An Integration of Research Findings of Effects of Firm Size and Market Competition on Product and Process Innovations

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Product and process innovations have been studied as distinct phenomena whose introduction is influenced differently by firm and market conditions. This study reviews and quantitatively integrates the findings of the empirical studies of the associations of firm size and market competition with product and process innovations. The accumulation of research results and subgroup analyses of construct measurement do not provide evidence of substantial differences in the strength of the influence of size or competition on the two innovation types. Implications of the results for future research on innovation types as distinct or integrative phenomena are discussed.

Introduction

Product and process innovations have often been conceived as distinct phenomena that contribute to organizational competitiveness and growth in different ways. Product innovations are pursued to respond to customers’ demand for new products or executives’ desire to capture new markets, whereas process innovations are pursued to reduce delivery lead-time or decrease operational costs (Knight, 1967; Martinez-Ros, 2000; Schilling, 2005). As distinct phenomena, both generation and adoption of product and process innovation are assumed to be determined differently by environmental and organizational factors; for example, the intensity of competition would influence product innovations more strongly than process innovations, or organizational size would affect product innovations less strongly than process innovations (Baldwin, Hanel and Sabourin, 2002; Cohen and Klepper, 1996; Fritsch and Meschede, 2001; Kraft, 1990). However, results of empirical studies have not been integrated systemically to verify whether prior research collectively supports these theories. Thus, the validity of the assumption that product and process innovations are independent yet determined differently by the same antecedents has not been examined. This study aims to address this issue by quantitatively integrating the findings of the empirical studies of the associations between size and competition, two commonly cited determinants of innovation, with product and process innovations to examine whether they are influenced differently by each determinant.1

1I make a distinction between ‘qualitative’ and ‘quantitative’ reviews and assume that the qualitative integration of research findings through traditional narrative reviews, especially when the number of studies is large, is imprecise because the studies are hardly comparable in design, context and measures (Hunter and Schmidt, 1990). Therefore, ‘traditional “narrative” reviews frequently lack thoroughness’, and ‘can be biased by the researcher and often lack rigour’ (Tranfield, Denyer and Smart, 2003, p. 207).

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The second, and a broader, goal of this study is to provide information to help determine the direction of future research on innovation types, whether product–process, technological–administrative or radical–incremental. In response to the criticisms of the instability of results among empirical studies of innovation in organizations (Downs and Mohr, 1976; Kimberly and Evanisko, 1981; Wolfe, 1994), prior research has mainly adopted a contingency view of innovation types assuming that they are distinct phenomena (Damanpour and Aravind, 2006). Finding significant differences in the effects of size and competition on product and process innovations will provide support for the pursuit of a ‘distinctive view of innovation types’ and will thus encourage more fine-grained research to discern how each type differs from the other and can be individually understood. An alternative and less researched view suggests that innovation types are complementary and each type cannot be truly understood without an understanding of its relationship with the other type (Damanpour and Gopalakrishnan, 2001; Pisano and Wheelwright, 1995; Roberts and Amit, 2003). Lack of significant differences in the effect of size and competition on product and process innovations will provide support for pursuing an ‘integrative view of innovation types’ and will encourage new studies to help better understand the interdependences of product and process innovations and identify environmental and organizational conditions under which the types of innovations are jointly generated or adopted.

**Theory**

**Definitions of product and process innovations**

Innovation is studied at different levels of analysis. At the organizational level, it represents the core renewal process and is usually defined as the development and use of new ideas or behaviours, where a new idea could pertain to a new product, service, production process, organizational structure or administrative system (Bessant et al., 2005; Knight, 1967; Zahra and Covin, 1994; Zaltman, Duncan and Holbek, 1973). Innovations have been categorized into administrative (or organizational) and technological to reflect a distinction between social structure and technology in organizations (Daft, 1978; Damanpour, 1991; Kimberly and Evanisko, 1981). Technological innovations pertain to products, services and production process technology. Thus, they are more directly related to primary work activities of the organization than administrative innovations, which are more directly related to its management (Damanpour, 1991; Kimberly and Evanisko, 1981; Zahra and Covin, 1994).

This study focuses on technological innovations. These innovations are further categorized into product and process innovations. **Product innovations** are defined as new products or services introduced to meet an external user need, and **process innovations** are defined as new elements introduced into a firm’s production or service operation to produce a product or render a service (Damanpour and Gopalakrishnan, 2001; Knight, 1967; Utterback and Abernathy, 1975). Product innovations change what the organization offers to the outside world; process innovations change the way the organization produces and delivers those offerings (Bessant et al., 2005). Product innovations have a market focus and are primarily customer driven; process innovations have an internal focus and are mainly techniques of producing and marketing goods or services (Martinez-Ros, 2000; Schilling, 2005; Utterback and Abernathy, 1975). Therefore, while product innovations are embodied in the outputs of an organization and may result in product differentiation or an increase in product quality, process innovations are oriented toward the efficiency or effectiveness of production and may result in a decrease in the cost of production (Schilling, 2005).

**Effects of size on product and process innovations**

Two types of argument have been advanced to explain the relationship between organizational size and innovation. On one hand, small organizations are more likely to be innovative because they have a more responsive climate for making quicker decisions to go ahead with new and ambitious projects, less bureaucratic inertia and more flexible structure, higher ability to adapt and improve, and less difficulty in accepting and implementing change (Chandy and Tellis, 2000; Dean, Brown and Bamford, 1998; Nord and Tucker, 1987). On the other hand, large organi-

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2Of course a quantitative review of the differences between antecedents of technological and administrative innovations (if any) is essential but it is not the goal of this study.
zations are more likely to be innovative because they have more financial and technical capabilities, the economies of scope to spread the risk of failure and absorb the costs of innovation, ability to establish and maintain scientific facilities, resources to hire professional and skilled workers in diverse disciplines, and ability to raise capital and market the innovation (Chandy and Tellis, 2000; Hitt, Hoskisson and Ireland, 1990; Nord and Tucker, 1987). While each theory has received empirical support, the findings from systematic quantitative reviews tip to a positive rather than a negative relationship between size and innovation. A meta-analytical review of 36 correlations from 20 empirical studies found a mean correlation of 0.32 ($p < 0.05$) between size and innovation (Damanpour, 1992, p. 384). A more recent and larger meta-analysis of 87 correlations from 53 studies (Camison-Zornoza et al., 2004, p. 331) found a smaller yet statistically significant mean correlation between size and innovation ($r = 0.15$, $p < 0.05$).

Regarding the relative effect of size on product and process innovations, researchers generally posit that size has a more positive association with process than with product innovations (Cohen and Levin, 1989; Fritsch and Meschede, 2001; Scherer, 1980). Small firms tend to spend more resources on new products than on new processes because product innovations are perceived to be a better means of entry into a market, spawn more rapid growth in output, and yield greater returns from licensing (as they are easier to market and sell as a licence) than process innovations (Cohen and Klepper, 1996; Fritsch and Meschede, 2001). Conversely, large firms benefit from investing in process innovations because they have a comparative advantage in exploiting their existing innovations in the marketplace (Cabagnols and Le Bas, 2002; Cohen and Klepper, 1996). Whereas only a fraction of the customers may buy a new product, a new process may more widely affect organizational output causing large organizations to gain advantages from spreading the costs of their investment on the innovation (Cohen and Klepper, 1996).

According to Scherer, large firms' incentive to develop process innovations is stronger because ‘a new process that reduces costs by a given percentage margin yields larger total savings to the company producing a large volume of output than to the firm whose output is small’ (1980, p. 414). Therefore, $H1$: Firm size is more positively associated with process than product innovation.

### Effects of competition on product and process innovations

Market structure has been portrayed by competition or concentration. Like size, there are competing arguments on the effect of market structure on innovation. According to one view, firms with monopoly power tend to have more slack resources, can employ ample R&D professionals and afford better salaries for skilled staff, show long-term commitments to costly and risky innovation projects, and internalize most of the benefits from the innovations they develop (Cohen and Levin, 1989; Scherer, 1980). In addition, firms may invest in innovation in the expectation of ex post market power (Cohen and Levin, 1989). Firms in concentrated markets would have a stronger incentive to innovate because they can more easily appropriate the returns from innovation (Baldwin, Hanel and Sabourin, 2002; Martinez-Ros, 2000).

According to an alternative view, competition, not concentration, is conducive to innovation. Monopoly of power reduces pressure to search for new and better solutions, and breeds complacency toward technological pioneering and a tendency to ignore rivals (Dean, Brown and Bamford, 1998; Scherer, 1980). Firms in concentrated industries are less likely to innovate because innovation may disrupt the equilibrium in their market (Zahra, 1993). Competition, on the other hand, creates strong incentives to acquire knowledge and put it to productive use. Insulation from competition can cause bureaucratic inefficiencies that inhibit innovation (Arrow, 1962; Baldwin, Hanel and Sabourin, 2002). Innovations in products and

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3I thank an anonymous reviewer who advised this justification for return from licensing.

4This argument was proposed by an anonymous reviewer. I appreciate his/her helpful comment.

5This study focuses only on the linear association between size and innovation because a quantitative review of non-linear associations requires access to a substantial number of empirical studies that have distinguished between product and process innovations and have examined non-linear relationships, but such studies are scarce. For example, among the studies that are included in this review only four tested non-linear relationships (Bertschek, 1995; Cohen and Klepper, 1996; Ettlie and Rubenstein, 1987; Lunn, 1987).
processes are among principal components of competition, providing competitive advantage by determining product differentiation, process substitution and cost leadership (Porter, 1985).

While scholars seem to disagree on the effects of concentration and competition on innovation, they are more unanimous on the relative effect of these factors on product and process innovations (Cohen and Levin, 1989; Kotabe, 1990; Scherer, 1983). Product and process innovations have different information properties (Kraft, 1990). Under conditions of high competition, if new products are not protected by patents, competitors quickly reverse engineer them. Competitors may even improve upon and invent around product innovations without violating proprietary protections (Kotabe, 1990). However, competitors cannot easily imitate process innovations because they are more internally driven (i.e. they depend more on intangible knowledge and human skills), can more easily be kept secret, and are less visible to competitors (Kotabe, 1990; Kraft, 1990; Zahra, 1993). Moreover, firms in less competitive (more concentrated) markets have greater incentives to invest in process than product innovations because the benefits from product innovations depend less on the firm’s monopoly power than do the returns from process innovation (Cohen and Klepper, 1996). Whereas a firm that already dominates its market has little to gain from introducing new products because there is not much it can take away from its competitors, it would have a greater share of cost savings from any process innovations it can appropriate (Scherer, 1983). Therefore,

\[ H2: \] Market competition is more positively associated with product than process innovation.

**Methods**

**Selection of the studies and coding**

The studies were selected by conducting a ‘title and abstract keywords search’ through electronic databases in 2003 (Damanpour and Aravind, 2006). The databases searched were ABI/Inform, Econlit, Ei Compendex, Inspec, IEEE Xplore and ACM Digital Library. The keywords used for the title and abstract search were ‘product innovation’ and ‘process innovation’ with ‘determinants’, ‘predictors’, ‘antecedents’ and ‘factors’. Only articles in the English language were considered. The search identified approximately 350 articles, but not all were directly related to the focus of this review. For example, some articles examined the association between innovation and other constructs such as new product success, firm performance and employment (e.g. Antonucci and Pianta, 2002; Cooper, Edgett and Kleinschmidt, 2001; Smolnyi, 1998) or the antecedents of product innovations only (e.g. Abratt and Lombard, 1993; Fritz, 1989; Herrmann, 1997). They were not considered for this review. Moreover, for better evaluation of the empirical validity of the hypotheses, only the studies that reported quantitative associations between at least one of the antecedents and both product and process innovations were included. Twenty empirical studies (18 journal articles and two book chapters) that were published between 1983 and 2003 met this condition (Table 1). The author and a PhD student independently coded the primary studies, met regularly to discuss disagreements, and recoded the studies until consensus was reached (Bullock and Svyantek, 1985). Consistent with past quantitative reviews (Camison-Zornoza et al., 2004; Damanpour, 1991), the independent samples within primary studies are used as units of analysis. The coders identified 28 independent samples from the 20 primary studies.²

The primary studies were diverse regarding time of data collection (they were nearly evenly distributed on the data collected in the 1970s, 1980s and 1990s) and authorship (only three authors were involved in more than one study). Nearly one half of the studies used data from firms in the USA, the other half from firms in

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²As expected the majority of the empirical studies examined the antecedents or success of product innovations. Whereas quantitative reviews that compare product and process innovations have not thus far been conducted, several quantitative reviews of the determinants or consequences of product innovations are available (e.g. Gerwin and Barrowman, 2002; Henard and Szymanski, 2001; Montoya-Weiss and Calantone, 1994; Pattikawa, Verwaal and Commandeur, 2002).

³It should be noted that the number of primary studies in this review is within the range of other quantitative reviews of the antecedents of innovation. For instance, Damanpour’s (1991) review of the determinants of innovation adoption includes 23 studies, and Camison-Zornoza et al.’s (2004) review of the size–innovation relationship includes 53 studies. Compared with Camison-Zornoza et al. (2004), this study includes a smaller number of primary studies because (1) it focuses on technological innovations only and (2) it relies on the studies that have examined the association of size with both product and process innovations.
Canada, Europe and Japan. Nearly all the studies conducted multivariate analyses (Table 1), alleviating statistical bias due to the omission of explanatory variables other than size or competition. However, they collected data mainly from manufacturing firms, limiting generalization of the results beyond this sector.

### Integration procedure

Because the studies in this sample relied on multivariate analysis using econometric models and most did not report correlation matrices, empirical results were aggregated by a procedure based on the percentage of significant statistical tests (p < 0.05) that support a relation (Boyne, 2002; Light and Smith, 1971). First, in each study the numbers of tests that show positive, negative or non-

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### Table 1. Information on the studies included in the review

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample size</th>
<th>National context</th>
<th>Analysis</th>
<th>Measure of size</th>
<th>Market structure</th>
<th>Measure of innovation</th>
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<tr>
<td>Baldwin et al. (2002)</td>
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<tr>
<td>≥ 500 employees</td>
<td>1078–1196</td>
<td>Non-US</td>
<td>β</td>
<td>Personnel</td>
<td>Competition</td>
<td>No. of innov.</td>
</tr>
<tr>
<td>100–499 employees</td>
<td>1078–1196</td>
<td>Non-US</td>
<td>β</td>
<td>Personnel</td>
<td>Competition</td>
<td>No. of innov.</td>
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<tr>
<td>Imports share</td>
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<tr>
<td>Low-growth firms</td>
<td>367</td>
<td>US</td>
<td>β</td>
<td>Financial</td>
<td></td>
<td>Patents</td>
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<tr>
<td>High-growth firms</td>
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<td>US</td>
<td>β</td>
<td>Financial</td>
<td>Patents</td>
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<tr>
<td>Ettlie and Rubenstein (1987)</td>
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<td>US</td>
<td>r and β</td>
<td>Personnel</td>
<td>Patents</td>
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<tr>
<td>Freel (2003)</td>
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<tr>
<td>Production-based firms</td>
<td>98</td>
<td>Non-US</td>
<td>β</td>
<td>Personnel</td>
<td>No. of innov.</td>
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<td>Science-based firms</td>
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<td>Non-US</td>
<td>β</td>
<td>Personnel</td>
<td>No. of innov.</td>
<td></td>
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<td>Supplier-based firms</td>
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<td>Non-US</td>
<td>β</td>
<td>Personnel</td>
<td>No. of innov.</td>
<td></td>
</tr>
<tr>
<td>Kotabe (1993)</td>
<td>71</td>
<td>Non-US</td>
<td>β</td>
<td>Financial</td>
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<tr>
<td>Kotabe and Murray (1990)</td>
<td>71</td>
<td>Non-US</td>
<td>r and β</td>
<td>Financial</td>
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<td>Kraif (1990)</td>
<td>56</td>
<td>Non-US</td>
<td>β</td>
<td>Personnel</td>
<td>Concentration</td>
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<td>Lunn (1986)</td>
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<tr>
<td>High-technology firms</td>
<td>43</td>
<td>US</td>
<td>β</td>
<td>Concentration</td>
<td>Patents</td>
<td></td>
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<tr>
<td>Low-technology firms</td>
<td>148</td>
<td>US</td>
<td>β</td>
<td>Concentration</td>
<td>Patents</td>
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<tr>
<td>Lunn (1987)</td>
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<tr>
<td>High-technology firms</td>
<td>95–104</td>
<td>US</td>
<td>r and β</td>
<td>Financial</td>
<td>Concentration</td>
<td>Patents</td>
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<td>Low-technology firms</td>
<td>186–196</td>
<td>US</td>
<td>r and β</td>
<td>Financial</td>
<td>Concentration</td>
<td>Patents</td>
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<tr>
<td>Scherer (1983)</td>
<td>443</td>
<td>US</td>
<td>r</td>
<td>Concentration</td>
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<tr>
<td>Zabra et al. (2000)</td>
<td>231</td>
<td>US</td>
<td>r and β</td>
<td>Personnel</td>
<td></td>
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</tbody>
</table>

Sample size: large (≥ 500); small (< 500). National context: US firms; non-US firms (firms from Canada, Europe and Japan). Analysis: bivariate (r); multivariate (β). Measure of size: financial; personnel. Market structure: competition; concentration. Measure of innovation: patents; number of innovations; R&D expenditure.

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8Hunter and Schmidt (1990, p. 468) order the efficacy of this integration procedure on extracting the information from the primary studies between ‘traditional narrative’ and ‘meta-analytical’ reviews. However, it should be noted that, while the meta-analysis integration procedure allows for the computation of effect size, it relies on the studies that have conducted bivariate analyses. The integrating procedure used in this paper allows for aggregating the results from the studies that have conducted multivariate analyses.
significant associations between the antecedents and product and process innovations are identified. Second, a 'support score' for the association between size and competition with product and process innovations in each study is calculated. Boyne (2002, p. 105) defines the support score as the number of tests that are consistent with the hypothesis as a percentage of all the tests conducted in a study. For full disclosure, I report the number of tests that are consistent with the positive, negative and non-significant relations in each study (Table 2). Third, an 'aggregate support score' across all the studies that support the hypothesis is calculated. This can be calculated by ‘unweighted’ or ‘weighted’ means (Boyne, 2002). The unweighted aggregate support score treats the support score from each study equally, regardless of the number of tests the study has conducted. The weighted aggregate support score weights the support score from each study by the number of tests in that study (Boyne, 2002). The weighted aggregate support score has the advantage that the studies that report one or few tests are not given undue weight; however, it is not fully certain that it provides a more accurate aggregate score in support of the hypothesis than the unweighted support score (Boyne, 2002). The real level of support for the hypothesis lies between these two aggregated scores (Boyne, 2002; Walker, 2004). Therefore, I report both unweighted and weighted aggregate scores for positive, negative and non-significant relations (see the last two rows in Table 2).9

Boyne (2002, p. 113) proposed that an aggregate support score of more than 50% represents moderate to strong support for a hypothesis as it is far higher than would be likely to occur by chance alone. Because each hypothesis in this study compares the strength of the association between an antecedent with two types of innovation, based on Boyne's 50% threshold in support of a hypothesis, I consider that a sufficient difference between the support scores for two innovation types exists when two conditions are jointly met: (1) the aggregate support score for one innovation type is more than 50% and for the other innovation type is less than 50%; and (2) the difference between the aggregate support scores of product and process innovations is at least 25% points.

9More information on this integration procedure can be found in Boyne (2002, pp. 103–106) and Hunter and Schmidt (1990, pp. 468–477).

Subgroup analyses

Empirical studies are seldom fully comparable; for instance one study may measure innovation in terms of inputs (e.g. R&D expenditure) and another study in terms of outputs (e.g. number of new products) (Adams, Bessant and Phelps, 2006). To account for the potential effect of such differences among the studies on the support scores, subgroup analyses were conducted when the studies provided clear information that enabled coding subgroups.

Prior quantitative reviews indicate that the contradictory results obtained in empirical studies are to a large extent due to differences in the operationalization of variables (Boyne, 2002; Camison-Zornoza et al., 2004; Damanpour, 1991). Thus, measures of size, competition and innovation were coded (Table 1). The primary studies measured firm size by financial (e.g. market share, sales, total assets) or personnel (e.g. number of employees) measures. Market structure was represented by concentration (operationalized mainly by the industry four-firm concentration ratio) or competition (operationalized mainly by the number of competitors or the percentage of innovative firms in the sector). Since competition and concentration are expected to influence innovation in opposite directions, I inverted the direction of the coefficient for the concentration–innovation relationship in computing the support scores. Finally, the studies were coded according to three measures they used for product and process innovations: R&D expenditure, patents and number of innovations.

In addition to measures of variables, data were available for examining the role of two other subgroups – national context and sample size. The first subgroup distinguishes the studies that collected data from US firms from those that surveyed non-US firms (firms from Canada, Europe and Japan). The second subgroup allows the results of the studies that used small samples (less than 500 companies) to be compared with those that employed large samples (500 or more companies) (Table 1).

Results

Main effects

Based on the 50% threshold in support of a relation, the results indicate that size affects both innovation types positively as the aggregate
<table>
<thead>
<tr>
<th>Study</th>
<th>No. of tests</th>
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<th>- n.s.</th>
<th>No. of tests</th>
<th>+</th>
<th>- n.s.</th>
<th>No. of tests</th>
<th>+</th>
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<th>- n.s.</th>
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*aThe support score is the number of tests that are consistent with the relation (+, −, n.s.) as a percentage of all the tests conducted in a study.
*bThe weighted aggregate support score weights the support for the relation (+, −, n.s.) from each study by the number of tests in that study.
*cThe unweighted aggregate support score treats the support score for the relation (+, −, n.s.) from each study equally, regardless of the number of tests in that study.
support scores are in the range of 59% (unweighted) to 64% (weighted) for product innovation, and 57% (unweighted) to 59% (weighted) for process innovation (Table 2, the last two rows). These findings of the effect of size on innovation types are similar to the results from the two existing quantitative reviews of the size–innovation relationship (Camison-Zornoza et al., 2004; Damanpour, 1992). However, because statistically significant (p < 0.05) associations between the antecedents and innovation types coded from the primary studies in this review are based mainly on regression coefficients from models that account for the effects of other explanatory variables, the findings reported here should help reduce concerns for potential statistical bias due to the omission of the explanatory variables other than size in the previous quantitative reviews which have relied mainly on correlation coefficients to accumulate the findings.

Hypothesis 1, which suggested a difference in the strength of the association between size and product and process innovation, was not supported as the aggregate support scores for positive relationships between size and both innovation types are more than 50% and the difference between weighted (64% versus 59%) or unweighted (59% versus 57%) support scores is less than 25% points (Table 2). Therefore, the accumulation of empirical findings does not provide any evidence to suggest that organizational size is more positively associated with process than product innovation.

The aggregated results do not indicate either a positive or a negative association between competition and product or process innovations as both weighted and unweighted mean support scores for positive and negative associations are below 50% (Table 2, the last two rows). Also, there is not a considerable difference between the weighted (27% versus 35%) or unweighted (23% versus 28%) aggregate support scores for a positive association between competition with product and process innovations (Table 2). Thus, contrary to Hypothesis 2, the accumulation of findings from the empirical studies suggests that competition does not affect product innovations more strongly than process innovations.

**Moderating effects**

Subgroup analyses were conducted to examine whether the hypotheses were supported in more specific conditions (Table 3). To further help evaluate the strength of evidence for each subgroup, the number of studies with ‘strong’ support scores (100%) for the size–innovation and competition–innovation associations are coded and shown in Table 4.

**Measure of size**

Subgroup analyses of financial and personnel measures of size produced variation in the strength of the association between firm size and innovation types. Whereas the differences between both weighted and unweighted positive aggregate support scores of product and process innovations for financial measure were large and nearly met the two conditions for considerable difference (65% versus 41% and 61% versus 43%, Table 3), the differences for personnel measure did not (64% versus 77% and 58% versus 68%, Table 3). The results further suggest that the difference between the two measures of size is mainly due to the relationship between size and process innovation. Whereas positive mean support scores for both measures of size and product innovation are more than 50% (Table 3), both weighted and unweighted positive aggregate support scores for size–process innovation associations are considerably greater for personnel than financial measure of size (77% versus 41% and 68% versus 43%, Table 3). Also for process innovation, a greater percentage of the studies show strong support score (100%) for personnel than financial measure of size (61.5% versus 10)

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**Because of focusing on the primary studies that include both innovation types, this review has only one primary study (Ettlie, Bridges and O’Keefe, 1984) in common with Damanpour’s (1992) and two primary studies (Ettlie, Bridges and O’Keefe, 1984; Zahra, Neubaum and Huse, 2000) in common with Camison-Zornoza et al.’s (2004) meta-analytical reviews of the size–innovation relationship.

**10**Only four studies tested the non-linear effect of size on product and process innovations (Bertschek, 1995; Cohen and Klepper, 1996; Ettlie and Rubenstein, 1987; Lunn, 1987) and reported mainly an inverse U-curve relationship between size and both innovation types. These studies’ findings suggest that innovation does not increase proportionally with size, but do not provide any evidence that firm size influences product and process innovations differently.

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36.4%, Table 4). Overall, the results suggest that measure of size may influence the association between size and innovation types, but the influence is primarily due to its effect on process, not product, innovations.12

12Previous quantitative reviews of firm size and innovation (Camison-Zornoza et al., 2004; Damanpour, 1992) distinguished between ‘direct’ and ‘logarithmic’ measures of size, but did not find significant differences between them. In this review, the primary studies were also coded for this subgroup. Like the prior reviews, Measure of market structure

Subgroup analyses of the differences between the studies that measured market structure by competition or concentration did not reveal a considerable difference between the aggregate support scores for product and process innovations. As shown in Table 3, both weighted and unweighted positive however, it was found that these two ways of measuring size do not affect product and process innovations differently (data not shown).
aggregate support scores for competition and innovation types are the same (50% versus 50%, and 38% versus 38%) and for concentration and innovation types are not considerably different (9% versus 25%, and 6% versus 17%). However, positive aggregate support scores are generally larger for the studies that used competition as an indicator of market structure than those that used concentration. For product innovations in particular, the difference between both weighted and unweighted scores satisfy the conditions for considerable difference (50% versus 9% and 38% versus 6%, Table 3). Moreover, none of the studies that used concentration reported a strong support score for either product or process innovations (Table 4). Therefore, the results suggest that the operationalization of market structure in terms of competition or concentration might influence the strength of its association with product innovations, but would not affect product and process innovations differently.13

Measure of innovation

Subgroup analyses provided two noteworthy results. First, for the size–innovation relationship, whereas positive aggregate support scores for influence of both patents and number of innovations on product versus process innovations (Table 3) were similar to those for the entire sample (Table 2, the last two rows), the weighted positive aggregate support score of R&D expenditure was considerably different for product versus process innovations (58% versus 25%, Table 3). This finding is contrary to Hypothesis 1; however, it should be considered cautiously because (1) it is based on the findings from two primary studies only and (2) it does not meet the conditions for considerable difference when unweighted aggregate scores are compared (75% versus 55%, Table 3). Second, for the competition–innovation association, while the studies that measured innovation by patents found comparable results with the entire sample, positive mean support scores for those that used number of innovations (60%–69% for both innovation types, Table 3) were considerably larger than for the entire sample (23%–27% for product innovation and 28%–35% for process innovation, Table 2). Moreover, none of the studies that measured innovation by patents found a strong support (100%) for the competition–innovation relationship, but 60% of those that used number of innovations did (Table 4). Overall, this subgroup analysis also suggests that while measure of innovation does not help distinguish product from process innovations, it may affect the strength of influence of size or competition on one type of innovation.

Other subgroups

As stated above, the studies were also coded for two additional subgroups – national context (US versus non-US firms) and sample size (large versus small samples). Considering the relationship between size and innovation, neither national context nor sample size revealed any considerable difference between product and process innovations (data not shown); the results were nearly identical to aggregate support scores for all studies (Table 2). Also, like the results for the entire sample (Table 2), all positive or negative aggregate support scores for the relationship between competition and both product and process innovation types were below the 50% threshold (data not shown).14

Discussion

Prior studies mainly followed the premise that product and process innovations are two ways of contributing to organizational competitiveness and are thus influenced differentially by environmental and organizational factors. This study integrated the results of the empirical studies of the effects of two commonly cited determinants of innovation but did not find considerable differences between the strength of the association of either size or competition with product and process innovations. Moderator analyses showed that, when there is a difference between

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13 It should be noted that these results were obtained when the majority of studies (ten out of 15, Table 1) that tested competition or concentration controlled for firm size in their multivariate models.

14 Subgroup analysis for competition showed one noteworthy difference between the pairs in national context and sample size. Whereas mean positive support scores for competition and both innovation types for US firms were generally smaller than those for non-US firms, they were generally larger for the large- than small-sample subgroup (data not shown). This result should be interpreted with caution, however, because the majority of studies of US firms (12 of 13) were in the small-sample subgroup, but the majority of studies of non-US firms (eight of 14) were in the large-sample subgroup (Table 1).
the subgroups, it is for one type of innovation (e.g. effect of financial versus personnel measures of size on process innovation) rather than between the two innovation types. In this section, I discuss the implications of this review for research on the development or adoption of innovations in organizations according to the distinctive and integrative perspectives of innovation types (Damanpour and Aravind, 2006).

Distinctive view of innovation types

The predisposition to view types of innovation as distinct phenomena is a consequence of ‘analytic’ thinking, which assumes that an understanding of the behaviour of a phenomenon is extracted from an understanding of the behaviour of its parts (Ackoff, 1999). It also reflects the dominance of the industrial organization perspective in the studies of product and process innovations, where the homogeneity of firms within the industry and the role of industry characteristics in determining firm performance are emphasized.

When empirical results do not support theory, the distinctive view advocates a search for more specific conditions for which theory might apply. For example, differences in the studies’ methods might be a source of instability of the results (Camison-Zornoza et al., 2004; Cohen and Levin, 1989; Damanpour, 1991). I conducted subgroup analyses based on the measurement of both independent and dependent variables. These analyses did not change the nature of the relationships of size or competition with product and process innovations. However, they produced two results, which from the distinctive perspective will motivate the need for more research to explain the moderating effect of construct measurement. First, support scores were generally stronger for personnel than financial measure of size for process but not for product innovations. This result suggests that perhaps the relative strength of the association between size and process innovation advanced in Hypothesis 1 could be a function of the measurement of firm size. Second, support scores were generally larger for operationalization of market structure in terms of competition than concentration, suggesting that either the inverse relationship between competition and concentration does not hold or more fine grain measurement of them is necessary to determine how each would truly affect innovation.

Data were not available to conduct subgroup analyses to examine the moderating role of other factors. In addition to construct measurement, past research has emphasized industry differences as a source of inconsistent findings in innovation research and has identified technological opportunity, market demand and appropriability as three primary factors representing inter-industry differences for innovation (Cohen and Levin, 1989; Scherer, 1980; Tidd, Bessant and Pavitt, 2001). Several studies in the sample controlled for these factors in their regression models. Five studies included both technological opportunity and market demand (Cabagnols and Le Bas, 2002; Lunn, 1986, 1987; Martinez-Ros, 2000; Meisel and Lin, 1983), two studies included technological opportunity and appropriability (Baldwin, Hanel and Sabourin, 2002; Cabagnols and Le Bas, 2002) and one study included all three factors (Cabagnols and Le Bas, 2002). While the inclusion of these variables in some of the studies helps assure that lack of support for Hypotheses 1 and 2 might not be due to inter-industry differences, from the distinctive view more direct analysis is necessary to rule out the possible moderating effect of industry differences.

Only three studies in the sample provided such analysis. Lunn distinguished between high-technology and low-technology industries and found that size influenced both product and process innovations positively in both industries, and competition had a mixed but generally non-positive effect on both innovation types in both industries (Lunn, 1986, 1987). And Freel (2003) distinguished among supplier-dominated, production-intensive and science-based firms and found that while size affects product innovations positively in two sectors (supplier-dominated and production-intensive), it does not significantly affect process innovations in any sector. Results from these three studies do not provide sufficient evidence to conclude that the impact of size or competition on product and process innovations varies in different industries. However, because the number of studies is limited and other aspects of industry or sector difference have not been compared (e.g. difference between manufacturing and service firms), from the distinctive view, more refined future studies comparing industries and sectors will probably discern the moderating role...
of industry differences and eventually show the unique influence of the antecedents on product versus process innovations.

**Integrative view of innovation types**

The integrative view relies on ‘synthetic’ thinking, which assumes that the behaviour of a phenomenon can be understood in terms of its interdependence with other parts within the larger phenomenon that includes them (Ackoff, 1999). According to this view, innovation types are complementary and influence organizations jointly; hence, each type cannot be truly understood without an understanding of its interrelationship with the other type. For example, product innovation could make corresponding process innovation necessary, and process innovation could enable the firm to improve its product quality or to produce completely new products (Fritsch and Meschede, 2001).

Three studies in the sample controlled for one type of innovation when predicting the other type, and found inconsistent results. Five studies included correlation matrices and unanimously showed a positive association (p < 0.05) between product and process innovations (Damanpour and Gopalakrishnan, 2001; Ettlie and Rubenstein, 1987; Ettlie, Bridges and O’Keefe, 1984; Kotabe and Murray, 1990; Zahra, Neubaurm and Huse, 2000). Elsewhere, researchers have also reported statistically significant associations (p < 0.05) between other types of innovations, such as between technological and administrative (Bantel and Jackson, 1989; Kimberly and Evanisko, 1981; Zahra and Covin, 1994) and radical and incremental (Dewar and Dutton, 1986; Ettlie, Bridges and O’Keefe, 1984; Germain, 1996). From the integrative view, these results provide evidence that innovation types are not necessarily independent, suggesting more research to examine their interrelationships.

Prior research has discussed the potential benefits of concurrent generation or adoption of innovation types for the firm’s long-term competitive position. For instance, Pisano and Wheelwright (1995) argue that pharmaceutical companies gain tremendous advantages by treating process development as an integral part of product development. The congruent development of product and process innovations results in a smoother launch of new products, easier commercialization of complex products, and more rapid penetration of markets (Pisano and Wheelwright, 1995). In a study of market performance of European and Japanese multinational firms in the USA, Kotabe (1990) finds that interaction of product and process innovations is the crucial determinant of market performance. Similarly, in a study of US commercial banks Damanpour and Gopalakrishnan (2001) report that over time high-performance banks adopt product and process innovations more congruently than low-performance banks. Finally, a recent quantitative review of empirical research on the relationship between innovation and firm performance finds that organizations that introduce product innovations in conjunction with process innovations are more likely to achieve higher levels of performance (Walker, 2004).

In sum, the integrative view advocates that instead of continuing to search for the conditions that determine how each innovation type can be individually understood, future research should focus on examining the conditions under which innovation types are synchronously introduced. That is, future research on typologies of innovation should depart from the current dominant logic and pursue studies that identify environmental and organizational conditions that enhance the joint generation or adoption of innovation types rather than the conditions that help distinguish them and understand each alone.

**Implications**

The dominance of the distinctive view on the studies of product and process innovation is influenced by the sequential development of product and process innovations proposed in the product life-cycle model (Abernathy and Utterback, 1978). However, as duration of product cycles are becoming increasingly shorter due to rapid technological developments, deregulation and global competition, a new product’s competitive advantage may not last long without new process capabilities that enable the firm to capture

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15Fritsch and Meschede (2001) found that while product innovations negatively affect process innovations, process innovations positively affect product innovations. Kraft (1990) found a positive impact of product innovation on process innovation, but not the reverse. Martinez-Ros (2000) found that each type positively predicts the other type.
significant economic return from the product (Kotabe, 1990; Pisano and Wheelwright, 1995). Bhoovaraghavan, Vasudevan and Chandran (1996) attribute the prevalence of the distinctive view to the dominance of supply-side orientation, which emphasizes an allocation of resources to different means of technological change (product versus process). These authors state that from a market orientation perspective product and process innovations occur interdependently to satisfy customer needs and contribute to firm performance (Bhoovaraghavan, Vasudevan and Chandran, 1996). The results of this study, combined with previous quantitative reviews (Camison-Zornoza et al., 2004; Damanpour, 1991), support Bhoovaraghavan, Vasudevan and Chandran’s argument by showing that the accumulations of empirical findings do not provide evidence that these two ways of technological change are determined by different factors, suggesting the need for pursuing a different approach in studying types of innovation in organizations.

The integrative view of research on innovation types reflects the resource-based view, where the synergistic influence of the firm’s internal resources, including product and process knowledge resources, on its competitive advantage and performance is emphasized. Achieving competitive advantage in today’s turbulent business environment requires dynamic capabilities for shifting emphasis on innovation types (Teece, Pisano and Shuen, 1997). As Volberda (2004) has observed for the field of strategy, innovation research should also move beyond classifications and examine environmental and organizational conditions that determine the synergetic generation or adoption of innovation types. Both product and process innovations have a role in supporting each of the generic business strategies and it cannot be assumed that product innovation only enhances differentiation and that process innovation is exclusively cost-oriented (Porter, 1985). Research on developing and testing dynamic perspectives of fit between innovation types is challenging because, given differences in organizational contingencies, the fit may be unique, and not even common across types of organizations. However, this challenge should be met in order to advance research on innovation in organizations.

In conclusion, whereas prior research has devised autonomous strategies of innovation types for competitive advantage, future research should consider a product–process innovation mix strategy. This strategy posits that innovation types are synchronously pursued for achieving competitive advantage, as the firm’s innovative performance depends on how well they work together, not on how each contributes independently. Innovative organizations are those that can combine innovation types in new ways to maintain their competitive advantage and achieve their performance goals. The full potential and benefits of one type of innovation cannot be realized unless the other type becomes an integral part of its development or adoption process. As the knowledge-based theory advocates, an organization’s primary role is to integrate specialized knowledge of its members into producing goods and services to gain competitive advantage, and the primary task of management is to facilitate and coordinate the knowledge integration process (Grant, 1996). In regard to product and process innovations, therefore, corporate executives are advised to manage the generation or adoption of innovation types synergistically and to avoid allocating resources to one type to the detriment of the other. Instead of assuming that product and process innovations are autonomous and each is motivated by a different set of drivers, innovation researchers are advised to examine the interrelationship between innovation types and the consequence of their concurrent generation or adoption.

References


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Fariborz Damanpour (PhD, University of Pennsylvania) is Professor of Management at Rutgers University. His primary area of research is management of innovation and change in organizations. His papers have been published in organization management and technology management journals. He served as chairman of the Department of Management and Global Business, Rutgers Business School, and editor of the Technology and Innovation Management Department, IEEE Transactions on Engineering Management.