Corporate Entrepreneurship in Global Auto Industry: A Supply Chain and Learning Perspective

Abstract

An organization's response to ever-increasing levels of industry change, global competition and flux determines its long-term survival and competitive advantage. Effective functioning of supply chains and organizational learning are hallmarks of firms that are better positioned to thrive in dynamic and global environments, while new product introductions are important contributors to corporate entrepreneurship (breakthrough and incremental innovations). We propose a framework relating these concepts and empirically examine the impact of supply chain integration and organizational learning on the pace of corporate entrepreneurship using a bi-variate negative binomial model. We found that supply chain integration and organizational learning each had a positive impact on the development of incremental and breakthrough innovations. Specifically, we found that there were two distinctive business strategies among the entrepreneurial companies (small to larger sized firms) that we studied in the global automotive industry. We interviewed managers and executives from multiple countries working in one of the biggest emerging markets, Brazil. Some firms achieved higher levels of corporate entrepreneurship by focusing on their supply chain, while others did so by focusing more on organizational learning. Our results suggest that it may be difficult for corporate entrepreneurs to focus on both strategies simultaneously.

Keywords: Supply chain management; Organizational learning, Corporate entrepreneurship, New product development; Breakthrough innovations; Incremental innovations; Automotive industry; Manufacturing, Lead times; International/global issues.

While the path to developing new product innovations is a long and expensive journey filled with risk and uncertainty, successful new product introductions are essential to the long-term viability of a firm. The literature overwhelming supports the notion that small firms are better able to develop breakthrough innovations than large firms. These studies suggest that smaller firms have greater "search" capabilities to undertake deliberate efforts directed toward creative-problem solving (Almeida and Kogut, 1997; Hannan and Freeman, 1984; Schumpeter, 1934; Nelson and Winter, 1982). Given the intensity of today's ever-increasing global competition, there has been a call for researchers to better understand how not only small, but also large firms can enrich their entrepreneurial and innovativeness capabilities. This research responds to this call by examining the commercialization of new product developments, both incremental and breakthrough innovations, for small to large corporate entrepreneurial firms in the global automotive industry.

By enhancing a firm's corporate entrepreneurship through the creation of new revenue streams for breakthrough (entirely new products) and incremental (product enhancements) product life cycles, firms generate potential sources of growth and financial capability. Our research makes the assumption that corporate entrepreneurship is more a complex process for large firms as they often have bureaucratic perspectives that negatively contribute to the flow of new ideas. We argue that regardless of the firm's size, the linkage between its (1) learning orientation and (2) supply chain can positively stimulate its entrepreneurial tendency to create higher levels of new product innovations. Put simply, we argue that in order for firms to develop new products and bring them to the globally competitive market more rapidly and efficiently, multiple departments and disciplines have to work closely with one another, requiring high levels of organization learning and tighter supply chain management.

The announcement of new product innovations may not only push a firm out of its established scientific knowledge platforms, but also may create a profound impact on the market value of the firm. According to the research of Srinivasan, Pauwels, Silva-Risso and Hanssen (2009), pioneering innovations (breakthrough) had a profound impact, nearly seven times greater, than minor updates (incremental) on the stock returns of firms in the automotive industry. Similarly, after examining the effect of new product announcements of both new products (breakthrough) and product updates (incremental) on stock values in 23 industries, Chaney, Devinney and Winer (1991) found that entirely new products (breakthrough) generated a 0.74% average 3-day excess stock appreciation return and product updates (incremental) generated a modest 0.41% average 3-day excess stock appreciation return. In the same vein, Bayus, Erickson, and Jacobson (2003) found that new product introductions positively impacted both profit rates and firm size in the computer industry.

In some situations, the enhancement of products may be of sufficient value to warrant a certain amount of delay in their introduction to the market (Cohen and Klepper, 1996). Delays in new product development initiatives can also turn out to be enormously expensive. For example, Hendricks and Singhal (1997) found that the announcement of product delays eroded a firm's market value by over 5% on average over a two-day period after the announcement. This corresponded to an average dollar market value loss of over $100 million. Given the substantial investment costs associated with new product introductions and the profound magnitude that their introduction has on the firm's long-term survival, this research examines the corporate entrepreneurial process for not only small firms, but also large firms.

Regular new product introductions are especially necessary in industries with higher rates of change and evolution or shorter product lifecycles. According to Fine (1998), any particular advantages that a firm might enjoy are temporary. Industry evolution eventually eliminates any such advantages, transforming them from sources of competitive strength into mere requirements for survival and perhaps even into obsolete liabilities which are dysfunctional to possess. The main drivers of rapid industry evolution are identified as the innovation of new technologies and the intensity of competition in an industry. New technologies open up substantial creative possibilities for addressing consumer needs, which then give rise to entirely new associated industries and service sectors. Intense levels of competition, by contrast, make it ever more imperative for firms to drive out costs and become efficient value providers. Intense global competition also forces firms to innovate more rapidly and produce new models and designs with more attractive features and more valuable capabilities that might have product lifecycles lasting only a few years. Firms recognize that competitor responses to new product introductions pose a competitive threat (Bowman and Gatignon, 1995) and thereby may lead to spiraling rates of change and innovation in an industry.

New product innovations, even breakthroughs alone are not enough to ensure the success of a product. We argue that product innovation must be supported by a well-integrated supply chain. Even highly desirable new products will be hamstrung if they are unavailable due to supply chain problems. It is perhaps thus not surprising that supply chain problems resulting in delays can also be costly. Hendricks and Singhal (2003) found that product delay announcements led to an average depreciation in shareholder value of over 10% in a 2-day period. However, when supply chains are functioning properly, their impact on firm performance is positive (Tan, 2002). These business realities play a central role; the importance of the supply chain is integral to this perspective (Fine, 1998).

Supply chains are argued to be so critical to firm performance and survival that their design is taken to be the 'ultimate core capability' of a firm (see Fine, 2000, p. 213). The potential benefits of a supply chain management-based approach to new product development as opposed to a traditional anticipatory approach were reviewed by Bowersox, Stank, and Daugherty (1999). The advantages of the former approach revolve around its ability to permit enhanced responsiveness so that the company produces at a level consistent with actual consumer demand. This allows losses to be more rapidly contained in the event of an unsuccessful product launch. It also allows firms to quickly increase production in the event that a product is especially successful. By contrast, in a traditional approach new product rollout decisions are made farther in advance based on forecasts and there are fewer opportunities to rapidly adapt to consumer demand. The potentially excessive costs associated with this approach may lead firms to be more cautious in their new product development efforts, only proceeding when they are particularly certain about both the product and its expected market impact.

"Best in class" manufacturers understand the notion of time-based competition (e.g., Stalk and Hout, 1990; Fujimoto, 2000) where product or process development innovations need to rapidly become service/product offerings. In highly sensitive time-to-market environments where commercializing new products is necessary to take advantage of first mover advantages, the ability to shorten product development times can confer an important advantage to these firms as they can more quickly react to highly dynamic factors such as changing consumer tastes and market conditions (Millson, Raj, and Wilemon, 1992). Blackburn (2002) gives an interesting counterexample from the automotive industry where pursuing a strategy based on slower time-to-market speeds and response times were found to be more adaptive for a firm than was pursuing a higher time-to-market strategy. In essence, the cost savings of higher time-to-market strategies may be eliminated by increases in other costs under certain circumstances. Conversely, the additional costs of lower time-to-market strategies may be eliminated due to other greater savings (Blackburn, 2002). Thus, these strategic business decisions must be assessed based on their benefits and costs; product development decisions must therefore be justified accordingly (e.g., Smith and Reinertsen, 1995; Urban and Hauser, 1980).

We argue that the firm's learning orientation is an important driving factor that explains its entrepreneurial ability to "search" for and create new product innovations beyond its current knowledge base and organizational routines, spanning global operations. We formulate several hypotheses among our key variables (supply chain integration, organizational learning, and new product introductions- breakthrough versus incremental for corporate entrepreneurship) based on data from manufactures in the global automotive industry.

Figure 1 provides a summary of our theoretical model. Figure 2 provides a more detailed version of our model taking into account our control variables.

INSERT FIGURE 1 ABOUT HERE

INSERT FIGURE 2 ABOUT HERE

Literature Review

Corporate Entrepreneurship

A common theme that appears to be present in innovation failure research is firm size. Current research supports this notion that even though small firms are limited by their production, marketing, financial and human resources (Schumpeter 1934), they are more likely to “search” for and produce more novel innovations that improve the firm’s current technology than larger firms. One explanation for the large firm's lack of creating breakthrough innovations has to do with its lack of internal flexibility, which is created through a complex system of self-sustaining, reliable routines that are narrow in scope and do not instigate organizational conflict. Using patent data, Almeida and Kogut (1997) found that small firms were more innovative in nature than large firms because they were tied to less 'crowded' local knowledge networks. Hannan and Freeman (1984) established that both age and size lead to inertia, which prevents the exploration of new opportunities.

Even though Schumpeter and many neo-Schumpeterians do not consider larger firms as possessing the “right” capabilities to generate more novel innovations (Phillimore 2001), the past several decades have witnessed increasing emphasis focused on traditional learning theories (Cyert and March 1963) that have attempted to understand how organizations of all sizes (including large firms) can gain knowledge from past innovative behaviors, routines and/or strategies to stimulate future entrepreneurial growth. Gifford Pinchott (1985) first developed the concept of intrapreneurship to describe entrepreneurial activities inside large corporate structures. Corporate intrapreneurship was viewed as the firm’s ability to constantly innovate and upgrade its unique core competencies (Kuratko and Welsch, 2001; Prahalad and Hamel, 1990).

In this research, we combine the more common definitions of entrepreneurship and intrapreneurship and further add to it by limiting the specific scope of attention to the polar extremes of technological impact. Our definition of corporate entrepreneurship centers on the firm's ability to generate, develop and implement new innovations that are both incremental and breakthrough. Our research addresses recent calls in the literature for more work on firm innovativeness for firms of all sizes (large and small).

The recognition that organizations must not just innovate occasionally, but often, quickly, efficiently and successfully to ensure future growth and renewal from revenues generated from customers purchasing new products and/or services that did not exist before is well-recognized in the literature (Hamel and Skarzynski, 2001; Lawson and Samson, 2001). It is possible to categorize new products with reference to an underlying continuum or dimension. The varieties of theoretical perspectives that have examined the innovation process include institution theory, cognitive theory, transaction cost economics, socio-technical approaches, market orientation and the resource-based view. The major theoretical difference between the most common labels of innovation impact from these perspectives involves the degree of novelty or change embedded in the following two types of innovations: incremental and radical/breakthrough innovations.

Christensen (1997) categorized new product introductions as being either sustaining innovations (incremental) or disruptive innovations (breakthrough). Sustaining innovations are refinements of existing products that represent incremental improvements. They often take over after radical innovations present a dominant design to an industry (e.g., personal computers, Post-it Notes) through new features, extensions and/or variations to an existing product line. While the definition of innovation itself implies risk, incremental upgrades to existing products can be quite profitable (Christensen, 1997; Damodaran and Wilhelm, 2004), have been found to be empirically less risky than breakthrough innovations (Palmer and Brookes, 2002) and possess the notable advantage of having a ready-made market.

Disruptive innovations, by contrast, have novel architectures and capabilities and thereby create entirely new markets or else sharp discontinuities in the product development curve (Christensen, 1997). Disruptive technologies can be extremely profitable for a firm, if they are accepted in the marketplace. Srinivasan *et al.* (2009) found that firms in the automotive industry achieved positive stock returns when they launched pioneering or breakthrough products to the marketplace with substantial advertising support. The application of disruptive innovations or what others in the scholarly literature refer to as breakthrough inventions (Ahuja and Lampert, 2001), breakthrough innovations (Mote, Boylan, and Rice, 2001), discontinuous innovations (Abernathy and Utterback, 1978) or pioneering products (Ali, 1994) attempt to make unprecedented, revolutionary improvements to existing technology. This type of discontinuous technology represents new product/process classes or features, product/process substitutions, or fundamental product/process improvements. These improvements in performance or cost alter existing markets or create entirely new ones in uncharted territories thereby stretching the firm's innovative core capabilities (Leifer, O'Connor, and Rice 2001; Tushman and Anderson 1986).

Although these technologies have the prospect of rewarding the firm with potential leadership positions in the marketplace, much of the current literature on the development of these innovations has been case specific (Leifer, O'Connor, and Rice, 2001). Of the studies that have examined the conceptualization, development and application/introduction of radical technologies, many have found that they did not materialize as anticipated or were temporarily "shelved" until the firm could support the new scientific knowledge or technology (Rice, Kelley, Peters, Colarelli, and Connor, 2001). Some of the unique characteristics that contribute to breakthrough innovation failure include that they are non-linear, stochastic, costly (e.g., low initial profits), difficult-to-measure and long-term investments that are filled with high technology, market, organizational, financial, and resource uncertainties (Christensen, 1997; Leifer, O'Connor, and Rice, 2001).

Unfortunately, truly disruptive innovations are rather rare and more importantly are usually better discerned through the lens of several years' hindsight, making them difficult to examine in the context of a study focusing on firms' current practices. According to Rice and colleagues (2001), even though successful organizations have learned that long-term competitive success requires that they introduce incremental innovations along with breakthrough innovations to generate new opportunities in the market (Christensen, 1997; Leonard-Barton, 1995), most predominantly normative theories and systematic frameworks guiding managers on how to develop innovations successfully have been more applicable for incremental rather than breakthrough innovation practices. To contribute to our scientific understanding of breakthrough innovation knowledge, we empirically examine this gap in the literature. Specifically, we study entirely new products (breakthrough innovations) vis-à-vis product updates or variants (incremental innovations). This delineation is also similar to that of Chaney *et al.* (1991).

Organizational Learning Orientation

Organizations must continually acquire knowledge if they are to maximize innovative output in terms of both quantity and quality. One school of thought argues that innovation is a process requiring greater knowledge specialization (Chiesa, 1996; Cohen and Klepper, 1996) since it has strong elements of path-dependency (David, 1988). Scholars purport that since there is a tacit component to knowledge, its accumulation is more experience-based, and knowledge transfer should take place primarily through shared social links (Metcalfe, 1992). Geographical proximity at a single location - preferably within a regionally or a nationally concentrated knowledge cluster – is preferred because it provides a fertile ground for efficiency, specialization and opportunities for in-depth problem solving in innovation.

The counter argument to this school of thought holds that cumulativeness and path dependency of innovation can lead to risks of "lock-in" into technological and institutional cul-de-sacs (Michie, 1998; Redding, 2002; Narula, 2002). Scholars suggest that learning from diverse knowledge resources creates positive synergist benefits leading to new opportunities to create novel innovations. Knowledge diversity increases the pool of know-how from which the firm can gain access to, which has been found to stimulate the innovative process further (Leonard-Barton, 1995) and create new ways of solving problems from dealing with environmental uncertainties and complexities (Andriani, 2001; Kaufman, 1995; Patel, Vimla, Kaufman, and Madger, 1996; Simon, 1985). We argue that firms enhance their corporate entrepreneurship, both in terms of incremental and breakthrough innovations when they adopt a learning orientation that emphasizes continual change through the "search" for knowledge diversity and different learning capabilities within its network of shared communication, etc.

Learning organizations need to understand the pace of innovation, the rate of change within the structure of the organization and the rate at which new products need to be introduced to the marketplace. Firms which are able to more rapidly reconfigure themselves to keep pace with industry developments display a higher level of this capacity. Employees at such firms should thereby be more accustomed to, and more comfortable with, organizational change. Such firms are not only willing to make internal changes, but also reward their employees for updating methodologies and procedures. We make the assumption that new and innovative ideas will be welcome at firms with higher learning environments.

The electronics and computer industries are known to be one of the highest velocity environments requiring high organizational learning (e.g., Bourgeois and Eisenhardt, 1988). In this research, we study the global automotive industry. The global automotive industry by contrast is one in which organizational learning is relatively accelerated (i.e., witness the proliferation of innovations such as in-vehicle DVD players, onboard navigation systems, superbright LED illumination devices and the like), but is not at the extreme. By focusing an industry in which the need for organizational learning is moderately rapid, but not so extreme, the results found herein should be more readily applicable to the majority of industries. Based on the learning perspective on strategy, we hypothesize that when firms are able to increase their "search" for new and existing knowledge from a diversity of resources through higher levels of organizational learning these firms eventually increase their corporate entrepreneurial ability to create new product introductions. We hypothesis the following:

Hypothesis 1a. *Firms exhibiting higher levels of organizational learning will have increased levels of greater breakthrough innovations (entirely new product development).*

Hypothesis 1b. *Firms exhibiting higher levels of organizational learning will have increased levels of incremental innovations (new product update development).*

Supply Chain Integration

Supply chain management has increasingly become the emphasis of organizational efforts to improve both operational efficiency and customer satisfaction objectives. Greater supply chain integration in manufacturing industries permits firms to forge and exploit alliances with their most critical suppliers (Porter, 1997) in the continual search for competitive advantage. This effective management of key business processes across a network of buyers and sellers has inspired managers to "search" for new business designs that can capture and sustain growth. New product development efforts have a large impact on profitability (Morash, Droge, and Vickery, 1997) and deserve special attention since the inter-functional process integration between sourcing, logistics, production, marketing, and new product development activities is a locus of competitive advantage.

Our theoretical framework emphasizes the important role of the supply chain integration in corporate entrepreneurship and sustainability. A successful supply chain requires close coordination between a manufacturer and its upstream supply links. In this research, we examine the extent of integration between the manufacturer and upstream suppliers. Supply chains are more integrated when member firms co-monitor the speed of production lines and regularly calibrate against external demand. Greater integration and involvement is frequently manifested by supplier willingness to station key personnel inside the manufacturing firm near the assembly line to ensure smoothness of operations. In the planning stage for new products, cross-functional and cross-firm teams are used to ensure more synchronized efforts. Structuring financial outcomes for member firms so that payoffs are linked together also leads to greater integration. Finally, when unexpected problems crop up, members of a well-integrated supply chain work together to resolve any product development problems thus increasing corporate entrepreneurship outcomes. Based on this analysis, we advance the following hypotheses:

Hypothesis 2a. *Firms exhibiting higher levels of supply chain integration will have higher levels of breakthrough innovations (entirely new product development).*

Hypothesis 2b. *Firms exhibiting higher levels of supply chain integration will have higher levels of incremental innovations (new product update development).*

Organizational Learning and Supply Chain Integration – Moderating Effect

The central theme of our study has been to establish how organizational learning and supply chain integration are key determining factors of corporate entrepreneurship (breakthrough and incremental) for global automotive firms. We also explore the possibility of their being a moderating effect between these two important variables. We ask the question of whether or not the interaction between supply chain and organizational learning increases the firms' corporate entrepreneurship (breakthrough and incremental innovation capability)?

The concept of absorptive capacity has had a profound impact on organizational research. Researchers have found that a reduction in "absorptive capacity" can negatively hurt firm performance (Miller, 1991, 1994; Miller and Cardinal, 1994; Stock, Greis, and Fischer, 2001). Cohen and Levinthal (1990) suggest that a firm's absorptive capacity is comprised of two interrelated concepts. First, the firm must have the capacity to not only identify, but also value new knowledge sources. Second, the acquiring of outside knowledge is critical to the creation or development of existing knowledge. In the context of our research, we refer to the former concept as the firm's learning orientation. We refer to the latter concept as the firm's well-integrated supply chain. We propose that the firm's absorptive capacity is determined by the moderating effect between its well-integrated supply chain and learning orientation.

We postulate that firms need to have some requisite level of organizational learning to benefit from knowledge sharing within an alliance relationship. Moreover, we posit that firms should participate in alliance partnerships in which they are able to overcome unique challenges such as communication issues and even mistrust. Both partners must benefit from their alliance relationship and be able to successfully assimilate and apply knowledge gained from one another. Building upon this rationale, we argue that the moderating effect between supply chain integration and organizational learning will have a positive influence on the firm's absorptive capacity to evaluate new technologies and "search" for new opportunities from diverse knowledge source. When firms fail to "search" for and exploit new knowledge, they run the risk of being "locked out" in the future from acquiring it. Increasing the firm's absorptive capacity for new knowledge can be particularly valuable if the new knowledge that the firm gains also affects a change in the firm's core knowledge or in-house innovative capacity. Thus, we argue that there are innovative benefits for firms that simultaneously have strong organizational learning capabilities and well-integrated supply chains. Given that a firm's absorptive capacity increases its opportunity to seek out new leading edge technologies and knowledge within and outside its current platform, we hypothesis the following:

Hypothesis 3a. *The moderating effect between supply chain integration and organizational learning will influence the firm's ability to develop breakthrough innovations (entirely new product development).*

Hypothesis 3b. *The moderating effect between supply chain integration and organizational learning will influence the firm's ability to develop incremental innovations (new product update development).*

Methods

Sample and Data Collection

The purpose of this study was theory construction and testing. Consequently, it was important to explore a wide range of approaches and perspectives in the context of supply-chain management, production, design and development of new products in a bipartite data collection effort. An overview of this process is as follows. In the first phase, an initial field study consisted of plant visits and in-depth interviews with several plant managers, manufacturing supervisors, supply-chain managers, and purchasing managers working for global automobile firms located in of the biggest emerging markets, Brazil. Based on these findings, we developed a more refined survey questionnaire that was administered by mail. The data for this second phase of the research were collected in 2002–2003 through a questionnaire mail survey of Brazilian automobile manufacturers and suppliers as part of a broader research project affiliated with the International Motor Vehicle Program at the Massachusetts Institute of Technology.

Of the 34 individuals interviewed in the initial field study, 19 were either plant managers or manufacturing supervisors from Ford (São Bernardo do Campo, São Paulo), DaimlerChrysler (São Bernardo do Campo, São Paulo), General Motors (Gravatai, Rio Grande do Sul), Volkswagen (Resende, Rio de Janeiro), and Troller (Maracanau, Fortaleza). Four of those interviewed were executives at Anfavea (the Brazilian Automakers Association) and Sindipecas (the Brazilian Auto Suppliers Association). In addition, one faculty member of the University of São Paulo whose research involves the development of the automobile industry in Brazil was also interviewed. A total of five automakers (i.e., Volkswagen, Ford, DaimlerChrysler, General Motors, and Troller) were included in the sample, and multiple individuals were interviewed. The companies represented in the interviews were multinational firms from multiple countries, including one Brazilian firm, two European firms, and two from the United States. In addition to the automaker's personnel, informal interviews were conducted with 10 plant managers from suppliers. Therefore, the sample reflected a diverse set of manufacturing companies within the supply chain of the automotive industry including automakers and suppliers and, in conjunction with the literature review, was well suited for obtaining a rich set of ideas and insights regarding the supply chain management implications impacting new product development.

A relatively general format for the in-person interviews was followed. First interviewees were provided with a brief description of the research project. Then each interviewee was asked questions around several issues relating to their production process. The personal interviews lasted an average of 60 minutes and were recorded unless requested otherwise. All interviews were followed by a tour of the production facilities, where the interviewer also had the opportunity to speak to other employees on the floor, including some of the suppliers. The interviews were conducted between October 21st and November 4th of 2001 in the states of São Paulo, Rio de Janeiro, and Rio Grande do Sul in Brazil.

The second stage of the research effort involved questionnaire development. Likert-type measurement scales for the constructs described in our framework for corporate entrepreneurship were generated (see Appendix). The development of the items was informed by the field studies and the semi-structured interviews with managers and executives working in the automobile industry in Brazil.

Before deciding on the final version of the questionnaire, a pilot version was administered at the Ford plant in São Bernardo do Campo. In addition, one expert on modular production at the University of São Paulo provided some feedback on a pilot version of the questionnaire, and helped refine key constructs and identify the appropriate use of words in the automotive industry. Then during the first visit to Brazil we discussed potential wording problems and possible sources of confusion with a Ford plant manager, which helped to further refine the items. Then, after we obtained the final version of the questionnaire, it was translated into Portuguese and then back-translated into English to assure that the translation had not obscured the meaning of the questions. The survey was distributed to those identified in the sample group via hard copies along with a request for participation and a brief description of the research in question.

The automobile and auto suppliers manufacturers were identified through lists provided by Anfavea and by Sindipecas. In addition, the two associations' lists were cross-checked with the Brazilian magazine Automotive News, an annual publication which profiles firms and executives in the auto industry in Brazil. After combining these data sources and deleting duplicated entries, the questionnaire was sent to the remaining sample of 493 business units in the automobile industry of Brazil. As mentioned earlier, the questionnaire was mailed along with an introduction letter requesting participation in the research, giving a brief description of the research in question, and listing the benefits of participating in the survey. The survey was mailed to managers at the plant/divisional level, who were asked to respond based on the products and characteristics of their division.

After the initial mailing, a total of 37 questionnaires were returned because of incorrect addresses, which reduced the sample size to 456 business units. Thirty days after the initial mailing 54 valid responses had been received. Follow-up letters and emails were sent to managers who did not respond to the initial mailing, and this second mailing resulted in another 47 valid responses, for a total of 101 valid questionnaires and a response rate of 22 percent. Firms of a variety of ages, sizes, and geographical scope were represented in the final sample group. In particular, the sample consisted of 17 OEM assemblers and 84 suppliers of parts and components.

Firm Characteristics: Control Variables

We also included key size-related firm characteristics that were likely to be influential in corporate entrepreneurship framework. In our study, these variables are explanatory variables of secondary concern, and thus may be viewed as control variables. Firm-level characteristics are often used in the innovation literature in this capacity (e.g., Sánchez and Pérez, 2003).

Information Technology. Information technology (IT) is an integral part of the modern supply chain. The mechanisms by which IT can be used to support supply chains within an organization have been considered by Hoogeweegen, Teunissen, Vervest, and Wagenaar (1999). IT has been empirically shown to positively impact firm performance via enhanced supply chain coordination (Ross, 2002). Moreover, increased IT investment within the supply chain can be used to signal increased commitment, thereby leading to greater inter-organizational trust (Kent and Mentzer, 2003). This is important as there are many potential sources of conflict and risk in supply chains (Kumar and van Dissel, 1996) which may degrade firm performance. One form of IT that has been identified as a key technology for supply chain management is electronic data interchange (Ross, 2002). Electronic data interchange (EDI) has been shown to create substantial business value and has long been used in the automotive industry. For example Mukhopadhyay, Kekre, and Kalathur (1995) estimated the annual savings of EDI to Chrysler to be approximately $220 million. The benefit of EDI in the supply chain context is that it facilitates information sharing (Sahin and Robinson, 2002); thereby promoting greater levels of integration and coordination as well as lowering costs (Cachon and Fisher, 2000).

Of particular relevance to the current research was the IT-oriented work by Guimaraes, Cook and Natarajan (2002). In somewhat related research, Jayaram, Vickery, and Droge (2000) examined the effects of eight different IT infrastructures on four measures of time-based performance in supply chains. They found a positive relationship between new product development time and the use of IT infrastructures supporting design-manufacturing integration, such as computer-aided design and computer-aided manufacturing. Mendelson and Pillai (1998) also found that firms were more likely to utilize IT such as electronic data interchange (EDI) in higher intra-organizational learning environments.

Firm Characteristics. The number of employees at a firm was found to be a relevant factor predicting lean manufacturing by Shah and Ward (2003). Furthermore, smaller firms are likely to be qualitatively different from larger firms in certain respects, innovation among them. As discussed earlier, smaller firms may be more likely to pursue disruptive innovations to reconfigure markets in their favor (Christensen, 1997). In terms of the number of employees, passing the 100–employee mark has been suggested to be a measure of firm maturity (e.g., Plenert, 2002, p. 314). As such, a firm size variable was employed which was coded 0 for smaller firms (100 or fewer employees) and 1 for larger firms. In the current study, 27% of the firms were of this smaller size, all of which were suppliers. An additional measure of a firm's size is its annual sales volume. Clearly, firms with larger sales volumes may have more financial resources to support new product innovation. Thus, we entered log annual sales volume into the model to control for differences in this firm characteristic. In a similar vein, Novak and Eppinger (2001) also found it useful to identify and control for multiple conceptualizations of firm volume in their empirical investigation of product complexity and the supply chain.

Firms which have a larger product line might be expected to continue to grow by product innovation. In a sense, the breadth of the product line could be viewed as a proxy for the past level of product innovation at the firm. Firms that have already developed a large number of products might be expected to continue their efforts. Thus, based on intuition we would expect the relationships between the number of products in the product line and the respective measures of entirely new products and product updates to be positive. As such, we include a variable that indicates the number of products currently produced by the firm.

Based on this discussion, we identify four firm characteristics which, while not cornerstones of our framework, control and account for important differences which exist across firms. We develop a conceptual model of the relationships between supply chain integration, organizational learning, and other firm characteristics which appears in Figure 2.

Construct Validation and Measurements

The construct validation followed the steps of exploratory factor analysis and the creation of indices summarizing the items. The structure of the constructs that were defined in this study was confirmed by factor analysis. The reliability factor of each of the scales was estimated by computing Cronbach's alpha. Each of the scales was refined by removing questions that exhibited low inter-question correlations. The reliability coefficients of each of the refined scales are reported in the Appendix along with the item text. Alphas ranged from 0.72 for organizational learning to 0.85 for supply chain integration (see Appendix). These refined scales have acceptable reliability coefficients according to the 0.70 criterion recommended by Nunnally (1978) and Mendelson and Pillai (1999). We adopt their approach here.

Empirical Model Specification

Given our interest in corporate entrepreneurship, we measured the number of new product introductions (breakthrough versus incremental). Breakthrough innovations were coded as entirely new products whereas incremental innovations were coded as product updates. The number of new product introductions in a particular time frame is a count variable and as such must be integer-valued and non-negative. By contrast, linear regression methods hinge on an important assumption that the dependent variable is real-valued. The analysis of count data through the use of linear regression models is typically not recommended as biased, inconsistent and inefficient estimates will likely result (Long, 1997, ch. 8). Monte Carlo studies have shown that attempting to model count data with OLS-based methods generally leads to substantively wrong conclusions being drawn (King, 1986). By contrast, Poisson regression models do not suffer from these problems as they are consistent, unbiased and efficient for count data. One feature of the Poisson model is that the mean and the variance of the dependent variable are equal. Equality of these two moments is often somewhat unlikely to be observed in real-world data. Rather, in practice we find that the variance in the counts is often larger than the Poisson model would specify. This is known as over-dispersion (McCullagh and Nelder, 1989, ch. 4). Over-dispersion leads to artificially small standard errors, which in turn lead to spuriously large test statistics.

A formal parametric approach to addressing this problem involves extending the model so that over-dispersion itself is directly modeled. The negative binomial model is one such model that allows over-dispersion to be assessed parametrically. The probability mass function for the negative binomial is:

$$p(y \mid \mu,\theta) = \frac{\Gamma(\theta + y)}{\Gamma(\theta) y!}\left(\frac{\theta}{\theta + \mu}\right)^{\theta}\left(\frac{\mu}{\theta + \mu}\right)^{y} \qquad (1)$$

Where μ is the mean and θ is a dispersion parameter. Here, $E(y) = \mu$ but in contrast with the Poisson we find that $\mathrm{var}(y) = \mu + \mu^2/\theta$. Thus, the variance is a quadratic function of the mean and is larger than the mean by a factor of $1+\mu/\theta$. We can easily see that $\lim_{\theta\to\infty} \mathrm{var}(y) = \mu$ so that the variance under the Poisson model is recovered as a special case of the negative binomial. We can also show that Equation 1 converges to the Poisson distribution

$$p(y \mid \mu) = \frac{e^{-\mu}\mu^{y}}{y!}$$

as $\theta \to \infty$. Conversely, we can see that as any finite value of θ becomes increasingly smaller, the Poisson model becomes increasingly untenable.

When there are multiple dependent variables, it is natural to consider a multivariate statistical framework. For models in the Poisson family, model fit can be considerably improved via the use of a multivariate Poisson approach as opposed to separate un-variate Poisson models (Karlis and Ntzoufras, 2003). Cameron and Trivedi (1998, §8.3.2) described a bi-variate negative binomial distribution. The joint probability mass function can be written as:

$$P(y_1, y_2) = \frac{\Gamma(y_1 + y_2 + \theta)}{\Gamma(\theta) y_1! y_2!} \left(\frac{1}{\mu_1 + \mu_2 + 1} \right)^{\theta} \left(\frac{\mu_1}{\mu_1 + \mu_2 + 1} \right)^{y_1} \left(\frac{\mu_2}{\mu_1 + \mu_2 + 1} \right)^{y_2}. \qquad (2)$$

Generalizing further, Guo (1996) presents a negative multinomial distribution in the case of $y_1, \ldots, y_k$ for arbitrary k.

A regression model based on the bi-variate negative binomial in Equation 2 may be introduced by analogy with Poisson regression. Recall that in ordinary least squares regression the relationship between the independent variables $\boldsymbol{x}$ and the dependent variable y is specified by the relation:

$$E(y_i|\boldsymbol{x}) = \mu_i = \boldsymbol{x}_i\beta \qquad (3)$$

where i indexes the respondents, μ_i is the conditional mean for respondent i having covariates $\boldsymbol{x}$ with regression coefficients β. Here, the linear predictor is $\boldsymbol{x}_i\beta$. In generalized linear models like the Poisson a link function $g(\cdot)$ is introduced such that $g(\mu_i) = \boldsymbol{x}_i\beta$. Hence the linear predictor is no longer equal to the expected value of the dependent variable but instead is equal to some function $g(\cdot)$ of it. For the Poisson, the link function is usually taken to be the natural log as this prevents the expected value of the count from being negative. We thus may rewrite Expression 3 in the generalized linear model framework as:

$E(y_i|\boldsymbol{x}) = \mu_i = g^{-1}(\boldsymbol{x}_i\beta)$

and in the case of the Poisson $g^{-1}(\cdot)$ is the exponential function. We are now in the position to obtain a likelihood function, L, from Equation 2. We have:

$$L = \prod_{i=1}^{n} \frac{\Gamma(y_{i1} + y_{i2} + \theta)}{\Gamma(\theta) y_{i1}! y_{i2}!} \left(\frac{1}{\exp(\boldsymbol{x}_i\boldsymbol{\beta}_1) + \exp(\boldsymbol{x}_i\boldsymbol{\beta}_2) + 1} \right)^{\theta} \left(\frac{\exp(\boldsymbol{x}_i\boldsymbol{\beta}_1)}{\exp(\boldsymbol{x}_i\boldsymbol{\beta}_1) + \exp(\boldsymbol{x}_i\boldsymbol{\beta}_2) + 1} \right)^{y_{i1}} \times \left(\frac{\exp(\boldsymbol{x}_i\boldsymbol{\beta}_2)}{\exp(\boldsymbol{x}_i\boldsymbol{\beta}_1) + \exp(\boldsymbol{x}_i\boldsymbol{\beta}_2) + 1} \right)^{y_{i2}} \tag{4}$$

Where $\boldsymbol{\beta}_j$ is the vector of regression coefficients for the j^{th} dependent variable. While applications of negative binomial regression are somewhat common, the use of multivariate negative binomial models seem relatively rare (although see Guo, 1996; Lee, 1999).

Results

Model estimation was by maximum likelihood in the *Mathematica* environment (Wolfram, 1999) using the likelihood function in Equation (4). The standard errors were obtained from the square roots of the diagonal entries of the estimated asymptotic covariance matrix, which themselves were obtained from the observed Hessian, $\left(\frac{\partial^2 \log L(\hat{\boldsymbol{\beta}})}{\partial \boldsymbol{\beta}\, \partial \boldsymbol{\beta}'} \right)^{-1}$. Maximum likelihood test statistics were formed in the usual way from the maximum likelihood estimates of the regression coefficients, $\hat{\boldsymbol{\beta}}$ and their standard errors. Table 1 contains these values as they pertain to the two dependent variables of breakthrough (entirely new products) and incremental (product updates) innovations.

INSERT TABLE 1 ABOUT HERE

We first examine the results for breakthrough innovations (entirely new product development) that appear in Table 1. With regard to Hypothesis 1a, higher levels of organizational learning were found to be associated with a greater number of breakthroughs ($\hat{\beta}$ = 1.61). This relationship was positive and statistically significant, thereby providing support for Hypothesis 1a. For Hypothesis 2a, higher levels of supply chain integration were also found to be associated with a greater number of breakthroughs (entirely new products developed) ($\hat{\beta}$ = 2.14). This relationship was also positive and statistically significant and hence Hypothesis 2a was also supported.

The interaction term between supply chain integration and organizational learning also deserves mention for Hypothesis 3a. The estimate is negative ($\hat{\beta}$ = -0.580) and statistically significant. This pattern of results can be described as follows. When both supply chain integration and organizational learning are low, the number of breakthroughs will be low. As the level of either supply chain integration or organizational learning increases, the pace of breakthroughs (entirely new product development) also increases. However, a negative synergy also exists between supply chain integration and organizational learning with regard to breakthroughs. The findings indicate that firms, which are able to successfully maintain high levels of supply chain integration in the face of high organizational learning introduce fewer breakthroughs perhaps because they may have fewer resources left over for innovation. The more innovative firms are those with higher organizational learning and less integration or more integration and slower organizational learning. The former type of firm could perhaps be thought of as the traditionally innovative firm having more individualistic tendencies as opposed to being involved in extensive collaborative networks. The latter type of firm is one that is highly integrated in a more stable environment and thus may be more able to afford the investment of resources to plan for the future. Our results suggest that a certain amount of stability seems is beneficial for supply chain operation.

We also comment on the impact of the remaining variables estimated in the model on breakthroughs. Firm size was found to be a firm characteristic with a statistically significant relationship with breakthroughs. The negative coefficient ($\hat{\beta}$ = -0.571) indicates that the smaller firms were more likely to generate entirely new product developments than were large firms if all other firm variables were to be held equal. This appears to be consistent with industry evidence that successful smaller firms may derive an advantage by being more innovative whereas larger firms may tend to eschew potentially disruptive innovations in favor of sustaining extensions of current products (Christensen, 1997; Boyle, 2004). The number of products a firm had in its product line was strongly predictive of its breakthroughs (z = 5.77, p < .0001). Similarly, increased log sales volume was also strongly predictive of an increased pace of entirely new product development (z = 4.43, p < .0001). Finally, the level of firm EDI was not related to entirely breakthrough innovations (z = -0.501, *n.s.*), contrary to our initial expectations. It would seem that higher levels of EDI do not by themselves accelerate the pace of breakthrough innovations. Given that EDI has long been in use in the automotive industry (Ross, 2002), the relative advantages associated with it may be declining (Mata, Fuerst and Barney, 1995; Powell and Dent-Micallef, 1997). Alternatively, perhaps more innovative firms have also found ways to innovate around varying levels of EDI that may be present.

Next we examine the results for incremental innovations (product update development) in Table 1. With regard to Hypothesis 1b, higher levels of organizational learning were again found to be associated with a greater number of product updates developed ($\hat{\beta}$ = 2.32). Concerning Hypothesis 2b, higher levels of supply chain integration were again found to be associated with a greater number incremental ($\hat{\beta}$ = 2.95). Thus, both Hypotheses **¡Error! No se encuentra el origen de la referencia.**1b and 2b were supported in the context of incremental product development. The interaction term between these two variables was also statistically significant for Hypothesis 3b. The estimate was again negative ($\hat{\beta}$ = -0.765), implying the same type of pattern of results that was observed for breakthroughs.

Firm size, however, was not quite a significant predictor for incremental product developments as it was for breakthroughs. The firm's number of products again was strongly predictive of incremental innovations (z = 11.1, p < .0001). The relationship was positive ($\hat{\beta}$ = 0.0139) indicating that firms with larger product lines introduced a greater number of incremental or new updates than those with smaller product lines. However, log sales volume was not predictive of incremental product development after controlling for other factors in the model. Finally, the level of EDI was not associated with incremental at conventional levels of significance. We also mention that the maximum likelihood estimate of the over-dispersion parameter, θ, was 1.74. From our earlier discussion, we can see the small magnitude of θ

indicates considerable over-dispersion was present in the data, so that the adoption of a bi-variate Poisson model would have been inappropriate.

Discussion and Implications

Our study provides theoretical and managerial insights into new product development strategies in buyer-supplier relationships in the organizational learning context and addresses important gaps in the literature. Our analysis supports the prediction that supply chain integration and organizational learning are important strategic factors influencing corporate entrepreneurship for two types of product innovation (breakthrough and incremental) in the global automobile industry for firms of all sizes.

The presence of significant moderating relationships between our major constructs indicates the pattern of relationships in our framework is actually more complex than indicated or expected, which has important implications for managers. In particular, higher rates of breakthroughs and incremental only occur when one of the two independent variables is at a high level. When both supply chain integration and organizational learning are at high levels, the level of innovation diminishes. An alternative interpretation of this pattern of results involves the notion of organizational learning at the industry level.

In an industry characterized by moderate organizational learning, it may be difficult to reshape the firm into a high organizational learning one. Doing so may have some unintended consequences such as inhibiting the amount of innovation. Specifically, firms seeking to increase the pace of new product development (breakthrough and incremental) should adopt either a higher organizational learning approach or instead strive for greater supply chain integration. Thus, there may limits to the amount of feasible organizational learning mobility possible within a particular industry. An interesting and beneficial area of future research could involve empirically identifying techniques for ameliorating the specific root causes of the challenges of extensive supply chain integration in high organizational learning environments.

The complexity of the organizational learning approach to innovation requires managers to develop a good understanding of new product development antecedents and outcomes to be able to take full advantage of the opportunities when developing supply chain strategies. Therefore, we suggest that our findings provide important normative guidelines to managers dealing with corporate entrepreneurship strategies and supply chain management in the context of organizational learning. A recommendation from this research is that managers need to better understand the degree of commitment to supply chain strategies in the context of organizational learning to better manage the factors associated with how their firms continuously improve internal processes to improve introductions of both breakthrough and incremental innovations (product updates). Managers can benefit from our results by developing a set of managerial tools that will help them become more competitive by balancing the degree of supply chain integration in light of their ability to change and adapt to the rate of change in their environment.

Above and beyond the strategic contributions described above, the current research also makes several contributions to the literature on organizational learning and corporate entrepreneurship. First, we have generated a detailed framework for understanding the relationships between the concepts of corporate entrepreneurship, organizational learning and supply chain integration. This new framework was developed from both theoretical perspectives as well as the relevant empirical literature. Our framework was then subjected to empirical investigation and the hypotheses derived from it were supported.

Second, our findings suggest that the concepts associated with the organizational learning perspective on business strategy appear to have generality to a broader set of firms than has been empirically documented previously. Third, we argue for and then utilize empirical methodology that is better suited to the count data measures that are often found in new product development contexts. In a sense, this is a continuation of a line of thinking originating with Mendelson and Pillai (1999), who called for more rigorous quantitative measures. Fourth, we developed and validated a new measure of organizational learning.

Our research is subject to the typical limitations associated with cross-sectional survey research. For example, longitudinal designs would permit more conclusive determinations regarding the direction of causality. Moreover, our study is more limited in certain respects than some of the other organizational learning research in that only a single industry, the automotive industry, is considered. This has the potential to circumscribe the generalizability of the findings. However, our research is likely to be more germane to the many moderate organizational learning industries. Future research should examine other organizational learning industries such as the pharmaceutical and airline industries. One variable that requires a caveat is our firm size variable as it overlaps with the supplier versus OEM manufacturer distinction. Our results associated with firm size should be regarded as illustrative.

Another limitation of the current study is that it involves Brazilian firms. The Brazilian automotive industry is highly globalized so we do not suspect that the patterns observed are only applicable there. The context of the automobile industry in Brazil was found to be an excellent environment to examine the antecedents and outcomes of modularization in the design and production of automobiles (Kotabe, Parente, and Murray, 2004). Given that Brazil hosts all of the global car manufacturers in the world and that it has served as the testing ground for innovative methods of modular production, it seemed to be a particularly appropriate setting for our current research. However, there may be some other important differences in organizational learning phenomena on an international scale. So this remains an area for further investigation.

An area for future research is the new measurement scales for our constructs of supply chain integration and organizational learning. Future research could adapt and/or refine improve our measurement scales of these constructs as well as incorporate other relevant constructs to the study of corporate entrepreneurship in the context of organizational learning and supply chain integration. A related limitation of this research is the one-dimensional nature of our dependent variables. Measuring only the number of new product introductions may have failed to capture the level of product complexity as well as other dimensions associated with new product development performance, such as amount spent on research and development or the level of co-design with suppliers. Similar to Chaney *et al.* (1991), we measured corporate entrepreneurship or new product introductions in two categories: breakthroughs (wholly new products) and incremental (product updates). We suggest that future researchers extend this conceptualization and explore possible multidimensional aspects and measures of product development performance as impacted by supply chain integration and organizational learning.

Besides the abovementioned main contributions and implications of the research, a final aspect of our research involves its implications to the international business context. We note that the Japanese have been recognized as being especially effective process innovators (e.g., Fine, 2000; Womack, Jones, and Roos, 1990) and many aspects of the modern supply chain draw lineage from Japan. Supply chains emphasize long-term relationships that require inter-firm commitment, partnership and coordination. A Japanese conception of change involves the notion of *kaizen* where change is constant but more gradual and subject to examination and feedback so that shared ownership can be created. By contrast, the United States notion of change may involve more dramatic initiatives, with expectations of rapid return on investment and the goal of creating a blockbuster where problems are solved in one fell swoop (Plenert, 2002, ch. 8). Thus, there may be some inherent tension between these two views of change, thereby accounting for the negative interaction that was found. It may be particularly challenging for firms to reconcile these two views of change. Indeed, Guimaraes *et al.* (2002) suggested that the effectiveness of Japanese-style firm interdependencies may be circumscribed in environments characterized by high rates of change. A lengthy highly interdependent supply chain may be too challenging to reconfigure when markets change rapidly. Since the interaction effect in our findings indicates that the two strategies seem to be mutually exclusive, it is possible that certain cultural aspects of the two strategic approaches would be an intriguing area for future study.

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FIGURE 1: Organizational Learning and Supply-Chain Integration Framework for Corporate Entrepreneurship in the Global Automotive Industry

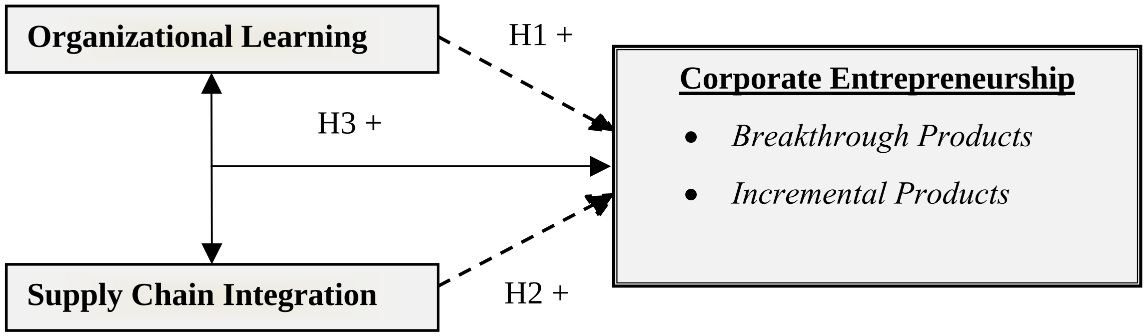

FIGURE 2: Organizational Learning and Supply-Chain Integration Framework for Corporate Entrepreneurship in the Global Automotive Industry with Control Variables

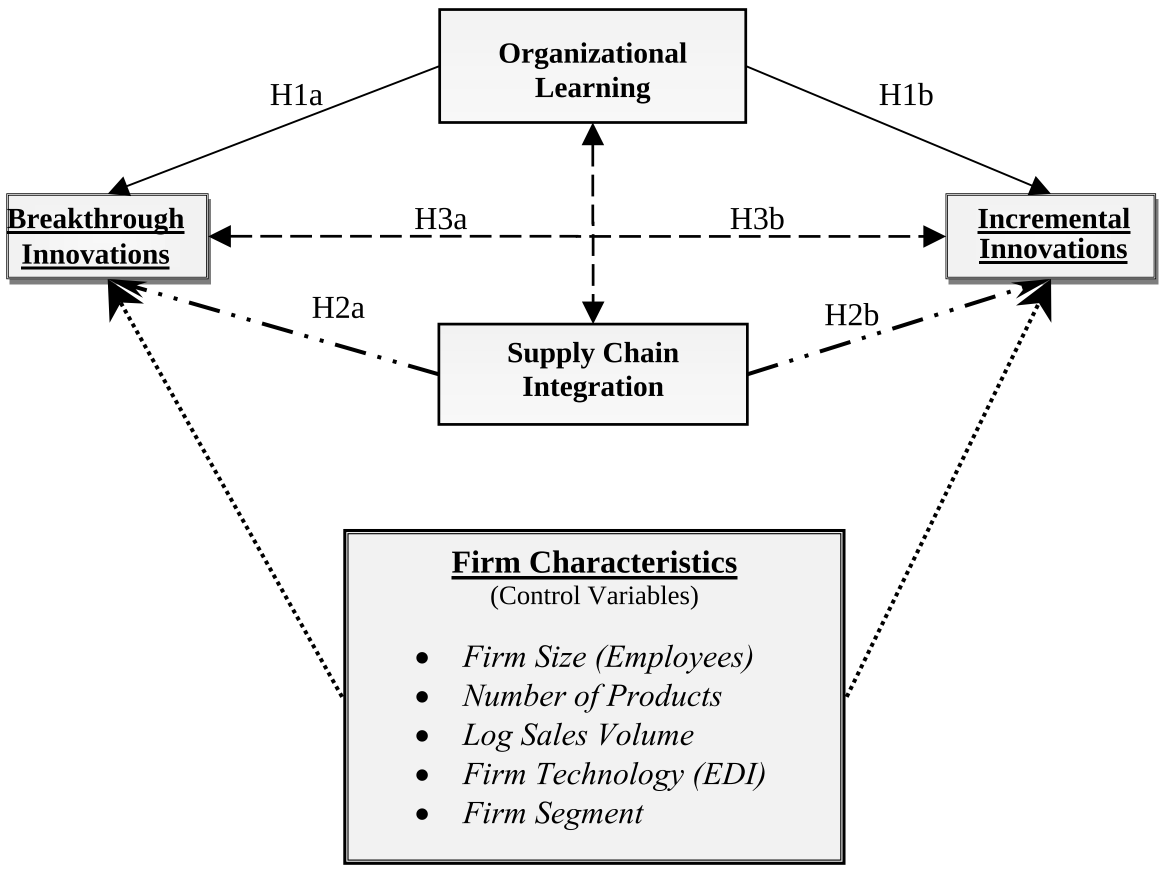

TABLE 1: Parameter Estimates and Test Statistics

	Breakthrough Innovations				*Incremental Innovations*			
Parameter	Estimate	S.E.	*z*	*p*	Estimate	S.E.	*z*	*p*
Intercept	8.19	2.90	2.83	.005	7.78	2.66	2.93	.003
OrgLg	1.61	0.688	2.34	.019	2.32	0.635	3.65	.0003
SCInt	2.14	0.920	2.33	.020	2.95	0.851	3.46	.0005
OrgLg*SCInt	0.580	0.226	2.57	.010	0.765	0.209	3.66	.0003
FSize	0.571	0.234	2.44	.015	0.360	0.217	1.66	.096
NProd	0.00782	0.00136	5.77	.0000	0.0139	0.00125	11.1	.0000
LogVol	0.187	0.0422	4.43	.0000	0.0504	0.0381	1.32	.187
EDI	0.0524	0.105	-0.5	.617	0.118	0.0984	1.20	.231

OrgLg - organizational learning, SCInt - supply chain integration, FSize - firm size, NProd - number of products, LogVol - log sales volume.

Note: *p* values of '.0000' denote *p* values less than .0001.

Appendix

Organizational Learning - Independent Variable (α=0.72)

1. In general, our people accept change readily.
2. New and innovative ideas are welcome in our business unit.
3. We reward people for updating our common methodologies and procedures.
4. We have a very decentralized decision making process.

Supply Chain Integration – Independent Variable (α=0.85)

1. Usually our major suppliers are paid only upon the approval of the final assembled product by us.
2. Our major suppliers are frequently monitoring the demand variations for our final products.
3. Our major suppliers are frequently monitoring the speed and flow of our assembly line.
4. Our major suppliers usually keep their own key personnel inside or at close distance to our final assembly line.
5. We use cross-functional teams with our people and with people from major suppliers to carry out key activities in the development stage.
6. We use cross-functional teams with our people and people from major suppliers to carry out key activities in the assembly line.
7. We cooperate with suppliers in order to resolve problems whenever an unexpected situation arises.

Information Technology – EDI – Control Variable (α=0.84)

1. Our product development engineers depend on electronic databases listing standard components and their interface specifications.
2. Our people follow standard procedures and rely on electronic systems for transferring knowledge across projects and business units.
3. We frequently use an online system for data exchange between our people and our major suppliers.
4. Our business unit and our suppliers frequently use an electronic data exchange system.