ACHIEVING SUCCESS IN THE SUSTAINED REGENERATION FORM OF CORPORATE ENTREPRENEURSHIP: EFFECTS OF PORTFOLIO TECHNOLOGICAL ADVANCEMENT ON A FIRM’S NEW PRODUCT LAUNCH RATE

Kimberly M. Green
Clemson University, USA, kgreen2@clemson.edu

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ABSTRACT

This study explores whether the average technological advancement of a firm’s new product development (NPD) initiatives has an impact on the firm’s NPD launch rate. A key premise is that success in developing product portfolios that are advanced beyond current market offerings is a function of the firm’s knowledge base. The study uses a dataset of drug development activity for 90 pharmaceutical companies over the period 1995 to 2006. A three-way interaction indicates that firms developing technologically advanced portfolios exhibit a higher launch rate when those portfolios combine either high breadth and low concentration across knowledge categories or high concentration and low breadth.

INTRODUCTION

Corporate entrepreneurship activities can be classified based on the focus of a firm’s innovative initiatives (e.g., internal, cooperative, and external innovation) and on the frequency with which entrepreneurial initiatives are undertaken. Established firms that continuously and systematically implement entrepreneurial initiatives exhibit behavior that has been labeled “sustained regeneration” (Morris, Kuratko, & Covin, 2008). The sustained regeneration form of corporate entrepreneurship is characteristically manifested through a heavy reliance on new product development (NPD) activity and in industries such as computers, electronics, and pharmaceuticals where the introduction of new products is continuous and a firm’s NPD activity has important implications for its performance.

Success in pursuing the sustained regeneration form of corporate entrepreneurship, as defined by the percentage of NPD initiatives that are launched, will be variously challenging for firms depending upon the extent to which the products under development are technologically advanced beyond current market offerings. Too little advancement over current offerings and the entrepreneurial new product initiatives may not garner much support for launch within their organizations or much enthusiasm from within their intended markets. On the other hand, firms whose portfolios are heavily weighted toward technologically advanced projects may find their launch rates hampered by the significant development-related challenges associated with trying to consistently introduce products that constitute major improvements over current offerings.

The present study explores whether the average technological advancement of a firm’s new product development initiatives has any impact on the new product launch rate of that firm. A premise of this study is that a firm’s success in pursuing technologically advanced product portfolios will be a function of the firm’s knowledge base in the product categories where the new initiatives are being pursued. The following specific research questions guide this study: Is the
average technological advancement level of the products under development related to the firm’s NPD launch rate? Is this relationship moderated by (1) the breadth of a firm’s product portfolio across knowledge categories, (2) the concentration level of a firm’s product portfolio within categories, and (3) the combination of breadth and concentration?

THEORY AND HYPOTHESES

The NPD process is a key set of activities in which both existing and new knowledge is put to use (Garvin, 1993; Shani, Sena & Olin, 2003). New product development provides evidence of organizational learning and the management of the resulting knowledge (Adams, Day & Dougherty, 1998). Research linking knowledge utilization to new product performance, timeliness, and creativity indicates that competitive advantage is tied to knowledge utilization activities in firms (Moorman, 1995). A firm’s ability to effectively manage knowledge in order to drive improved new product outcomes is particularly important in industries in which the continuous introduction of new products is a way of life.

Launch rate is an indicator of a firm’s proficiency with the NPD process. Learning is generally believed to improve proficiency with processes, so proficiency with the NPD process can be characterized as a learned competency. Researchers note that it is when NPD issues are complex that learning occurs (Kim & Wilemon, 2007). Further, a learning orientation has been linked to firm innovativeness (Calantone, Cavusgil & Zhao, 2002). These perspectives suggest that firms developing products that are technologically advanced and innovative are also the firms with a learning orientation. That learning orientation would permit those firms to demonstrate a high proficiency with the complexities of managing a portfolio of advanced NPD projects.

Further, low levels of product advancement could be associated with low launch rates for firms who initiate many products only to discontinue development when additional information reveals that the investment is not worthwhile. Firms can have a high launch rate by improving their ability to develop products and by improving their selection ability so that they avoid initiating products that would not be launched. Knowledge about new product development includes not only knowledge about the development stages and the technology but also knowledge about the market. For some products, minor advances would not be sufficient to offset consumers’ switching costs or to overcome their reluctance to change (Hauser, Tellis & Griffin, 2006). Firms with a keen understanding of the market may be less likely to initiate development of products that represent only minor advances beyond existing products, anticipating that these products will not produce a return sufficient to justify the NPD investment. It is hypothesized that a portfolio of technologically advanced products will be associated with a higher launch rate.

Hypothesis 1: The average level of advancement of a firm’s NPD portfolio is positively related to the firm’s NPD launch rate.

An explanation of how firms might be able to achieve a high NPD launch rate in a portfolio of technologically advanced NPD initiatives can be developed by considering how firms structure and utilize their product knowledge. A portfolio perspective in NPD research recognizes the distribution of products across product categories (Henderson & Cockburn, 1994) or across technology categories (Lin & Chen, 2005). The number of categories and the number of products in each category can have implications for the efficiencies or inefficiencies in the NPD process. Interdependencies or synergies can exist among the products under development (Ding & Eliashberg, 2002; Lin & Chen, 2005), or resource cannibalization can cause some products to suffer when new ones are introduced (Roberts & McEvily, 2005; Wheelwright & Clark, 1992).
Product categories in NPD provide an approach for understanding a firm’s stock of knowledge. Products in the pipeline can be considered to be physical manifestations of a company’s stock of accumulated knowledge (DeCarolis & Deeds, 1999). The extent to which firms benefit from flows of new knowledge has been found to depend on their stock of existing knowledge and how closely related it is to the new knowledge that is being acquired (Nerkar & Roberts, 2004; Penner-Hahn & Shaver, 2005). Studies analyzing firms’ existing knowledge stock have found that the firms that gain more from their radical innovations are firms with greater breadth in their product portfolio (Sorescu, Chandy & Prabhu, 2003). Scope or breadth has also been identified as a driver of performance in drug development (Cockburn & Henderson, 2001). Conversely, a strategy of focusing on only a few technologies can make high-quality patents increasingly difficult to obtain (Lin & Chen, 2005).

To manage a NPD portfolio that has a high level of technological advancement and a high launch rate, firms must be able to recognize the value of and integrate knowledge that is distal from the knowledge embedded in products currently on the market. A broad, varied knowledge base can offer greater opportunity for making new, innovative associations between knowledge flowing into the firm and the existing base. These points suggest that portfolio breadth will positively moderate the relationship between the average level of technological advancement in the NPD portfolio and the NPD launch rate.

Hypothesis 2: The relationship between the average technological advancement of the firm’s NPD portfolio and the NPD launch rate is moderated positively by the breadth of the portfolio.

Focusing knowledge accumulation efforts on certain product categories is another approach that firms can use to facilitate the successful development of advanced products. By having an NPD strategy in which the firm operates in selected categories, the firm can take advantage of the path-dependent nature of knowledge accumulation to develop advanced knowledge and capabilities. Highly-developed knowledge and capabilities can support the firm’s attempts to make major technological advancements as it develops products. Additionally, because the development of knowledge is often category-specific (Thomke & Kuemmerle, 2002), concentrating product development in certain categories can take advantage of synergies in within-category knowledge accumulation. Strategic focus, synergy and leveraging existing knowledge have been identified as critical success factors in new product development (Cooper & Kleinschmidt, 1995; Zirger & Maidique, 1990).

The knowledge that a firm accumulates about NPD includes both technological and product-market knowledge. Category-specific technological experience has been shown to benefit products within the category that rely on technological novelty (Nerkar & Roberts, 2004). Focus on a few product categories may also facilitate the deep understanding of customers which has been linked to new product success (Zirger & Maidique, 1990). Meyer and Roberts (1988) noted that companies that focused on related market applications achieved a deep understanding of their customers. Atuahene-Gima, Slater and Olson (2005) suggest that a proactive market orientation in which firms seek to discover and meet unarticulated customer needs may be linked to radical innovation. These observations suggest an interaction between portfolio concentration and the portfolio’s level of technological advancement in which the launch of products with a high level of technological advancement is facilitated by higher portfolio concentration. It is hypothesized that portfolio concentration will positively moderate the relationship between portfolio technological advancement and NPD launch rate.
Hypothesis 3: The relationship between the average technological advancement of the firm's NPD portfolio and the NPD launch rate is moderated positively by the concentration of the portfolio.

The two preceding hypotheses have considered two portfolio structure dimensions separately. However, each NPD portfolio will have both a breadth value and a concentration value. Both dimensions are available to managers for manipulation. Consequently, specific combinations of levels of portfolio breadth and concentration may influence the relationship between portfolio technological advancement and NPD launch rate. As a statistical matter, this argument implies that a three-way interaction effect on NPD launch rate exists among portfolio technological advancement, breadth, and concentration.

Theory suggests that a firm’s existing knowledge base will influence the parameters of a firm’s search for new knowledge and the ease of integrating and using that knowledge. The concept of absorptive capacity has been developed to explain how a firm’s ability to recognize the value of external information, assimilate it, and apply it to commercial ends is a function of the firm’s prior level of related knowledge (Cohen & Levinthal, 1990). When considering knowledge categories, at least two perspectives on absorptive capacity are possible. On one hand, an extensive level of prior related knowledge may be associated with a knowledge base that includes a wide number of categories. Alternatively, absorptive capacity can arise from having a greater base of knowledge in a few categories and can contribute to the firm’s ability to absorb knowledge in those categories.

In portfolios of high concentration, technological advancement will be most positively associated with NPD launch rate when breadth is low. Portfolios characterized by this structure take advantage of synergies within categories. These synergies can facilitate the knowledge extension and creation that are required for radical innovation. This portfolio structure recognizes the interdependencies in product development and path-dependent accumulation of knowledge within categories. On the other hand, high levels of concentration can have a downside. High levels of concentration in NPD activity may be prone to many of the pitfalls of excessive reliance on knowledge exploitation, such as myopia (Levinthal & March, 1993) and competency traps (Michael & Palandjian, 2004). Lower levels of concentration offer greater potential for synergies both within and across categories. Consequently, it is argued that, in portfolios of high breadth, technological advancement will be most positively associated with NPD launch rate when concentration is low. Portfolios that are high in breadth and low in concentration offer synergies in search and knowledge processing across categories. By contrast, a portfolio that is broad but also concentrated is not taking full advantage of its breadth of knowledge. This three-way interaction is stated in the following hypothesis:

Hypothesis 4: There exists a three-way interaction between portfolio technological advancement, breadth, and concentration in explaining a firm’s NPD launch rate. The relationship between portfolio technological advancement and NPD launch rate will be most positive when breadth and concentration are negatively correlated.
METHODS

Research Setting

To investigate the hypotheses, this research examines the development of new drugs. Drug data are useful for investigating three broad stages of new product development (Henderson & Cockburn, 1994; Roberts & McEvily, 2005; Thomke & Kuehmerle, 2002). The present research concentrates on the middle stage, or the development of the new product from the time it is identified as a potentially viable candidate up until the point of launch. A “success” would be a launched product, while a “failure” would be a drug that was never launched because its development was discontinued. Once drug candidates reach the development stage, they proceed through a specified set of testing phases that are defined consistently across all firms in the industry (Danzon et al., 2005). Consequently, all firms within the pharmaceutical industry are subject to similar development constraints. Issues such as time-to-market and cost of development are impacted by the drug testing and marketing regulations which are administered, in the United States for example, by the Food and Drugs Administration (FDA) (Tonkens, 2005). By focusing on the pharmaceutical industry, this study controls for variations in the level of innovation and new product development activity which might differ in different industries.

Data and Sample

The data for this study were gathered from the Adis R&D Insight database of drug development activity, Compustat, firm annual financial reports and SEC 10-K filings. For the years covered by the Adis R&D Insight database, the comprehensive profiles of firms developing drugs report the status of all development activity – drugs that have been launched, drugs under development, and drugs for which development has been discontinued. This study focuses on the development activity for the period 1995 to 2006 for firms that remained in existence in 2006. As of October 2006, the Adis R&D Insight database included 281 companies. For the purpose of this study, a firm’s new product development portfolio is defined as consisting of launched drugs and those drugs that are actively under development. A minimum portfolio size of 15 active products (i.e., drugs launched and drugs under development) was established for inclusion in this study. Setting a minimum portfolio size is useful in this study because the values of key variables such as portfolio breadth would have limited meaning for portfolios consisting of only one or two drugs. Only active drugs (not discontinued drugs) were used to establish the minimum threshold to ensure that firms with on-going NPD activity are included.

One additional criterion was applied to the portfolios to arrive at the final dataset. Only those drugs that were originated by a firm were included in that firm’s product portfolio. A firm could originate those drugs either alone or cooperatively, but it must have been included in the list of originators. Including only those drugs that the firm had a role in initiating is consistent with this study’s focus on the ability of firms to move products through the development process. Including drugs that were acquired or licensed from another firm in later development stages could lead to incorrect conclusions about a firm’s ability to develop products.

Applying these selection criteria yielded a final dataset consisting of 90 firms and 7,524 drugs. Demographic data indicate that, in 2005, the firms ranged in age from a minimum of 10 years to a maximum of 337 years, and the median age was 76 years. The smallest firm had 100 employees while the largest had over 110,000 employees. The age and size ranges demonstrate that the companies are established firms. The use of established firms is important to the corporate entrepreneurship framework of this study. There is also evidence that this dataset is appropriate
for a study of new product development as an example of the sustained regeneration form of corporate entrepreneurship. On average, the percent of each portfolio that is represented by drugs that are under development is 83%. The majority of the drugs in the portfolios of the firms in this study are under development, indicating that NPD is continuous in this industry.

The status of each drug in each year is needed for the computation of many variables in the study. For example, in order to compute the portfolio concentration level for a given year, it is necessary to know which drugs were actively under development or already launched that year and the categories into which they are classified. The portfolio concentration computation for that year would not include any drugs that had been discontinued in prior years. It is not uncommon for one drug to be developed to treat potentially more than one medical condition. In the terminology of the industry, these drugs have more than one indication. Development activity may not occur simultaneously for all of a drug’s indications. For all drugs having more than one indication, the development activity was consolidated so that the earliest date that a drug entered a development phase for any indication or in any country was used as that drug’s date of entry into that development phase.

An outcome or final resolution for a drug’s development is that either (a) the drug is launched or (b) the development process is discontinued for all indications. If a drug is launched, the earliest launch date for any indication or in any country is used as the launch date for the drug. However, for discontinued drugs, the latest “discontinue” date for any indication or any country is recorded as the date development was discontinued for that drug. Using the latest “discontinue” date ensures that a drug is not counted as discontinued until all development activity has ceased. Using the consolidated development activity for each drug, the yearly status of a firm’s portfolio can be determined. It should be noted that a full development history was not available for all drugs. In such cases, no activity was assumed for a given year if the database did not explicitly confirm a drug’s status for that year. For example, if the earliest date of development activity was for Phase III trials, the drug was recorded as “active” beginning with that date.

Measures

The following paragraphs describe the operationalization of the dependent, independent, and control variables used in this research.

NPD Launch Rate

The dependent variable in the analysis is the NPD launch rate which represents the percentage of products that have a “launch” outcome versus a “discontinued” outcome. Drugs classified as “discontinued” for the purpose of this study include those identified in the Adis database with a status of Discontinued, No Development Reported, Suspended, or Withdrawn. The denominator in computing the NPD launch rate is the number of products for which an outcome – either launched or discontinued – has been determined during a specified period of time. That period of time has been set at two years in this study because of a pattern observed in the way discontinued development activity is recorded in the database. Launch dates can be recorded with relative accuracy; however, dates when development is discontinued are generally more difficult to pinpoint. As a result, many drugs in a firm’s portfolio may have the same discontinue date because that is the date when the pharmaceutical firm confirmed for the database developer the status of the drugs in its portfolio. All drugs discontinued since the last confirmation date may, thus, be assigned a common discontinue date. To smooth the effects of discontinue dates being recorded in this manner, the launch rate variable is computed using a rolling two-year launch rate.
Portfolio Technological Advancement

The portfolio technological advancement level is computed as an average of individual technological advancement values for drugs in the portfolio. The technological advancement of a product represents a new product’s degree of innovativeness or novelty relative to products that are already on the market. In this study, the technological advancement of a product is operationalized using the therapeutic advantage ratings assigned to drugs in the Adis R&D Insight database. The therapeutic advantage measure reflects the potential incremental benefits a drug under development is expected to offer relative to existing drugs already on the market. Industry experts employed by Adis assess the clinical potential of new agents undergoing research and development and assign a therapeutic value rating that has a numerical value ranging from 0 to 100 inclusive. Ratings closer to 100 indicate potential major therapeutic advances in providing substantially greater clinical advantages in comparison with other therapies. For a portfolio of drugs, the average technological advancement variable is computed each year as the average of the numerical therapeutic value ratings for all drugs that are active in the portfolio (i.e., launched or under development) that year and that have a rating. One limitation associated with this variable is that not all drugs in the dataset have a therapeutic advantage rating. A comparison between the full dataset and the subset of rated drugs led to the conclusion that the therapeutic advantage ratings are not more commonly assigned to active drugs than to discontinued drugs in the dataset.

Portfolio Breadth

The breadth of the firm’s portfolio is measured as the number of different therapeutic categories in the portfolio. Standardized categories are used by the pharmaceutical industry to classify drugs based on the conditions they are intended to treat and their chemical composition. Products and their associated knowledge bases are assumed to be more similar within categories than between categories (Nerkar & Roberts, 2004). Therefore, the therapeutic categories are used in this study to represent distinct categories of knowledge. A larger number of knowledge categories is indicative of greater portfolio breadth. The Adis R&D Insight database reports the World Health Organization’s Anatomical Therapeutic Chemical (WHO-ATC) class for each drug. This classification system divides the drugs into groups according to the organ or system on which they act and their chemical, pharmacological and therapeutic properties. For the purpose of this study, the Level 1 classification is used to define the therapeutic categories because the categories are sufficiently different from each other to capture specialized and non-overlapping knowledge without being too narrow. Classification levels below Level 1 have larger numbers of much narrower categories (Level 2, for example, has 112 categories) which could result in many categories that have too few drugs for meaningful analysis (World Health Organization, 2006). The number of therapeutic classes in a firm’s portfolio is, therefore, the number of different Level 1 classes represented among the drugs in that firm’s portfolio, including both those under development and those that have launched. Additionally, discontinued drugs are counted in this computation for the year in which they are reported as discontinued. The possible values for this variable range from 1 to 14.

Portfolio Concentration

The concentration level of a firm’s portfolio represents the extent to which the firm focuses its product development attempts in relatively few categories or spreads its efforts across numerous categories. In this study, portfolio concentration is calculated based on the principle underlying the Herfindahl index which is designed for measuring an industry’s concentration using the market shares of the firms in the industry. The Herfindahl index is computed as the sum across $n$ firms of
each firm’s squared share of the market. This concentration formula can be applied to product portfolios. Just as each firm’s market share impacts the industry’s concentration, each product category’s share of the portfolio impacts the portfolio’s concentration. Product categories are defined as the Level 1 WHO-ATC classes, consistent with the computation of portfolio breadth described above. The share that each product category represents in a portfolio can be calculated by dividing the number of drugs in each category by the total number of drugs in the portfolio. (The portfolio shares sum to 1 or 100% for each firm.) These category shares are squared and then summed for all product categories within a firm’s portfolio to produce the concentration index for each firm’s portfolio. As is commonly done with the Herfindahl index, the sum of the squared shares is multiplied by 10,000 to more clearly differentiate the levels of concentration. A more concentrated portfolio is indicated by a higher index. This variable can take on values up to 10,000. This use of the Herfindahl index to measure focus or concentration is consistent with other NPD studies using pharmaceutical data (Danzon et al., 2005; Henderson & Cockburn, 1996).

Control Variables

Other variables will be included in the analysis to control for possible alternative explanations for the hypothesized relationships. The variables to be included and their theoretical linkage to the other variables in the study are explained here.

Firm size. Firm size has been linked empirically and theoretically to several of the variables in this study. For example, large firms might have a higher success rate because they may be better able to afford the specialized equipment that is often required by different therapeutic categories (Graves & Langowitz, 1993). Small firms are associated with more innovative products and large firms are associated with less innovative products (Kotabe & Swan, 1995). Firm size is measured as the number of employees.

Firm age. A premise of this study is that a firm’s knowledge base influences a firm’s proficiency with NPD. Because knowledge accumulates over time, older firms will have had more time to build a knowledge base than younger firms. Firm age has been linked to a firm’s ability to innovate (Calantone et al., 2002; Hauser et al., 2006). Firm age is measured as the years since the firm’s founding date or date of incorporation when the founding date is not available.

R&D intensity. Firms with a high level of drug development activity might have a better NPD launch rate not because they are accumulating knowledge and building competences in particular therapeutic categories but because their higher expenditures for R&D include higher salaries that enable them to attract the best scientists (Henderson & Cockburn, 1994). R&D intensity is measured on an annual basis as the firm’s R&D expenditures for the year divided by the annual sales revenue.

Total Number of Drugs in a Firm’s Portfolio. Research has found that R&D productivity is subject to economies of both scale and scope (Henderson & Cockburn, 1996). To account for this potential influence, the size of a firm’s NPD portfolio is included as a control variable. Firms with large portfolios might not experience an improvement in success rate not because knowledge management and portfolio structure do not affect launch rate but because it is difficult to make noticeable gains over and above the position they have already achieved.

Analytical Techniques

This study uses NPD portfolio characteristics to explain NPD launch rate. Because the intent of the study is to assess the effect of the firm’s knowledge base and NPD portfolio structure
existing while a product is being developed, the portfolio structure measures (the IVs) should precede the NPD launch rate measure (the DV) in time. Using measures of the IVs and DV from the same point in time would not account for the realities that product development occurs over time and that the knowledge base and the portfolio traits in existence during a product’s development affect the launch/discontinue decision about that product. As described earlier, the NPD launch rate variable is computed on a two-year rolling basis. The first NPD launch rate figure recorded for each company in the dataset is the value for the 1996/1997 two-year period. The 1995 values for the portfolio structure variables are used to explain that 1996/1997 NPD launch rate, and so on.

The data used for tests of these hypotheses are structured as panel data – repeated measures of the same firms across consecutive years. An examination of the dependent variable – NPD launch rate – revealed some skewness and kurtosis in the distribution. Because this dependent variable is not normally distributed, an ordinary least squares estimation procedure would be inappropriate since OLS assumes a normal distribution. Additionally, tests for heteroskedasticity and autocorrelation revealed that both are present in these data. The presence of heteroskedasticity and autocorrelation also violate assumptions of an OLS model for panel data. A panel data estimation procedure that provides reliable estimates in the presence of heteroskedasticity and autocorrelation is a cross-sectional time series feasible generalized least squares (FGLS) regression model (Wooldridge, 2002). Therefore, the results of the tests of the hypotheses are FGLS estimates that control for heteroskedasticity and autocorrelation across panels. Additionally, time dummy variables were included as recommended by Certo and Semadeni (2006) for analyses of cross-sectionally dominated datasets (N > T) as is the case for the dataset used in this study (N = 90; T = 10). The results were computed using STATA 9.2.

RESULTS

Because some skewness was detected in the distributions of two of the control variables – firm size and firm age – a log transformation of these variables is used in hypothesis testing. A few of the correlations among variables in the study were found to be relatively high (i.e., r > |.60|). However, only one of these correlations is found among the variables that are central to the hypothesized relationships in this study rather than the control variables. The correlation between portfolio breadth and portfolio concentration (r = -.75) required further investigation. Variance inflation factors (VIFs) in excess of 10 and condition indices in excess of 30 indicated that multicollinearity was a concern within these data (Belsley, Kuh & Welsch, 1980), and steps were taken to remedy these problems. First, to minimize correlations between the independent variables and their interaction terms, the independent variables were centered in the manner suggested by Aiken and West (1991) prior to the computation of the interaction terms. Further, the portfolio concentration variable and all interaction terms using that variable were orthogonalized. Following this procedure, the collinearity diagnostics were in line with generally accepted targets (i.e., VIFs below 10 and condition indices below 30).

Table 1 presents the results of the regression analyses. Model 1 is the base model which includes only the control variables and the year dummies. Model 2 tests the main effect for portfolio technological advancement that is the focus of hypothesis 1. This model also includes the other two independent variables that will be used to create interaction terms for the remaining hypotheses tests. The p-value (p < .05) and positive coefficient for the linear relationship between portfolio technological advancement and NPD launch rate indicate that H1 is supported.
Model 3 includes the two-way interaction terms. Hypothesis 2 predicted a positive interaction between portfolio technological advancement and portfolio breadth. The positive and significant (p < .05) coefficient for the interaction between technological advancement and portfolio breadth indicates that H2 is supported by these data. Similarly, the positive and significant (p < .05) coefficient for the interaction between technological advancement and portfolio concentration indicates that H3 is supported.

Finally, Model 4 contains the three-way interaction that is the focus of hypothesis 4. Hypothesis 4 predicted that portfolio technological advancement would exhibit its most positive association with NPD launch rate when portfolio breadth and portfolio concentration are negatively correlated. This prediction is supported by the negative and significant (p < .01) coefficient for the three-way interaction of portfolio technological advancement, breadth, and concentration. A graph illustrating this interaction is shown in Figure 1.

**DISCUSSION AND CONCLUSION**

The results of this study provide insight into the structure of the NPD portfolios of firms for whom new product development is an on-going, continuous process. The positive relationship between average technological advancement of products in the portfolio and the NPD launch rate (Hypothesis 1) is consistent with research suggesting that more complex NPD projects are associated with a learning orientation. Firms pursuing technologically advanced projects may have more opportunities to learn and, thereby, improve their NPD proficiency.

The test of hypothesis 1 provided support for a linear relationship. However, a premise of learning theory is that, as tasks become more complicated, mastering them becomes more difficult. Additionally, when projects are unfamiliar, there is likely to be greater uncertainty about how to complete them and the risk of failure will be higher. Consistent with this perspective, Chandy, Hopstaken, Narasimhan and Prabhu (2006) found that a higher degree of novelty was associated with a lower probability of converting a patented drug idea into a launched drug. This observation implies that the relationship between the average advancement level of the products in the NPD portfolio and the firm’s NPD launch rate could be curvilinear. To the extent that a higher launch rate is a measure of learning how to succeed in new product development, an increasing level of innovativeness would be associated with an increasing launch rate up to a point. Beyond that point, further increases in a product’s advancement level would be associated with a decreasing launch rate. A supplemental analysis of this data did not find support for a curvilinear relationship between average technological advancement and NPD launch rate. However, one explanation for finding a linear rather than a curvilinear relationship may lie in the operationalization of the technological advancement variable. In this study, portfolio technological advancement is calculated as an average of all active drugs in a firm’s portfolio that have been assigned a technological advancement rating. Not all drugs in each portfolio are rated. The mean percentage of drugs rated per portfolio is 19%. Consequently, one limitation of this variable is that, for each firm, it is based on a minority of the drugs in the portfolio. Future research should continue to explore the relationship between technological advancement and NPD launch rate.

The significant results for hypotheses 2, 3, and 4 provide support for the idea that the firm’s knowledge base influences the relationship between the average level of technological advancement in the NPD projects being pursued and the firm’s proficiency in launching those products. In this study, the knowledge base has been operationalized using two structural dimensions of the firm’s portfolio of NPD activity – breadth across product categories and concentration within product categories. The tests of hypotheses 2 and 3 demonstrated that
portfolio breadth and portfolio concentration, respectively, are positive moderators of the relationship between average technological advancement and NPD launch rate. The three-way interaction that is the focus of hypothesis 4 indicates how breadth and concentration together interact with average technological advancement to influence NPD launch rate. The results of the test of hypothesis 4 demonstrate that the average technological advancement – NPD launch rate relationship is more positive in portfolios that pair high breadth and low concentration or that pair low breadth and high concentration.

In the present study, the breadth measure considers simply the number of product categories. Two portfolios with development activity in seven categories have the same breadth regardless of the activity level in each category (i.e., one portfolio could have, for example, ten or more products in each category while the second portfolio could have three or fewer products in each category). The concentration measure depends more heavily on the relative level of activity in the firm’s chosen categories. Greater concentration implies greater levels of activity in some of a portfolio’s product categories and limited activity in other categories. The findings in this study regarding portfolio structure dimensions are consistent with research that has concluded that scale and scope or breadth are drivers of performance in drug development (Cockburn & Henderson, 2001; Henderson & Cockburn, 1996). This study adds to a pattern of findings which indicate that the combination of breadth and depth (Prabhu, Chandy & Ellis, 2005; Sorescu et al., 2003) or scope in a portfolio (Cockburn & Henderson, 2001) promote radical innovation.

The findings also provide additional insight into questions about exploration and exploitation in facilitating radical innovation. Research has associated exploration with radical innovation (Atuahene, 2005). The present study suggests two different perspectives on exploration or distal search. Breadth of product categories may be interpreted as exploration or breadth of search, but concentration on certain categories and depth within those categories may also be interpreted as extensiveness of search for solutions to problems within category. A wide set of possible solutions may be explored by expanding across categories or by delving deep within a category.

**Implications**

This research has implications for theory and practice. First, the relationship between technological advancement and innovative proficiency is influenced by how firms structure their product portfolios. How a firm distributes its development activity across its chosen set of product categories seems to influence its ability to utilize NPD knowledge in the development of advanced products. Additionally, this study suggests that different strategies for structuring and utilizing knowledge can support successful pursuit of radical innovation. Since both broad bases of knowledge and concentrated bases of knowledge offer advantages and pitfalls, it appears that firms can successfully employ strategies based on either high breadth or high concentration.

The finding that portfolio structure influences the relationship between R&D activity and innovative proficiency suggests that managers should articulate a strategy for knowledge accumulation in their NPD activity. By specifying the product categories that will be part of the firm’s portfolio and the desired level of activity within each category, the firm provides a useful screen for identifying and selecting NPD initiatives that will effectively utilize and build on its existing knowledge base. A strategy for knowledge accumulation facilitates sustained innovative activity in established firms.
Limitations

A few limitations of this study should be noted. First, the average technological advancement level for a firm’s portfolio is computed using relatively few of the firm’s products. Second, because this study examines only the pharmaceutical industry, the results may not generalize to other industries. However, patterns in this industry may be similar to other high-tech industries that rely on sustained new product development and that have long lead times for development. A final limitation of this research is that the dependent variable of interest – NPD launch rate – may be only weakly tied to the commercialization success of the product introductions. This fact is significant because it can be argued that what matters most in NPD efforts is not necessarily a firm’s ability to launch individual new products or even the percentage of launches achieved but, rather, the payback from innovation efforts relative to the total costs incurred.

CONTACT: Kimberly M. Green; kgreen2@clemson.edu; (T): 864-656-3768; (F): 864-656-2015; College of Business and Behavioral Science, Department of Management, 101 Sirrine Hall, Clemson University, Clemson, SC 29634.

REFERENCES


Table 1. Cross-Sectional Time-Series FGLS Estimates

<table>
<thead>
<tr>
<th>Dependent Variable: NPD Launch Rate</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1: Controls and Year Dummies</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log Firm Size (employees)</td>
<td>0.026‡ (0.008)</td>
<td>0.029** (0.010)</td>
<td>0.030** (0.009)</td>
<td>0.032** (0.010)</td>
</tr>
<tr>
<td>Log Firm Age (years)</td>
<td>0.025† (0.012)</td>
<td>0.014 (0.015)</td>
<td>0.020 (0.015)</td>
<td>0.019 (0.015)</td>
</tr>
<tr>
<td>R&amp;D Intensity</td>
<td>0.011 (0.005)</td>
<td>0.036** (0.011)</td>
<td>0.034** (0.011)</td>
<td>0.035** (0.011)</td>
</tr>
<tr>
<td>Total Products in Portfolio</td>
<td>-0.001† (0.000)</td>
<td>-0.001† (0.000)</td>
<td>-0.001† (0.000)</td>
<td>-0.001† (0.000)</td>
</tr>
<tr>
<td>Year_1996</td>
<td>-0.040 (0.018)</td>
<td>-0.052** (0.019)</td>
<td>-0.058** (0.019)</td>
<td>-0.053** (0.019)</td>
</tr>
<tr>
<td>Year_1997</td>
<td>-0.033 (0.022)</td>
<td>-0.044† (0.023)</td>
<td>-0.059 (0.024)</td>
<td>-0.057 (0.023)</td>
</tr>
<tr>
<td>Year_1998</td>
<td>-0.039 (0.024)</td>
<td>-0.049† (0.025)</td>
<td>-0.068 (0.026)</td>
<td>-0.068 (0.026)</td>
</tr>
<tr>
<td>Year_1999</td>
<td>-0.122 (0.025)</td>
<td>-0.140† (0.027)</td>
<td>-0.158† (0.027)</td>
<td>-0.156† (0.027)</td>
</tr>
<tr>
<td>Year_2000</td>
<td>-0.150† (0.026)</td>
<td>-0.167† (0.027)</td>
<td>-0.189† (0.028)</td>
<td>-0.186† (0.028)</td>
</tr>
<tr>
<td>Year_2001</td>
<td>-0.149† (0.026)</td>
<td>-0.168† (0.027)</td>
<td>-0.195† (0.029)</td>
<td>-0.193† (0.028)</td>
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<tr>
<td>Year_2002</td>
<td>-0.142† (0.026)</td>
<td>-0.164† (0.027)</td>
<td>-0.192† (0.029)</td>
<td>-0.190† (0.029)</td>
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<tr>
<td>Year_2003</td>
<td>-0.116† (0.026)</td>
<td>-0.129† (0.027)</td>
<td>-0.158† (0.029)</td>
<td>-0.157† (0.029)</td>
</tr>
<tr>
<td>Year_2004</td>
<td>-0.146*** (0.026)</td>
<td>-0.167*** (0.027)</td>
<td>-0.198*** (0.030)</td>
<td>-0.196*** (0.029)</td>
</tr>
<tr>
<td>Step 2: Independent Variables</td>
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<td></td>
</tr>
<tr>
<td>Portfolio Technological Advancement</td>
<td>0.003 (0.002)</td>
<td>0.007** (0.002)</td>
<td>0.008** (0.002)</td>
<td></td>
</tr>
<tr>
<td>Portfolio Breadth</td>
<td>-0.002 (0.006)</td>
<td>0.008 (0.007)</td>
<td>0.005 (0.007)</td>
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</tr>
<tr>
<td>Portfolio Concentration</td>
<td>0.004 (0.019)</td>
<td>0.079 (0.034)</td>
<td>-0.032 (0.049)</td>
<td></td>
</tr>
<tr>
<td>Step 3: Two-Way Interaction Terms</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tech Advancement x Breadth</td>
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<tr>
<td>Tech Advancement x Concentration</td>
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</tr>
<tr>
<td>Breadth x Concentration</td>
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<tr>
<td>Step 4: Three-Way Interaction Term</td>
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</tr>
<tr>
<td>Tech Advance. x Breadth x Concent.</td>
<td></td>
<td></td>
<td></td>
<td>-1.008† (0.344)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.108† (0.045)</td>
<td>-0.030 (0.121)</td>
<td>-0.331† (0.173)</td>
<td>-0.361† (0.169)</td>
</tr>
<tr>
<td>Wald χ²</td>
<td>98.85***</td>
<td>104.07***</td>
<td>116.51***</td>
<td>129.42***</td>
</tr>
</tbody>
</table>

*a* Unstandardized regression coefficients are reported. Standard errors are in parentheses.

For Model 1, the number of observations = 839 and the number of firms = 84. For Models 2, 3 and 4, the number of observations = 761 and the number of firms = 79.

† p < .10;  * p < .05;  ** p < .01;  *** p < .001
Figure 1. Three-way Interaction Plot

Low Portfolio Breadth

High Portfolio Concentration

Low Portfolio Concentration

NPD Launch Rate

Portfolio Technological Advancement

High

Low

High

Low

High Portfolio Breadth

Low Portfolio Concentration

High Portfolio Concentration

NPD Launch Rate

Portfolio Technological Advancement

High

Low

High

Low