more intensively in strategic outsourcing. Second, increasing reliance on strategic outsourcing implies that firms engage in multiple outsourcing agreements simultaneously at any given point in time, and thus managerial attention, frequently a constrained resource, may become overloaded and thus inadequate to oversee a firm's alliance activities. Increasing demands on managerial attention in turn accentuates the cognitive limitations of managers. Third, as firms enter an increasing number of outsourcing alliances, their commensurate transaction and bureaucratic costs increase, beyond a point where gains to additional alliances are outweighed by their marginal costs (Jones and Hill, 1988), thus producing diminishing returns.

Hypothesis 3: The effects of a firm's degree of strategic outsourcing on the size of its product portfolio (3a), new product success (3b), and firm performance (3c) are characterized by diminishing returns such that the relationships resemble an inverted U-shape.

Product portfolio, product success, and firm performance

Firms tend to add new products to their portfolios as they acquire new knowledge and integrate it with their existing knowledge base, in particular in highly dynamic industries. The new knowledge often builds upon the existing knowledge, allowing for improvements in existing products such as higher quality and greater ability to satisfy consumer needs. As a result, this process of knowledge creation and integration often improves the success of the related products in the portfolio. The mix of different knowledge stocks enriches the firm's capability to expand its product portfolio and to offer a greater variety of related products; in so doing, the firm can better satisfy customer needs in a manner superior to competitors' product offerings (Brown and Eisenhardt, 1997; Sirmon, Hitt, and Ireland, 2007).

In a highly dynamic industry, a larger product portfolio often is important to gain and maintain a competitive advantage. Technological and market uncertainties provide entrepreneurial opportunities (McGrath and MacMillan, 2000), which firms can exploit by developing new technologies and products that satisfy market requirements. Firms with rich product portfolios are also in a position to gain first mover advantages as opportunities arise (Lieberman and Montgomery, 1988). In addition to knowledge spillovers, a large portfolio of related products also helps to achieve economies of scale and scope in production as well as marketing and distribution, thus reducing unit production costs while simultaneously increasing product variety (Kotha, 1995). Furthermore, firms that regularly develop and introduce new products to the market tend to improve their innovation processes over time, and are thus in a better position to affect market change that favors their new product introductions (Brown and Eisenhardt, 1997).

Product portfolios, however, must also be managed. While larger product portfolios provide multiple benefits, they also produce non-trivial managerial costs. Even related products engender coordination costs. As a result, managers may experience information overload, as has been demonstrated by firms with more diversified product portfolios (Hoskisson and Hitt, 1994). In fact, to create synergy and to gain the greatest value from related products, substantial coordination is often required, particularly with a large portfolio of related products. A large portfolio requires managers to carefully coordinate a diverse set of activities along the value chain to meet market demand; the managerial attention that can be given to any one product is thus limited. In addition, marketing budgets can also be diluted in firms with overly large product portfolios. As a result, overall product success is likely to be lower if product portfolios are increased indiscriminately. Without efficient managerial coordination to compensate for increasing production complexities, new product introductions can suffer from poor product quality, lack of necessary differentiation, and other shortcomings, directly reducing firm performance.

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When striving to optimize new product success and firm performance, it is necessary for firms to achieve a close match between the size of their product portfolios and external market demand, otherwise negative performance implications are likely to exist. For example, the technology-based firm, Texas Instruments (TI), experienced a drastic erosion of its market share because of its single-minded focus on the experience curve concept, which required product portfolios with large scale and low variety. Over time, TI had developed a strong core competence in high-volume, low-cost manufacturing (Prahalad and Hamel, 1990). As market demand shifted, however, towards calculators with more features, TI was surpassed by competitors, Casio and Hewlett-Packard, because its strong core competence became a core rigidity (Leonard-Barton, 1992). In contrast, Sony attempts to maintain an innovative product portfolio that provides a variety of high-quality products while simultaneously maintaining its product portfolio at a reasonable size. Sony holds the actual number of its Walkman models on the market more or less constant at any given time. It maintains this balance by continuously introducing new models while retiring older ones (Sanderson and Uzumeri, 1995). Integrating the set of arguments suggests that the effects of the size of the firm's product portfolio on product success and firm performance are curvilinear, such that they are positive for small and medium size product portfolios, but turn negative for large product portfolios.

Hypothesis 4: The effects of the size of a firm's product portfolio on new product success (4a) and firm performance (4b) are characterized by diminishing returns such that the relationships resemble an inverted U-shape.

METHODS

Research setting

The research setting for this study is the global microcomputer industry. This industry is composed of firms manufacturing a variety of smaller computers such as desktops, laptops/notebooks, servers/workstations, and handhelds. We chose the microcomputer industry for several reasons.

First, this industry exhibited considerable growth in the past two decades, largely due to continuous technological innovations that resulted in greater computing power and simultaneously lower prices. For example, Moore's law predicting an exponential growth in the number of transistors per integrated circuit every 12–18 months became a self-fulfilling prophecy. Second, a large number of firms compete in this industry, thereby enabling meaningful firm-level statistical analysis over a number of years. The microcomputer industry's Herfindahl–Hirschman index, for example, was 811 during the mid-1990s, indicating a fairly low level of concentration in the industry. Third, firms in this industry tend to introduce many new products. As a result, the random factors that might affect the success of any single new product development effort can be balanced over time, resulting in more reliable measures of a firm's product portfolio and product success. Moreover, the microcomputer industry is generally not characterized by blockbuster successes based on a single product introduction, unlike the pharmaceutical industry, which attenuates a potential skewness in proxies for product success. Finally, while many microcomputer firms tend to pursue some degree of taper integration, they differ significantly in the extent to which they emphasize vertical integration and strategic outsourcing, respectively. For example, IBM maintained a relatively high level of vertical integration over time, while Dell outsources a large number of its components.

These characteristics explain why the microcomputer industry is viewed as a hypercompetitive, high-velocity environment (D'Aveni, 1994; Bettis and Hitt, 1995; Brown and Eisenhardt, 1997). Overall, the microcomputer industry presents a suitable research setting to test our theoretical model of the relationships among vertical integration, strategic outsourcing, product portfolio, product success, and firm performance.

To test the hypotheses advanced, we created a longitudinal panel dataset covering the 4-year time period between 1994 and 1997. We focused on this particular time period for several reasons. First, this period was characterized by incremental product innovations in the microcomputer industry within a given dominant design (Teece, 1986; Anderson and Tushman, 1990), thus allowing us to control for more radical innovations. Second, the microcomputer industry is a standards-driven industry to ensure that all components work together reasonably well. The microcomputing standard was established in the early 1980s with the introduction of the IBM PC built on an open architecture with a Microsoft operating system (MS-DOS) and Intel's X86 microprocessor architecture (Hill, 1997). Finally, the time period under investigation witnessed the rise of multimedia applications and the Internet, in addition to the continued convergence with the telecommunications and consumer electronics industries. These factors placed a premium on continuously introducing successful new products. A similar time frame was used by Brown and Eisenhardt (1997) in their study of continuous organizational change and product innovations in the computer industry.

Sample and data

We gathered the data for this study from the Computer Select and Computer Company Profiles databases, numerous computer industry and company publications, Security Data Company (SDC Platinum), Lexis/Nexis, Compustat, Mergent FIS, SEC 10-K reports, and the U.S. Patent and Trademark Office. While several of the sources have been used in strategic management research, others are unique. The latter category includes the Computer Select and Computer Company Profiles databases published by Ziff Communications of New York. These databases are publicly available and contain abstracts, full text, and graphics from over 150 computer and general publications. They are published monthly, and each issue contains a rolling year of data. The Computer Company Profiles database is factual and objective in nature and does not include any comparative or evaluative analyses. This database lists qualitative information about each firm such as its participation in the industry value chain, product portfolio, year of founding, whether the firm is public or private, whether the firm is a U.S. or an international firm, etc.

This sampling approach required us to address censoring issues. Some firms in the sample did not offer applicable products at the beginning of the study, and other firms withdrew from the market within the time frame of the study. Ignoring data from these firms creates a potential bias, so we included all firms that received at least four qualifying product reviews, which equates, on the average, to one product review per year for each firm during the study period. The purpose for choosing this cut-off point was to ensure that an adequate number of data points would be available for each firm. Moreover, including multiple product reviews for a single firm enhanced the reliability and validity of the new product success measure.

The worldwide population of microcomputer companies as listed in the Computer Company Profiles database consisted of 224 firms as of December 1997. Applying the sampling frame described above, we were able to obtain complete data on 123 microcomputer manufactures (55% of the population), for a sample size of 492 firm years over the 4-year study period. The sample is quite diverse with small and large, public and private, U.S. and non-U.S. firms. Comparing the means of the sample with those of the population reveals, however, that the sample is not significantly different statistically (annual revenues $p < 0.63$; number of employees $p < 0.40$; public vs. private ownership $p < 0.56$; U.S. vs. non-U.S. firms $p < 0.53$), which further enhances our confidence in the representativeness of the sample drawn.

A second issue in the sample construction involved methods of treating subsidiaries of a larger parent firm. We aggregated data from subsidiaries to obtain a composite score for a single parent firm. For example, this was done in the case of AT&T and NCR. NCR was acquired by AT&T in 1991 and subsequently spun-off in the fall 1996 trivestiture of AT&T, the new NCR, and Lucent Technologies. All of the NCR products that qualified for product reviews were pre-trivestiture products and hence classified as AT&T products. Similarly, all of the qualifying Packard-Bell product reviews occurred after the July 1996 merger of Packard-Bell and NEC. Finally, all of the qualifying Zenith Data Systems reviews occurred prior to NEC's February 1996 acquisition of Zenith Data Systems. A detailed review of the Lexis/Nexis Computing and Telecommunications database revealed no other changes in ownership status that affected the measurement of the variables.

Variables and measures

Product portfolio

We proxied the size of a firm's product portfolio by the number of microcomputer products that a firm offered in each year between 1994 and

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1997. During this time period, all sample firms combined had a total of 13,125 products in their portfolios, which equates to an average of 27 products per year for each firm. This measure includes all microcomputer products that the firms sold during each year, rather than limiting it to the products that were newly introduced and reviewed in computer publications.

Product success

Measuring the performance of individual new products across a different range of products and a diverse set of companies is challenging, because firms generally do not reveal revenues for individual products. Therefore, any attempt to measure the success of newly introduced products entails significant ambiguity. One of the goals for this research, however, is to develop and contribute a theoretically proximal and fine-grained measure of the performance of newly introduced products. Here, Godfrey and Hill (1995) suggest that researchers should track the observable consequences of otherwise illusive constructs.

Thus, to assess the success of individual product introductions in the microcomputer industry, we relied on experts' ratings in industry publications. Expert evaluations have been used in prior research, for instance, in the assessment of the performance of strategic alliances (Lane and Lubatkin, 1998). To proxy a firm's new product success, we gathered individual new product evaluations from microcomputer product reviews contained in the Computer Select publications database. We limited the searches to the top-ten computer industry publications as measured by computer industry advertising revenues.[1] We employed two primary criteria in selecting new product reviews. First, we required that a minimum of four products be included in the review. This procedure allowed for a more effective comparison of products because product reviews with fewer than four products tended to rate all products highly, and thus were more akin to advertisements. Second, the new product reviews had to provide a competitive evaluation indicating that one or more of the products were favored over the others. Based on these criteria, we calculated and recorded the individual evaluations for 3,559 newly introduced microcomputer products during the study period.

We classified each of the 3,559 products reviewed into one of four coding categories: clear winners = 4; runners-up = 3; neutral = 2; losers = 1.[2] Next, we calculated an aggregated measure of new product success at the firm level of analysis. The development of this measure was complicated by a high variance in the selectivity of the different product reviews. For example, a product review article with 5 winners out of 100 is much more selective than one with 5 winners out of 10. We corrected for this selectivity in the development of the product review scores. We calculated an adjusted review score to account for the variance in difficulty inherent in the product reviews. Here, we set the adjusted review score (*ARS*) equal to the assigned review score (*RS*) multiplied by one minus the *ex ante* probability of any single product in that review receiving a winning rating (p). We set the value of p equal to the number of winning products divided by the total number of products in each review. By definition, the adjusted review scores [$ARS = RS \times (1 - p)$] varied between zero and four. Finally, we calculated the annual adjusted review scores for each firm. To accomplish this, we set the denominator k equal to the number of products that were reviewed per firm in each year t. The following formula summarizes this procedure and depicts the measure to proxy a firm's new product success in year t:

$$\text{New product success}_t = \frac{\sum_{1}^{k_t}[RS \times (1 - p)]}{k_t} \quad (1).$$

While the sample firms may compete in different segments of the microcomputer industry (desktops, laptops/notebooks, servers/workstations, and handhelds), the vast majority of microcomputer

[1] The top-ten industry publications by computer advertising revenues (in millions) in 1995 were: (1) *PC Magazine* ($213.9); (2) *Wall Street Journal* ($129.4); (3) *PC Week* ($118.0); (4) *Computer Shopper* ($103.3); (5) *Computer World* ($87.3); (6) *PC World* ($86.1); (7) *Computer Reseller News* ($80.0); (8) *Info World* ($79.6); (9) *Business Week* ($74.8); (10) *PC Computing* ($70.2) (Computer Industry Almanac, 1996).

[2] Assessment of inter-rater reliability was necessary for the *Computer Shopper* articles due to the lack of an objective scheme underlying the review. A random sub-sample of 10 *Computer Shopper* reviews was independently coded by a second researcher. The inter-rater reliability for these ten articles was equal to 1.0 (i.e., perfect inter-rater agreement).

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products offered in this industry were desktops and laptops/notebooks (hereafter referred to as laptops). The microcomputer industry largely consisted of two primary segments—desktops and laptops—during the study period covering the mid-1990s. This skewed distribution between different types of microcomputer products is mirrored in the frequency of product evaluations. Accordingly, the majority of products reviewed were desktops (66.5% or 2,368 product evaluations) and laptops (29.3% or 1,043 product evaluations), together composing almost 96 percent (or 3,411 product evaluations) of the 3,559 product evaluations. Servers/workstations composed only 3.9 percent (138 product evaluations), and handhelds made up merely 0.3 percent (10 product evaluations) of all products evaluated. To ensure a more homogeneous sample, we eliminated the 148 product evaluations for servers/workstations and handhelds, thereby focusing on the dominant segments of desktops and laptops (this did not, however, affect the robustness of the results; see the Appendix for more details). Thus, we used a total 3,411 product evaluations in the final analyses. The average product reviewed received a neutral evaluation in terms of its adjusted review score (2 out of 4), regardless of market segment.

To account, however, for the variation in the frequency of product evaluations and to assess potential idiosyncrasies of different market segments, we developed three different measures to assess a firm's new product success: (1) a composite new product performance score for the full sample containing both desktop and laptop computers; (2) a new product performance score for desktop computers only; and (3) a new product performance score for laptop computers only. While the sample comprises 123 firms, 108 firms competed in desktops, and 69 firms competed in laptops, with 54 firms competing in both segments. All firms in the sample competed in desktops and/or laptops, and no single firm competed in either servers/workstations or handhelds exclusively. Thus, all firms were retained in the sample.

Firm performance

We proxied overall firm performance using total annual revenues. If a firm's products succeed in the marketplace, they capture higher revenues regardless of whether a firm pursues a low-cost leadership or a differentiation strategy (Porter, 1985). Further support for revenues as a performance metric is shown by the fact that the large majority of the sample firms (92%) focus on computers as their dominant business. In addition, revenue data were more readily available than alternative performance measures such as net income or return on assets, because the majority of the firms in the sample were privately held (71%), and some were international firms (10%). All revenue data were converted into U.S. dollars corresponding to the historic dollar value. Due to skewness in the revenue data, we applied a logarithmic transformation. Further, we lagged firm revenues by one time period (*Lagged firm performance)*, and included it in the regression model to control for a potential specification bias arising from unobserved heterogeneity (Jacobson, 1990).

Vertical integration

We based the measure of vertical integration on each firm's participation in different activities of the industry value chain. In particular, we assessed whether a certain value chain activity was pursued within the boundaries of the firm. To construct the vertical integration measure, we combined a deductive approach to the value chain (Porter, 1985) with detailed industry descriptions of the microcomputer industry (e.g., Grove, 1996; Rivkin and Porter, 1999). The microcomputer industry value chain consists of five distinct activities depicting a product's progression from upstream to downstream stages in the value chain (Grove 1996: 39-45): (1) chips; (2) computers (desktops and laptops); (3) software: operating system; (4) software: applications; (5) sales and service. Drawing on data from the Computer Select database, we developed a matrix of indicator variables to code each firm's participation/non-participation in the different activities of the microcomputer industry value chain (1 = activity pursued in-house). To obtain a vertical integration score at the firm level, we summed the scores from the five different value chain activities to obtain an aggregate measure to proxy each firm's degree of vertical integration.

To assess the validity and reliability of the Computer Select data, a second researcher independently coded business press coverage during the study period drawn from Lexis/Nexis. These sources, such as the *Wall Street Journal* and *Business Week*, frequently provide information on the

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value chain activities of microcomputer companies. We found the intersource reliability to be $r = 0.68$ ($p < 0.001$), and thus providing evidence of acceptable reliability (Cohen *et al*., 2003). Given the variance in the sample with respect to firm size, level of vertical integration, public and private ownership, U.S. and international firms, the similarity of these relatively coarse-grained data is heartening. Furthermore, the results reported below are consistent regardless of the data source employed, providing further evidence of acceptable reliability.

Based on the sample construction, all firms in this study were involved in the second value chain stage, in-house manufacturing of microcomputers. Thus, the minimum score of vertical integration is 1, while the maximum score is 5, implying full vertical integration. Indeed, the full range of vertical integration is represented in the sample.[3]

Strategic outsourcing

Firms generally structure their outsourcing activities through strategic alliances, defined as 'voluntary arrangements between firms involving exchange, sharing, co-development of products, technologies, or services' (Gulati, 1998: 293). We focused on contractual relationships between firms because such inter-firm cooperation reflect formal collaboration between independent firms, and thus are more likely to capture the theoretical construct of strategic outsourcing.

To develop fine-grained and theoretically proximate strategic outsourcing measures required several steps. First, we proxied each firm's degree of strategic outsourcing by the total number of strategic alliances in which a firm engaged for each year *t* during the study period. To enhance the accuracy and reliability of the strategic outsourcing data, one researcher obtained alliance data from the strategic alliance database published by Security Data Company (SDC Platinum),[4] while a second researcher independently coded press coverage documenting the sample firms' alliance activity drawn from the Lexis/Nexis database. The intersource reliability was $r = 0.86$ ($p < 0.001$), suggesting high reliability (Cohen *et al*., 2003).

In a second step, to closely tie the strategic outsourcing measure to the theory advanced above, we developed two fine-grained measures of strategic outsourcing based on a detailed content analysis of each alliance. Overall, the firms in the sample entered a total of 1,205 alliances during the study period. Central to our theoretical arguments is the concept of taper integration, which occurs when a firm pursues the same value chain activity in-house as well as through strategic outsourcing with external partners. Thus, to develop two distinct strategic outsourcing measures, we compared the content description of each alliance to a firm's value chain activities pursued in-house, the proxy for vertical integration. We coded alliances that mapped to a value chain activity that a firm pursued in-house as *strategic outsourcing taper*, while alliances that did not map onto a firm's value-chain activities pursued in-house were coded as *strategic outsourcing quasi*. The latter construct captures the theoretical notion of quasi integration (Harrigan, 1984), because one part of the value chain is internalized, while another part is conducted through outsourcing with external partners.

The 1,205 alliances represented 852 taper alliances (71%) and 353 quasi alliances (29%), and are count measures based on whether an alliance mapped onto a value chain activity of the firm (*strategic outsourcing taper*) or not (*strategic outsourcing quasi*). Moreover, the discriminant validity of the two strategic outsourcing proxies is highlighted in their low bivariate correlation of $r = 0.29$ (8.4% common variance), well below the common variance necessary to be considered a single construct (Cohen *et al*., 2003). About 41 percent of the sample firms pursued taper integration, and approximately 36 percent of the firms engaged in quasi integration. Additionally, about 22 percent of the sample firms simultaneously pursued both taper and quasi integration.

[3] It is important to note that a value of 1 for vertical integration merely captures microcomputer manufacturing, and thus, one could argue, does not represent vertical integration. Applying ranges of 1 to 5 for a firm's value chain activities rather than ranges of 0 to 4, where one would only focus on vertical integration *beyond* microcomputer manufacturing was necessary, however, to construct fine-grained measures of strategic outsourcing discussed directly below. Moreover, given that all firms participate at least in the same one value chain activity (in-house manufacturing), results are affected only when there is one or more additional value chain activities in which the firm participates, producing the necessary variance.

[4] For a recent application of the SDC alliance database in strategic management research see Anand and Khanna (2000).

Control variables

We included a diverse set of control variables to account for other potential effects on a firm's product portfolio, product success, and firm performance, and thus to reduce the threat of a potential specification bias due to unobserved heterogeneity.

Firm age

Research suggests that older firms tend to introduce more innovations, albeit incremental ones (Sørensen and Stuart, 2000). Over time, firms also establish routines and overcome the liability of newness (Stinchcombe, 1965), which should enhance their performance and likelihood of survival. We calculated firm age as the difference between the current year and the firm's founding date for each year *t* during the study period. The average microcomputer firm in the sample was 14 years old.

Herfindahl–Hirschman Index

A firm's market power, frequently reflective of its size, changes over time as firms merge, pursue vertical integration, or exit certain industries, all of which affect firm performance. We controlled for this potential effect when estimating the impact of vertical integration and strategic outsourcing on product portfolio and product success by including in the analyses firm-level Herfindahl–Hirschman indexes (HHI) for each year *t*, which were proxied by each firm's annual squared market share (Carlton and Perloff, 1994).

Employees

When estimating firm performance, a firm-level Herfindahl–Hirschman index was not a suitable measure for firm size, because the construction of the index directly depends on firm revenues, our proxy for performance. We thus used the number of employees as a control for firm size when estimating firm performance, commonly used to control for firm size in high-technology industries (Sørenson and Stuart, 2000; Rothaermel and Deeds, 2004). The average firm in the sample employed about 14,000 people. Because the employee data were only available for about 60 percent of the sample, we needed to impute the missing data, which did not affect the robustness of the results (see Appendix for more detail). It is noteworthy that other control variables such as firm age, number of patents, and lagged firm performance are highly correlated with firm size, and thus we are reasonably confident of our ability to isolate the effects of vertical integration, strategic outsourcing, and product portfolio on firm performance beyond firm size effects.

Patents

Firm patents are a potentially important input into the new product development process (Griliches, 1990). We proxied each firm's patenting activity using a count of the total number of patents received in each year *t* during the study period. Prior research has established the reliability of patent count data because it has shown that patent count data are highly correlated with citation-weighted patent measures, thus proxying the same underlying theoretical construct (Hagedoorn and Cloodt, 2003; Stuart, 2000). For example, the bivariate correlation between patent counts and citation-weighted patents has been shown to be above 0.77 ($p < 0.001$) in the pharmaceutical industry (Hagedoorn and Cloodt, 2003), and above 0.80 ($p < 0.001$) in the semiconductor industry (Stuart, 2000), indicating some generalizability of this assertion. The average microcomputer firm in the sample obtained about 75 patents per year.

U.S. firm

We controlled for institutional differences (Hennart, Roehl, and Zietlow, 1999) by including in the analyses a dummy variable distinguishing U.S. and non-U.S. based microcomputer companies (1 = U.S. firm) using the firm's headquarters location; 90 percent of the sample firms were headquartered in the United States.

Public firm

We controlled for the ownership status of the firm by including a dummy variable with 1 = public firm and 0 = private firm. Only about 29 percent of the sample firms were public.

Dominant microcomputers

It is critical to control for the degree of overall firm diversification when assessing the effect of different organizing forms on product portfolio, product success, and firm performance in a single industry. We assessed each firm's level of diversification based on Rumelt's (1974) seminal work. He classified a firm's business as dominant if the firm obtains 70 percent or more of its revenues from a single business activity, which is indicative of a low level of diversification. Building on this definition, we created a dummy variable indicating that a firm's dominant business is in microcomputers if the firm obtained 70 percent or more of its revenues from microcomputers (1 = dominant business is in microcomputers, 0 = all others). The vast majority of firms in the sample exhibited little unrelated diversification; as 92 percent of the firms' dominant business was microcomputers.

Mergers and Acquisitions

A third alternative to structure innovation—in addition to vertical integration and strategic outsourcing—is to engage in mergers and acquisitions (Nicholls-Nixon and Woo, 2003). We controlled for this option by including a count variable indicating the number of mergers and acquisitions in which the focal firm was engaged in year t during the study period (*Mergers & Acquisitions*). To assess the validity and reliability of the SDC data, a second researcher independently coded business press coverage pertaining to M&A activity in the microcomputer industry during the study period drawn from Lexis/Nexis. We found the intersource reliability to be $r = 0.72$ ($p < 0.001$), and thus above the recommended criterion (Cohen *et al*., 2003). The average sample firm engaged in one merger or acquisition every 2 years.

Estimation procedure

The data used in this study are longitudinal, and thus represent a panel dataset. Panel data follow a given set of companies over time, and thus provide multiple observations on each firm. In this sample, we followed 123 firms over 4 years, which equals 492 firm years. It is important to note that a majority of empirical work in strategic management relies on cross-sectional data, and does therefore not allow for causal inferences (Hitt, Gimeno, and Hoskisson, 1998). Panel data are considered a superior alternative due to distinct advantages over cross-sectional data (Hsiao, 2003). Panel data allow the researcher to control for the initial values of the dependent variable and to recognize time lag effects. Panel data also enable the researcher to draw on a larger sample, and thereby increase statistical power and reduce the threat of multicollinearity among independent variables, which in turn enhance the efficiency of the econometric estimates (Boyd, Gove, and Hitt, 2005).

We used generalized least square (GLS) regression analysis to test the hypotheses advanced (Greene, 2003).[5] The GLS procedure produces more efficient estimates than a general linear regression model, because it minimizes a weighted sum of squared residuals. GLS estimates are corrected for autocorrelation and cross-section heteroscedasticity, while estimating weighted averages of the within and between firm effects. We applied a more conservative approach by estimating the GLS regression models with White heteroscedasticity-consistent standard errors and covariances. This estimation procedure produces covariances that are robust to general heteroscedasticity, because variances within a cross-section are allowed to differ across time.

All hypotheses advanced in the theoretical model above indicate the inclusion of interaction terms, either as linear cross-products of two different variables (Hypothesis 1) or as cross-products of the same variable to create squared terms to assess the potential for diminishing returns (Hypotheses 2–4). Testing moderated regression models requires the inclusion of the direct effects as well as the interaction effects. This approach is a relatively conservative method for examining interaction effects, because the statistical significance of the interaction term is evaluated after all lower-order effects have been controlled (Jaccard, Wan, and Turrisi, 1990).

To enhance the interpretability of the regression results and to reduce potential multicollinearity, we standardized all independent variables (Cohen *et al*., 2003). While neither degrading the quality of the data nor affecting the statistical significance levels, this procedure allows us to directly compare beta coefficients across different variables with different scales. The variables for the interaction terms were standardized prior to creating the

[5] For a recent application of GLS regression analysis in strategic management research, see Kotha and Nair (1995).

respective cross products. To assess the threat of multicollinearity, we calculated the variance inflation factors (VIFs) for each coefficient. The maximum estimated VIF for all direct effects across the three different dependent variables was 3.7, and thus well below the recommended ceiling of 10 (Cohen *et al*., 2003).

As expected, the VIFs for the interaction terms, however, were somewhat elevated. This is because these interaction terms are either linear cross products of two different variables or cross products of the same variable to construct squared terms. One undesirable consequence of potential multicollinearity is inflated standard errors that can result in overall statistically significant regression models, while failing to identify statistically significant coefficients for individual variables. Thus, multicollinearity can lead to Type II errors. The results presented below, however, are not materially influenced by potential multicollinearity, because most of the individual cross products and squared terms are statistically significant. Moreover, the coefficients behave appropriately and consistently across different regression models. It is also important to note that potential multicollinearity does not bias the coefficient estimates or influence the overall model fit (Kennedy, 1996: 177).

RESULTS

Table 1 presents the descriptive statistics for and bivariate correlation among the variables, while Tables 2–4 contain the regression results. We first estimated a respective baseline model for each dependent variable, containing the control variables only (Models 1, 5, 7, 9, and 11). All models used to assess the hypotheses represent a statistically significant improvement over their respective baseline models ($p < 0.001$ in all cases).

In Hypothesis 1, we postulated that the interaction between a firm's degree of vertical integration and level of strategic outsourcing has a positive effect on the number of related products in the firm's portfolio. Because the results of direct effects cannot be interpreted in a meaningful way when the regression contains both direct and interaction effects, based on the cross-products of the direct effects of interest (Cohen *et al*., 2003: 259–260), we first inserted the direct effects for strategic outsourcing quasi, strategic outsourcing taper, and vertical integration to predict a firm's product portfolio (Model 2). This allows us to isolate the effect of each organizing form individually, while controlling for the other organizing forms. The results in Model 2 indicate that each organizing form has a positive and statistically significant effect (at $p < 0.01$ or smaller) on the size of a firm's product portfolio. In Model 3, we inserted the interaction terms to assess the simultaneous effect of vertical integration and strategic outsourcing on the size of a firm's product portfolio. The statistically significant positive interaction terms between strategic outsourcing quasi and vertical integration ($p < 0.001$) and between strategic outsourcing taper and vertical integration ($p < 0.05$) indicate that firms pursuing quasi integration or taper integration tend to have larger product portfolios. Thus, the individual effects of strategic outsourcing are enhanced synergistically in the presence of vertical integration, above and beyond each organizing forms' direct effects. These results provide support for Hypothesis 1.

In Hypothesis 2, we stated that the effects of a firm's degree of vertical integration on the size of its product portfolio (Hypothesis 2a), new product success (Hypothesis 2b), and firm performance (Hypothesis 2c) are characterized by diminishing returns such that the relationships are inverted U-shaped. Model 4 contains the linear terms for strategic outsourcing quasi, strategic outsourcing taper, and vertical integration along with the squared terms for each organizing form to assess the diminishing returns hypothesis for the product portfolio (Hypothesis 2a). Model 4 does not contain the interaction effects that were included in Model 3, because an inclusion of the interaction terms would cause the direct effects, necessary to analyze Hypotheses 2 and 3, to be uninterpretable (Cohen *et al*., 2003: 259–260). If interaction terms are included, the direct effects of each organizational form can only be understood contingent upon the moderating variable, as in Model 3. Based on the results obtained in Model 4, we find support for Hypothesis 2a, because the linear term of vertical integration is positive and statistically significant ($p < 0.001$), while the squared term is negative, and also statistically significant ($p < 0.001$).

We assessed Hypothesis 2b in Models 6, 8, and 10. When relating vertical integration to product success in the combined desktop and laptop

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Table 1. Descriptive statistics and bivariate correlation matrix

	Mean	S.D.	Min.	Max.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Product portfolio	26.70	31.29	1	189															
2. Product success (full sample)	1.887	0.421	0.75	3.77	0.20														
3. Product success (desktop)	1.905	0.415	0.75	3.77	0.15	0.94													
4. Product success (laptop)	1.880	0.526	0.80	3.70	0.21	0.77	0.36												
5. Firm performance (sales million $)	4,960	14,715	0.73	87,000	0.38	0.06	0.07	0.08											
6. Firm age	14.27	18.89	0	109	0.34	0.02	0.06	0.08	0.64										
7. Herfindahl–Hirschman index	6.50	26.00	1.41E-08	173.11	0.31	−0.02	0.09	−0.01	0.55	0.62									
8. Employees	13,954	42,721	2	250,000	0.41	0.01	0.09	0.00	0.66	0.66	0.93								
9. Patents	74.66	262.24	0	1,895	0.40	0.03	0.01	0.09	0.53	0.59	0.47	0.57							
10. U.S. firm	0.90	0.30	0	1	0.08	0.08	0.05	0.08	−0.31	−0.31	−0.15	−0.17	−0.35						
11. Public firm	0.29	0.45	0	1	0.24	−0.02	−0.09	0.10	0.50	0.37	0.22	0.29	0.39	−0.30					
12. Dominant micro-computers	0.92	0.27	0	1	0.02	0.06	0.03	0.00	−0.48	−0.58	−0.32	−0.35	−0.50	0.60	−0.43				
13. Mergers & Acquistions	0.47	1.78	0	15	0.55	0.08	0.05	0.09	0.52	0.49	0.67	0.77	0.64	−0.07	0.29	−0.18			
14. Strategic outsourcing quasi	0.72	3.16	0	37	0.42	0.03	0.06	0.03	0.42	0.34	0.30	0.38	0.42	−0.06	0.29	−0.15	0.44		
15. Strategic outsourcing taper	1.73	8.65	0	99	0.63	0.10	0.07	0.10	0.39	0.42	0.47	0.57	0.57	0.02	0.24	−0.02	0.72	0.29	
16. Vertical integration	1.68	0.90	1	5	0.50	0.09	0.01	0.24	0.22	0.17	0.15	0.26	0.19	0.25	0.14	0.09	0.37	0.13	0.53

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Table 2. Regression results estimating the effects of vertical integration and strategic outsourcing on a firm's product portfolio

	Model 1 Product portfolio	Model 2 Product portfolio	Model 3 Product portfolio	Model 4 Product portfolio
Constant	25.8400***	25.4988***	25.2716***	31.0313***
	(0.3038)	(0.4465)	(0.3803)	(0.9175)
Firm age	7.3412***	2.7037***	2.4779***	3.6585***
	(0.5645)	(0.4216)	(0.4634)	(0.4443)
Herfindahl–Hirschman index	−0.8096	−1.5008*	0.4258	−2.8676***
	(1.2741)	(0.7239)	(0.4767)	(0.8691)
Patents	4.4980***	0.0537	4.1861***	−0.9984
	(0.3336)	(0.9925)	(0.3064)	(1.3565)
U.S. firm	1.6933***	−0.7690†	−0.0800	−1.5760***
	(0.5204)	(0.4753)	(0.5148)	(0.4591)
Public firm	3.6929***	0.9657***	0.8915***	1.9851***
	(0.4565)	(0.2238)	(0.1657)	(0.3375)
Dominant microcomputers	8.6366***	4.3545***	4.9466***	5.5537***
	(0.7605)	(0.6847)	(0.5606)	(0.6175)
Mergers & Acquisitions	10.7128***	4.6616**	0.3959	6.1638***
	(1.2346)	(1.9680)	(1.3676)	(1.6369)
Strategic outsourcing quasi		5.1958**	5.0253***	0.8534
		(2.0644)	(0.8762)	(2.1289)
(Strategic outsourcing quasi)^2				0.1112
				(0.2049)
Strategic outsourcing taper		8.4980***	4.5643**	34.0091***
		(2.1589)	(1.7964)	(5.1525)
(Strategic outsourcing taper)^2				−2.1005***
				(0.3674)
Vertical integration		8.0046***	7.3485***	8.7234***
		(0.2220)	(0.3256)	(0.4060)
(Vertical integration)^2				−4.1693***
				(0.9685)
Strategic outsourcing quasi × Vertical integration			4.3557***	
			(1.0310)	
Strategic outsourcing taper × Vertical integration			1.1831*	
			(0.5808)	
R^2	0.39	0.50	0.54	0.52
Improvement over base (ΔR^2)		0.11***	0.15***	0.13***
N	486	486	486	486

† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Models are GLS, estimated with White heteroscedasticity-consistent standard errors (in parentheses) and covariances (corrected for degrees of freedom).

sample (Model 6) and in the desktop market only (Model 8), we find that both the linear and squared terms are each negative and statistically significant ($p < 0.001$). This implies that the relationship between vertical integration and new product success is non-linearly negative rather than inverted U-shaped. We thus fail to find support for Hypothesis 2b in the combined desktop and laptop segments, and in the desktop market. We do find support, however, for a diminishing returns hypothesis between vertical integration and product success in the laptop market (Model 10). Here, the linear term for vertical integration is, as expected, positive and statistically significant ($p < 0.001$), while the squared term for vertical integration is negative and statistically significant ($p < 0.001$).

We evaluated Hypothesis 2c, indicating diminishing returns between vertical integration and firm performance, in Model 12 presented in Table 4. We find that the squared term for vertical integration is positive and statistically significant ($p < 0.001$). Thus, we fail to find support for Hypothesis 2c. Rather this result implies a non-linear positive effect of vertical integration on firm performance.

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Table 3. Regression results estimating the effects of vertical integration, strategic outsourcing, and product portfolio on a firm's product success across different microcomputer segments

	Model 5 Product success Full sample	Model 6 Product success Full sample	Model 7 Product success Desktop	Model 8 Product success Desktop	Model 9 Product success Laptop	Model 10 Product success Laptop
Constant	1.8828***	1.9277***	1.9173***	1.9407***	1.8741***	1.9368***
	(0.0050)	(0.0041)	(0.0033)	(0.0097)	(0.0031)	(0.0338)
Firm age	0.0454***	0.0095	0.0190**	0.0125	0.0563***	0.0415**
	(0.0047)	(0.0101)	(0.0066)	(0.0121)	(0.0009)	(0.0142)
Herfindahl–Hirschman index	−0.0805***	−0.0493***	0.0332†	0.0566	−0.0778***	−0.0729***
	(0.0058)	(0.0119)	(0.0211)	(0.0456)	(0.0084)	(0.0133)
Patents	0.0043	0.0150	−0.0108	−0.0212	−0.0219**	−0.0445**
	(0.0104)	(0.0180)	(0.0146)	(0.0256)	(0.0096)	(0.0164)
U.S. firm	0.0302***	0.0365***	0.0167***	0.0261***	0.0641***	0.0023**
	(0.0052)	(0.0042)	(0.0022)	(0.0035)	(0.0067)	(0.0101)
Public firm	−0.0123***	−0.0193***	−0.0295***	−0.0269***	0.0552***	0.0611***
	(0.0009)	(0.0034)	(0.0014)	(0.0039)	(0.0043)	(0.0066)
Dominant microcomputers	0.0101	−0.0066	0.0104†	−0.0080	0.0029	0.0014
	(0.0149)	(0.0127)	(0.0066)	(0.0090)	(0.0118)	(0.0154)
Mergers & Acquisitions	0.0742***	0.0255*	0.0088	−0.0501***	0.0785***	0.0754***
	(0.0081)	(0.0130)	(0.0097)	(0.0086)	(0.0091)	(0.0214)
Strategic outsourcing quasi		0.0345***		0.0793***		−0.1115**
		(0.0099)		(0.0076)		(0.0410)
(Strategic outsourcing quasi)^2		−0.0689***		−0.0113***		0.0165†
		(0.0008)		(0.0024)		(0.0124)
Strategic outsourcing taper		0.0393***		0.0857***		0.2033*
		(0.0129)		(0.0170)		(0.1231)
(Strategic outsourcing taper)^2		−0.0017†		−0.0044**		−0.0163*
		(0.0013)		(0.0018)		(0.0087)
Vertical integration		−0.0221***		−0.0367***		0.0683***
		(0.0046)		(0.0047)		(0.0119)
(Vertical integration)^2		−0.0128***		−0.0145***		−0.0507***
		(0.0023)		(0.0039)		(0.0110)
Product portfolio		0.0982***		0.0569***		0.0830***
		(0.0073)		(0.0088)		(0.0078)
(Product portfolio)^2		−0.0071***		0.0002		−0.0161*
		(0.0012)		(0.0025)		(0.0095)
R^2	0.03	0.06	0.02	0.05	0.05	0.09
Improvement over base (ΔR^2)		0.03***		0.03***		0.04***
N	312	312	246	246	146	146

† $p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Models are GLS, estimated with White heteroscedasticity-consistent standard errors (in parentheses) and covariances (corrected for degrees of freedom).

Taken together, we find support for a diminishing returns hypothesis between vertical integration and product portfolio (Hypothesis 2a) and between vertical integration and product success in the laptop market (Hypothesis 2b).

In parallel to the vertical integration hypothesis (Hypothesis 2), in Hypothesis 3 we suggested that the effects of a firm's degree of strategic outsourcing on the size of its product portfolio (Hypothesis 3a), new product success (Hypothesis 3b), and firm performance (Hypothesis 3c) are characterized by diminishing returns such that the relationships are inverted U-shaped. Because the theoretical focus of this study is on taper integration, we consider quasi integration to be a control variable. Thus, we are able to assess the effect of strategic outsourcing taper above and beyond a firm's level of strategic outsourcing quasi and vertical integration. We assessed Hypothesis 3a in Model 4, Hypothesis 3b in Models 6, 8, and 10, and Hypothesis 3c in Model 12.

The results in Model 4 provide support for a diminishing returns to the effects of strategic outsourcing taper and the size of a firm's product portfolio, because the linear term for this variable is positive and statistically significant ($p < 0.001$), while the squared term is negative and also statistically significant ($p < 0.001$). The results presented in Models 6, 8, and 10 offer support for Hypothesis 3b, because in each model the linear term of strategic outsourcing taper is positive and statistically significant (at $p < 0.05$ or lower), while the squared term is negative and statistically significant (at $p < 0.10$ or lower). Thus, the results suggest that the relationship between strategic outsourcing taper and new product success is inverted U-shaped, across the product categories of the combined desktop and laptop sample, the desktop segment alone and the laptop segment alone. The results presented in Model 12 lend support for Hypothesis 3c, because the linear term of strategic outsourcing taper is positive and statistically significant ($p < 0.01$), while the squared term is negative and also statistically significant ($p < 0.01$). Taken together, the results provide support for a diminishing returns effect of strategic outsourcing taper on the size of the firm's product portfolio (Hypothesis 3a), new product success (Hypothesis 3b), and firm performance (Hypothesis 3c). The observed curvilinear relationship between strategic outsourcing taper and new product success appears to be quite robust because it holds regardless of the underlying microcomputer market segment.

In Hypothesis 4, we postulated that the effects of the size of a firm's product portfolio on new product success (Hypothesis 4a) and firm performance (Hypothesis 4b) are characterized by diminishing returns such that the relationships are inverted U-shaped. We tested Hypothesis 4a in Models 6, 8, and 10. We find support for a diminishing returns hypothesis of product portfolio size on new product success in the combined desktop and laptop sample (Model 6) and in the laptop segment (Model 10), because in both cases the linear term of product portfolio is positive and statistically significant ($p < 0.001$), while the squared term is negative and statistically significant ($p < 0.05$ or lower). We fail to find support, however, for the diminishing returns hypothesis of product portfolio size on new product success in the desktop segment (Model 8). While the linear term is, as predicted, positive and statistically significant ($p < 0.001$), the squared term does not reach statistical significance.

We assessed Hypothesis 4b in Model 12. The diminishing returns hypothesis between product portfolio size and firm performance is supported, because the linear term for product portfolio is positive and statistically significant ($p < 0.001$), while the squared term is negative and statistically significant ($p < 0.001$). To determine the theoretically optimal size of a firm's product portfolio that maximizes its revenues, we calculated the absolute

Table 4. Regression results estimating the effects of vertical integration, strategic outsourcing, product portfolio, and product success on firm performance

	Model 11 Firm performance	Model 12 Firm performance
Constant	18.6950***	18.4007***
	(0.2229)	(0.2422)
Firm age	0.6067***	0.5213***
	(0.0269)	(0.0400)
Employees	0.9088***	1.0076***
	(0.2086)	(0.2501)
Patents	0.1893***	0.0928*
	(0.0266)	(0.0477)
U.S. firm	−0.1366***	−0.1650***
	(0.0291)	(0.0409)
Public firm	0.8972***	0.7074***
	(0.0365)	(0.0198)
Dominant microcomputers	−0.0899***	−0.2035***
	(0.0216)	(0.0245)
Mergers & Acquisitions	0.0392	0.0070
	(0.0536)	(0.1269)
Lagged firm performance	0.3804*	0.1127
	(0.2131)	(0.2218)
Strategic outsourcing quasi		0.5163**
		(0.1670)
(Strategic outsourcing quasi)^2		−0.0363**
		(0.0152)
Strategic outsourcing taper		0.5183**
		(0.2031)
(Strategic outsourcing taper)^2		−0.0875**
		(0.0248)
Vertical integration		0.0176
		(0.0209)
(Vertical integration)^2		0.1811***
		(0.0247)
Product portfolio		0.2890***
		(0.0337)
(Product portfolio)^2		−0.1271***
		(0.0217)
R^2	0.59	0.64
Improvement over base (ΔR^2)		0.05***
N	486	486

†$p < 0.10$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. Models are GLS, estimated with White heteroscedasticity-consistent standard errors (in parentheses) and covariances (corrected for degrees of freedom).

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value of the partial derivative with respect to product portfolio size ($0.2890/[2 \times 0.1271] = 1.1369$). We know that this is a maximum in the function relating product portfolio size to revenues because the second partial derivative with respect to product portfolio is negative. Because we standardized all independent variables prior to entering them in the regression equations to enhance their interpretability and comparability, we had to transform the standardized optimum into a non-standardized solution for accurate interpretation. Note that the standardized optimum is a z-score; thus the non-standardized solution is obtained as follows:

$$X = \text{mean} + (\text{standardized z-score} \times \text{standard deviation}), \text{ or}$$

$$X = 26.70 + (1.1369 \times 31.29) = 62.27$$

Therefore, the average firm reaches its optimum product portfolio size when attempting to maximize revenues at about 62 products in its portfolio. We need to be mindful, however, that this number is more suggestive than normative because it is context dependent in terms of the underlying sample and time period studied. In sum, we find support for Hypothesis 4a (except in the desktop segment) and Hypothesis 4b, indicating that the relationship between the size of a firm's product portfolio and new product success (Hypothesis 4a) and firm performance (Hypothesis 4b) is inverted U-shaped.[6]

DISCUSSION

Scholars in multiple disciplines have focused sustained attention on the boundaries of the firm. This emphasis has been particularly evident in the prolific literature on vertical integration and strategic alliances (cf. Gulati, 1998; Leiblein and Miller, 2003). Yet, these two significant streams of research have not been integrated to understand the benefits and costs of internalizing some value chain activities and simultaneously outsourcing other value chain activities. This practice, however, has become increasingly common since Harrigan (1984) identified it over 20 years ago. Simultaneous internalization and outsourcing of value chain activities are referred to as taper integration and quasi integration; taper integration is of special importance for this study. We add value to our knowledge of vertical integration and strategic outsourcing, because we relate the theoretical arguments explaining the underlying benefits and costs of taper integration to the development of the firm's product portfolio, the success of new products introduced to the market, and ultimately to firm financial performance.

The totality of the results provides strong evidence for the value of balancing vertical integration and outsourcing of value chain activities, and especially of engaging in taper integration. Taper integration was found to have a positive effect on both development of related products for the firm's product portfolio and on the success of those new products upon introduction to the marketplace. Taper integration provides several potential benefits.

In particular, taper integration, more than most other forms of outsourcing, provides a significant potential to access new external knowledge and to internalize it. By performing some activities in a particular stage of the value chain internally and some externally, a firm keeps its pulse on external technology and new knowledge developed outside the firm (Cohen and Levinthal, 1990). Importantly, the firm also has the absorptive capacity to learn the new knowledge and to quickly apply it within the firm. In this way, the firm can develop more effectively new products that are technologically current. Because taper integration allows a firm to be at the cutting edge of technology by internalizing it quickly, the firm is more likely to enjoy success with its new products introduced to the market. Additionally, taper integration provides the benefits from the synergy created by integrating complementary resources from the external partner with the firm's internal resources (Teece, 1986), and thus enables the firm to develop new advantage-creating capabilities (Sirmon *et al*., 2007). Finally, taper integration affords more strategic flexibility to the firm. Operating in dynamic environments common in high-technology industries, the use of taper integration allows a firm to internalize a complete value chain stage or to outsource it. It can also more easily change to use a new technology without significant losses of current assets. For example, Dell often outsources design activities to firms such as Flextronics, while maintaining in-house R&D

[6] We conducted a number of robustness checks which we report in the Appendix.

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capabilities to develop many of the product components. Today, Flextronics can develop superior designs at a lower cost than many of its primary customers. For example, Flextronics reported that it can design a high-end cell phone for about $10 million when the average cost to design such a phone by the original equipment manufacturer (OEM) is $30–50 million (*BusinessWeek Online*, 2005).

The benefits from taper integration are critical, but our research strongly suggests the importance of balance. There are limits to the benefits of taper integration, thus, increasing taper integration beyond some point begins to produce decreasing returns. Overuse of external sources to complete value chain activities could lead to opportunism and excessive transaction costs. It also reduces the firm's ability to absorb external knowledge thereby decreasing the learning opportunities. While external sourcing is likely to increase a firm's flexibility in the short term, it also increases its path dependence in the use of external sources. As the firm loses its internal capability to perform certain value chain activities, it becomes increasingly dependent on its external partners to perform those activities (Bettis, Bradley, and Hamel, 1992; Lei *et al.*, 1996). Firms in which design is a core competence should not outsource the activity (Prahalad and Hamel, 1990). For example, Steve Jobs claims that Apple is able to design 'insanely great' new products that contribute to a competitive advantage. While Apple may design products with high market demand, it also engages in outsourcing (quasi) by having its products manufactured by outsourced design manufacturers (ODMs) (Burrows, 2005).

Other results in this study also support the importance of balance. For example, while vertical integration was found to have an increasingly positive effect on firm performance, it also had an increasingly negative effect on new product success (except in the laptop segment, where the relationship was inverted U-shaped). The positive effect on performance is likely due to the reduction in transaction costs by internalizing the value chain activities. Yet, vertical integration reduces access to new knowledge that can be used to develop successful new products. Full vertical integration, for example, could create an environment in which the firm operates almost like a closed system because all value chain activities are internalized with few external linkages. This in turn reduces a firm's strategic flexibility to respond to changing technologies and other contingencies in its environment, for example, and thus commensurately enhances the probability of firm obsolescence. Thus, while vertical integration reduces transaction costs, it also creates opportunity costs with potential negative performance implications for the firm in the long term. The difference in the effects of vertical integration on new product success in the desktop market (non-linear negative effect) and the laptop market (diminishing returns effect) could possibly be attributed to a differential level of maturity in these two industry segments, with the desktop segment being more mature than the laptop segment.

The results also suggest that increases to a firm's product portfolios generally improve new product success and lead to higher firm performance. Firms that increase their product portfolios too much, however, also experience diminishing returns. Larger product portfolios allow firms to gain synergy from related products. This synergy can materialize in the form of economies of scale and scope, and thus result in lower unit product costs and higher sales through complementary products that enhance customer demand. Alternatively, a large portfolio requires coordination among the various products to achieve these economies (Sanderson and Uzumeri, 1995). An overly large product portfolio can increase managerial costs to the point where they overcome the benefits.

Limitations and future research

This study has limitations, which in turn provide opportunities for future research. One limitation is the way we proxied some of our measures. For example, while the results concerning new product success are intuitive and fit well with the theoretical arguments advanced, the outcome could partly be due to the measure of new product success. The ratings of newly introduced products are conducted by individuals who often have a technological lens. As a result, products with cutting-edge technology might be rated highly but the advance in technology may be greater than desired by the customers to satisfy their needs or the costs are too high to generate profits from the sales. This resonates with Christensen and Bower's (1996) observation that, over time, the rate of technological progress

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frequently exceeds the performance improvements demanded in a market.

While the possibility of a technology bias by industry experts exists, careful steps were taken in this study to ensure the construct validity of the measures employed. In designing and executing this study, we followed many of the recommendations made by Boyd *et al.* (2005). In sum, while this study is one of very few that has measured the success of *individual* new product introductions, more research is needed to examine the performance of newly introduced products.

Because we had to rely on firm revenues as a proxy for firm performance (due to the fact that the large majority of firms in this sample were privately held), using more fine-grained measures of firm performance in future research may help to validate the findings of this study. Additionally, more fine-grained measures of vertical integration might contribute to our knowledge of appropriate levels of internalization and especially identifying which activities should be maintained in-house and which ones should be outsourced. This knowledge would provide the base for future research to determine the appropriate balance between vertical integration and strategic outsourcing. This question is particularly interesting because firm boundaries are dynamic, and thus change over time (Afuah, 2001). In particular, the effects of taper integration on product portfolio, product success, and firm performance are likely to vary depending on the stage of the industry evolution and the dynamism inherent in the industry (Leonard-Barton, 1992; Eisenhardt and Martin, 2000).

While the sample is representative of the population of microcomputer manufacturers, there is a need to test the theoretical model in other industry settings to establish the generalizability of our findings. In addition, future research should study time periods characterized by both incremental and radical innovations, because the emergence of a new dominant design is likely to demand a more contingent approach to organizing for innovation (Anderson and Tushman, 1990; Afuah, 2001). These efforts would help in strengthening the external validity of the theoretical model developed and tested herein. In sum, the measures for strategic outsourcing (taper and quasi) provide a methodological contribution. More importantly, we hope that this contribution spurs future research on this important phenomenon.

Conclusion

This study contributes to our understanding of the boundaries of the firm. Prior research focused primarily on vertical integration (internalization) or on external strategic alliances and networks. Thus, the results obtained in prior research may have been an artifact of unobserved heterogeneity when specifying that outcomes were due to one specific organizing form, unless alternative organizing forms were controlled in the analyses, which was rare. By contrast, we simultaneously investigate the effect of vertical integration *and* strategic outsourcing, while controlling for mergers and acquisitions. The new findings presented provide broad support regarding the need for balance between internalization and outsourcing of value chain activities. In particular, we show the value of taper integration in developing new products and their success in the marketplace.

This study also provides some relevant managerial implications. Our results sound a cautionary note that pursuing *either* vertical integration *or* strategic outsourcing in isolation appears to be suboptimal. While this is clearly an important question at the transaction level of analysis, a manager generally faces questions pertaining to boundaries of the firm at a more aggregate level. In particular, a manager frequently needs to determine the degree of vertical integration *and* the extent of strategic outsourcing *simultaneously*. Here, balancing vertical integration and strategic outsourcing to achieve a prudent level of taper integration seems to be a valuable strategy in striving for superior performance.

When discussing options of dynamic firm boundaries within the context of the microcomputer industry, we noted that integration into some value chain activities appears to be fairly effortless, while integration into other parts of the value chain seems to be rather difficult. If managers identify value chain activities in which the firm should participate, but are not able to vertically integrate into them, quasi integration provides a potentially valuable option. In this case, the needed value chain activities are accessed through strategic outsourcing.

Taken together, managers should strive to identify the appropriate level of taper integration to

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generate a product portfolio that contributes to the 'optimum' levels of new product success and firm performance. While finding the appropriate balance between internalizing value chain activities and strategic external sourcing can be difficult, maintaining the right balance over time can prove even more challenging because the competitive landscape is often highly dynamic (Bettis and Hitt, 1995; Brown and Eisenhardt, 1997). We thus suggest that matching the appropriate level of taper integration with a firm's resources and with the industry environment is a firm dynamic capability, which has been described as a 'firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments' (Teece, Pisano, and Shuen, 1997: 516). In conclusion, taper integration seems to be beneficial in organizing for innovation, but an intricate balance appears to exist that optimizes a firm's product portfolio, product successes, and overall performance. Discovering and maintaining this balance between vertical integration and strategic outsourcing is a critical and challenging, but potentially rewarding, task for managers.

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APPENDIX: RELIABILITY, VALIDITY, AND ROBUSTNESS CHECKS

In designing this study, we took several actions to ensure unbiased and objective coding of the data proxying different organizational forms (vertical integration, strategic outsourcing, and M&A activity), because they pertain to a firm's array of sourcing options. Moreover, vertical integration and strategic outsourcing are the key theoretical constructs of this study. In total, we employed a team of five research assistants (all graduate students) to code the qualitative data. First, the research assistants were not aware of the theory or hypotheses to be tested. Second, we used two independent data sources for each of the key independent variables. Third, the physical coding of the data from the two independent sources used for each measure was conducted at two different institutions, and the research assistants were neither in direct contact with one another nor did they know of each other.

In addition, we explored the robustness of the results described above in several unreported analyses:

- We employed structural equation modeling (SEM). The results of SEM indicated statistical support for most of the individual hypotheses (in the expected direction), but the overall fit of the structural equation model was not satisfactory because of the small cross-sectional sample size ($N = 123$ firms). SEM draws on

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the bivariate correlation matrix; therefore, it does not leverage the econometric advantages of longitudinal panel data (Hsaio, 2003). Tabachnick and Fidell (2001:659) describe the problem of estimating structural equation models based on a relatively small sample as follows: 'Covariances, like correlations, are less stable when estimated from small samples. Structural equation modeling (SEM) is based on covariances. Parameter estimates and chi-square tests of fit are also very sensitive to sample size. SEM, then, like factor analysis, is a large-sample technique ....' Thus, applying GLS regression analysis is the preferred method here because it enables us to draw on a much larger sample ($N = 492$), and to access the advantages of panel data.

- To assess if the results were biased by M&A activity, we eliminated all cases where mergers or acquisitions occurred in which the research and development for new microcomputer products may have been conducted prior to the merger in the firm that did not survive, and thus may bias the surviving firm's post-merger new product portfolios and performance scores. We reran the analysis on the revised sample.
- Because the equity acquired in a partner can span the entire spectrum from minority to majority investments all the way to outright purchase or merger, we also constructed the variable *Mergers & Acquisitions* (*majority*), where the acquired firm purchased more than 50% of the target company. This variable captures the qualitatively somewhat stronger M&A activity. We reran the analysis using the revised variable.
- We eliminated all firms that either entered or exited the microcomputer industry during our study period and reran the analysis on the revised sample.
- We added the 148 product reviews evaluating servers/workstations and handhelds to the 3,441 product evaluations for desktops and laptops, and reran the analysis including all 3,559 product evaluations.
- We varied the time window of the study period by shortening it 1 year, and conducted new analyses using the different time windows. Thus, we were able to assess the robustness of the results on a moving 3-year window.
- We assessed the validity of revenues as a proxy of firm performance by applying return on assets on the sub-sample of firms for which this measure was available.
- We reran the regression models on the subsample of firms for which employee data were directly available.

In all these additional analyses, the results were consistent with the ones presented above.

In a *post hoc* analysis, we assessed the interaction effects of vertical integration and strategic outsourcing quasi as well as those between vertical integration and strategic outsourcing taper on new product success and firm performance. We found that the interactions were generally negative and statistically significant. Recall that the interactions between vertical integration and strategic outsourcing (quasi and taper) were positive. Taken together, these results further highlight the importance of balancing vertical integration and strategic outsourcing in the pursuit of new product success and firm performance.