# VALUING STRATEGIC ALLIANCES IN THE PHARMACEUTICAL / BIOTECHNOLOGY INDUSTRY

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## ABSTRACT

In an era of rapid and changing technological advances, a firm's survival and growth depends on its' ability to introduce products to the market. Since a firm's growth and survival depends on its' ability to develop products and services over time (Penrose, 1959), the question posed by this study is what determines a firm's ability to introduce products to market? In this study, a firm's ability to introduce product to markets are influenced by its' "absorptive capacity" to identify and internalize the resource benefits of its' alliance partners. Such an integrated view is absent in firm level and strategic alliance studies of product development. A conceptual model of firm product introductions is developed and empirically tested. Results generally support the hypotheses of this study.

## VALUING STRATEGIC ALLIANCES IN THE BIOTECHNOLOGY INDUSTRY

## INTRODUCTION

In an era of rapid and changing technological advances, a firm's survival and growth depends on its' ability to introduce products to the market (Bettis and Hitt, 1995; Deeds and Hills, 1996; Rothaermel 2001 a,b; Rothaermel and Deeds, 2004; Nerkar and Roberts, 2004; Werther and Kerr, 1995). Since a firm's growth and survival depends on its' ability to develop products and services over time (Penrose, 1959), the question posed by this study is what determines the successful launch of a firm's products? Such a question is of particular importance to high technology industries. This is because rapid changes in competitive, technological conditions and changing consumer needs require firm's to continually introduce products to meet the changing conditions of the market (Bettis and Hitt, 1995). Learning races demand firms to not only bring products to markets early (Liebeskind, Oliver, Zucker & Brewer, 1996) but also to continually innovate and introduce products to the market. The biotechnology industry is reflective of such changing market condition and thus, the question posed by this study is particularly relevant to the survival and growth of biotechnology firms. As a result, a number of studies have examined the causes that determine a firm's product success (Deeds and Hill, 1996; Nerkar and Roberts, 2004; Rothaermel, 2001 a, b; Rothaermel and Deeds, 2004)

However, research on firm product success tends to mutually exclude firm level and inter-firm level causes for firm product success. Firm's can no longer rely on the internal technological and marketing competences in bringing products to market but require a greater reliance on strategic partners for the

advancement of their products to market (Teece, 2000). Yet, firm level studies emphasize the firm's technical and marketing competencies (Danneels, 2002; Helfat and Peteraf, 2002; Helfat & Raubitschek, 2001; Nerkar and Roberts, 2004; Tripsas and Gavetti, 2000) as instrumental to the firm's product success. Specifically, such views are founded on Penrose's (1959) theory of the firm. According to Penrose (1959), a firm is a bundle of productive resources that yields a multiplicity of goods and services. Prahalad and Hamels' (1990) concept of "core competence" as well applications of Resource Based View (RBV) (Peteraf and Bergen, 2003) emphasize the duality that firm's internal resources and products are two sides of the same coin (Wernerfelt, 1984). Yet, Strategic alliances and social network researchers find the cooperation and pooling of resources advances the development and marketing of products (Chan, Kesinger, Keown & Martin, 1997; Deeds and Hill, 1996; Dyer and Singh, 1998; Gulati et al., 2000; Powell et al., 1996; Rothaermel 2001a, b; Rothaermel and Deeds, 2004). Hence, according to a strategic network / alliance perspective, a firm's ability to introduce products to markets require combining technologies, resources and commercializing experiences that no one company possesses (Teece, 2000). That is, research breakthroughs are broadly distributed so that no single firm has all the internal capabilities necessary for product market success (Powell, Koput, and Smith-Doerr 1996). In particular, biotechnology firms are compelled to rely on strategic alliances for support in the various phases of the product and market development process (Teece, 2000). For instance, the studies of Deeds and Hill (1996), Rothaermel (2001a, b) and Rothaermel and

Deeds (2004) show the number of new product introductions are affected by its strategic alliances.

As high technology industries tend to be driven by heightened reliance on knowledge as a sources of competitive gain (Bettis and Hitt, 1995), a firm's internal knowledge and resource and its' ability to access external knowledge and resources jointly impact a firm's ability to bring products to the market. In particular, a firm's knowledge and learning –as a resource- has been advanced by Cohen and Levinthals' (1990) concept of "absorptive capacity" (Cohen and Levinthal, 1990). According to Cohen and Levinthal (1990), a firm's prior knowledge experience positively influences its ability to absorb external information and resources. Hence, given the increasing attention to the knowledge dimension of a firm's resources and the increasing reliance of firm's on strategic alliances, a firm's absorptive capacity impacts its ability integrate alliance expertise and thus impact a firm's product success. Namely, this study argues a firm's ability to introduce products to market is constrained by a firm's absorptive capacity in gaining access to resources of its' strategic alliance partners. In Harrison, Hitt, Hoskisson & Irelands' (2001) study of strategic alliances, they contend strategic alliance failure is largely attributed to failures of management to not only correctly identify the gains afforded from complementary partners but also the ability to exploit such gains. In this study, we argue a firm's product performance is influenced by its' absorptive capacity to identify and internalize the resource benefits of its' alliance partners. Such an integrated view is absent in either of the firm and inter-firm levels focus of prior studies.

This approach is examined in the biotechnology industry for two reasons. First, the biotechnology industry has and continues to experience continual and rapid technological changes and therefore examining the causes that determine a firm ability to introduce product to markets is particularly important to the survival and growth of this industry. Second, prior studies has examined in albeit separate developments absorptive capacity (Lane and Lubatkin, 1998; Mowery, Oxley & Silverman, 1996; Nerkar and Roberts, 2004) and strategic alliances (Chan et al., 1997; Deeds and Hill, 1996; Dyer and Singh, 1998; Gulati, Nohria, & Zaheer, 2000; Powell et al., 1996; Rothaermel 2001a, b; Rothaermel and Deeds, 2004) arguments in this industry. Since a firm's ability to introduce product and services are highly dependent on a firm's internal R&D develop experiences and its' strategic alliances, the integration of absorptive capacity and strategic alliances arguments appears particularly relevant for this industry.

To organize this study, the first section provides a background of the biotechnology industry and reviews the literature on strategic alliances and absorptive capacity. Hypotheses are derived that incorporate arguments from these different levels of analysis as causal factors impacting a firm's ability to introduce products to the biotechnology market. The second section is a discussion of our data and methods. A sample of 209 biotechnology firms in the 2004 was collected. Based on this sample, Weighted Least Squares estimations were conducted. Lastly, the conclusions and contributions of this study are discussed.

## CONCEPTUAL MODEL

### Industry Background

Although there is no formal definition of biotechnology, an agreed upon definition is “processes that seek to preserve or transform biological materials of animal, vegetable, microbial or viral origin into products of commercial, economic, social and/or hygienic utility and value’’(Hulse 2004). This definition includes biotechnology firms, such as Amgen, Biogen and Genentech, Pfizer, Monsanto, Dow Agrosciences etc. The growth of biotechnology related products and services had been advanced by basic biotechnology research in genetic engineering, genome mapping, recombinatory chemistry. Since 1992, U.S. biotechnology related produce and service related revenues increased from $8 billion in 1992 to $39.2 billion in 2003. As the study’s focus in understanding the determinants that impact a firm’s ability to bring products to market, a firm’s product-market performance is our dependent variable of interest and is defined as the cumulative number of commercialized products that have received regulatory approval. Similar definitions of firm performance have also been used by prior studies (Deeds and Hill, 1996; Rothaermel 2001a,b; Rothaermel and Deeds, 2004; Nerkar and Roberts, 2004)

Through out the inception of the biotechnology industry, the population of U.S biotechnology companies has grown to 1,473 firms by 2004 (Biotechnology Industry Organization). This explosive growth of biotechnology companies in the United States has bred highly competitive conditions that have induced a “winner takes all” technology race for industry profits ((Liebeskind et al., 1996). As a result, a firm’s competitive survival rests on the firm’s ability to rapidly develop new products and bring them to market so as to gain early cash flows for greater financial independence, external visibility and legitimacy, and early market share

(Deeds and Hill, 1996; Schoonhoven, Eisenhardt, and Lyman 1990). Along with a highly competitive market, the development of biotechnology products and service is an expensive, time consuming and risky endeavor. Drug development timelines average 7 to 11 years from discovery to launch and Research and commercializing investments range from $100 to 300 million per product) (Powell et al., 1996). FDA regulatory approval and market approval have also raised the uncertainty in the success of product launches (Deeds and Hill, 1996; Pisano, 1990)

These highly competitive conditions have compelled biotechnology firms to form strategic alliance to commercialize basic biotechnological research (Deeds and Hill, 1996; Teece, 2000). As result, since the inception of the biotechnology industry, strategic alliances have grown significantly (Chan et al., 1997; Powell et al., 1996). A strategic alliance is as:

> "…as any voluntarily initiated cooperative agreement between firms that involves exchange, sharing, or co-development, and it can include contributions by partners of capital, technology, or firm specific assets" (Rowley, Behrens, & Krackhardt, 2000, p.370).

**Strategic Alliance**

Various arguments have been used to explain the relationship of strategic alliances to firm's product performance. Strategic alliances can be leveraged into dominant market share positions that translate into learning curve advantages to advance future product developments (Deeds and Hill 1996; Stalk and Hout, 1990; Schoonhoven et al., 1990). In addition, strategic alliances can increase a firm's ability to bring products to market through increased flexibility to changing

technology conditions, access to external and complementary commercializing assets (Deeds and Hill, 1996; Harrison et al., 2001; Pennings and Harianto, 1992), access to foreign markets, and development new distribution channels (Deeds and Hill, 1996; Harrison et al., 2001; Koza and Lewin, 1998; Parkhe, 1991; Rothaermel and Deeds, 2004). Of particular import to the biotechnology industry is strategic alliances provide access to complementary research expertises and provides access to commercializing assets, such as downstream marketing, production and distribution assets (Deeds and Hill, 1996; Rothaermel and Deeds, 2004; Teece, 2000). In discussing a firm's product performance, Schumpeter's (1934) distinction of "invention" and "innovation" is worthy of mention. According to Schumpeter (1934), invention occurs through the novel recombination of knowledge experiences, while invention occurs when an innovation has a marketable use (Nerkar and Roberts, 2004). Through strategic alliances, the pooling of complementary research expertises among Research start-ups and access to downstream pharmaceutical firms' commercialization assets serve to transform biotechnology inventions (i.e. genetic engineering, genome mapping, recombinatory chemistry, etc) of start-up operations into commercializable product innovations (i.e. therapeutic products). Hence, strategic alliances are positively related to a firm product performance.

However, increasing the number of strategic alliances could eventually exhibit diminishing firm product performance. In drawing on Deeds and Hill (1996), they argue the relationships between the number of firm strategic alliances and the number of products marketed exhibits a non-monotonic or inverted U shape relationship. They reason, as the individual firm increases its

number of alliances, it is “likely to enter some alliances whose marginal contribution is relatively minor.”(p.44) Deeds and Hill (1996) continue that “selection and management of alliance partners is likely to be negatively related to the number of alliances the firm is managing.” They attribute this to the managers’ bounded rationality to select and monitor alliance partner behaviors. The second reason for the “inverted U” shape takes into account contractual problems involved in forming alliances. Strategic alliances are subject to threats from adverse selection, moral hazard and hold up (Barney, 2002). Such alliance threats are particularly problematic in the presence of co-asset specificity among partnering firms (Jones et al, 1997; Osborn & Hagedoorn, 1997; Pisano, 1990). In particular, increases in firm alliances, increases the chances for firms to align with firms that have a poor match of assets, do not hold up to their end of the deal, and or can exhibit opportunistic behavior in exploiting the agreement terms Jones et al., 1997; Osborn & Hagedoorn, 1997;. Pisano, 1990). Although these arguments draw on Transaction cost considerations, this consistent with the diminishing effects found by Deeds and Hill (1996).

Strategic alliances can be leveraged into dominant market share positions that translate into learning curve advantages to advance future product developments (Deeds and Hill 1996; Stalk and Hout 1990; Schoonhoven et al., 1990). Strategic alliances also increases a firm’s ability to bring products to market through increased flexibility to changing technology conditions, access to external and complementary commercializing assets (Deeds and Hill, 1996; Koza and Lewin, 1998; Harrison et al., 2001; Pennings and Harianto, 1992), and access to foreign markets, and developing new distribution channels (Deeds and

Hill, 1996; Harrison et al., 2001; Koza and Lewin, 1998; Parkhe, 1991; Rothaermel and Deeds, 2004). Of particular import to the biotechnology industry is: strategic alliances provide access to complementary and commercializing assets (Deeds and Hill, 1996; Rothaermel and Deeds, 2004; Teece, 2000). As Deeds and Hill (1996), note "strategic alliances are an effective way of quickly assembling the required set of complementary assets". Hill and Jones (1995) also note strategic alliances allow the sharing of risks and costs involved in product development and thus should positively increase the number of product market launches. As a result, consistent with a general premise of social network research, strategic alliances should positive impact an organizational performance in regards to the number of products markets. This is because the greater the number of alliances, the greater the ability for a firm to be responsive to new technologies and provide access external yet complementary assets. All of which facilitate the creating of new products as well as provide access to downstream marketing, distribution and production assets in bringing such new products to market (Deeds and Hill, 1996; Rothaermel and Deeds, 2004). Deed and Hills proposes and finds support for a linear relationship between a firm's product performance and strategic alliances.

However, increasing the number of strategic alliances yield diminishing effects on firm's product performance. As an alternate hypothesis, Deeds and Hill (1996) find a firm's product performance has a non-monotonic or inverted U shape relationship to the number of a firm's strategic alliances. They reason, as the individual firm increases its number of alliances, it is "likely to enter some alliances whose marginal contribution is relatively minor." (pg. 44) Second, they

attribute the diminishing effects to the managers' bounded rationality in selecting and governing effective alliance behaviors. Contractual problems grow with increasing alliances. Strategic alliances are subject to threats from adverse selection, moral hazard and hold up (Barney, 2001). Such alliance threats are particularly problematic in the presence of co-asset specificity among partnering firms (Jones et al., 1997; Pisano, 1990). In particular, as the firm enters into more and more alliances, its chances of making alliances with firms that have a poor match of assets, do not hold up to their end of the deal, and or can exhibit opportunistic behavior in exploiting the agreement with the other firm increases (Deeds and Hill, 1996; Jones et al., 1997). Third, bounded rationality places limits on the firm's ability to learn the experiences and knowledge from their alliance partners and thus result in diminishing effects to a firm product performance. The following is hypothesized:

*H1: a firm's product market performance –number of products on the market- has an "inverted, U-shaped relationship" to the total number of its' strategic alliances.*

Since strategic alliances can take a variety of exchange relationships – such as licensing, manufacturing, research and development, equity and non-equity forms of agreements (see Deeds and Hill, 1996; Harrison et al., 2001; Koza and Lewin, 1998; Lane and Lubatkin, 1998; Pennings and Harianto, 1992; Rothaermel and Deeds, 2004), different types of alliances should have different impacts on a firm's product performance. As the pooling of research and commercializing assets are requisites to the transformation of a firm's

inventions into an innovation, Schumpeter's (1934) invention and innovation distinction are examined with the following hypotheses,

*H2: A firm's R&D and Marketing alliances have the greatest positive effect on a firm's product performance.*

As a firm's technological expertise and market experiences often develop in tandem (Danneels, 2002; Nerkar and Roberts, 2004) and since research and development and marketing alliances mutually complement the commercialization of basic research (Nerkar and Roberts, 2004;Teece, 2000), an addendum to hypothesis 2 is proposed

*H2a: A firm's product performance is positively related to the joint influence of a firm's R&D and marketing alliances.*

**Absorptive Capacity**

In addition to strategic alliance arguments, a firm's absorptive capacity also impacts firm product performance. Forwarded by Cohen and Levinthal (1990), the concept of "absorptive capacity" refers) refers to the firm's "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990, p. 128). A firm's absorptive capacity to assimilate new information is directly a function of the firm's prior knowledge and, therefore, absorptive capacity tends to develop in a cumulative or path dependent manner (Bosch, Volberda, & Boer, 1999; Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Pennings and Harianto, 1992). Cohen and Levinthal (1990) further add that a firm's absorptive capability in assimilating

"… information is a function of the richness of pre-existing knowledge structure: learning is cumulative and learning performance is greatest

when the object of learning is related to what is already known" (1990:131).

Nerkar and Roberts (2004) find a firm's prior technological and product-marketing experiences jointly impact a firm's "combinative" ability in developing and introducing pharmaceutical products to the market. Namely, Nerkar and Roberts (2004) argue a firm's ability to relate its' technological and product-market experience to other "promixal" and distant" experiences positively impacts a firm's ability to launch products on to the market. In Danneels (1999) study of the apparel industry, a firm's marketing experiences shapes its ability to introduce new product lines. In Pennings and Hariantos' (1992) study of the U.S. banking system, a firm's prior technological experiences impacts its ability to launch new information technology services. As firm's age has been used as a proxy for a firm's prior experience (Pennings and Harianto, 1992), the following firm level hypothesized is proposed:

*H3: A firm's accumulated experiences is positively related to its' product performance.*

However such firm level investigations of absorptive capacity omit inter-firm transfers of knowledge. In drawing on Cohen and Levinthals' (1990) notion of "absorptive capacity", Lane and Lubatkin (1998) examine the transfer of knowledge among strategic alliance partners in the biotechnology industry. In citing Nicholls-Nixon, Lane and Lubatkin (1998) cautions:

"the findings from this study [Nicolls-Nixon, 1993:191) suggest that it is a dangerous to regard strategic alliances as a panacea for staying in touch with rapidly changing technological environments. This is because the

> benefits associated with the use of strategic alliances are not automatic. Conscious management action is required…to ensure that externally sourced technology can be acquired and integrated into the firm's technological capabilities' (Nicholls-Nixon, 1993:191)" (463)

Namely, in order for a firm to understand and commercialize the value of external knowledge, a firm needs to meet two criteria (Lane and Lubatkin, 1998). First, a firm is required to have a basic and prior understanding to the new and external knowledge (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998). Basic knowledge consists of the "general understanding of the traditions and techniques upon which a discipline is based" (Lane and Lubatkin, 1998, pg. 464). For instance, a chemist will not appreciate advances in biotechnology with out first having a basic understanding of the biological sciences (Lane and Lubatkin, 1998). For instance, in Monsanto's entrance into the biotechnology industry, it first developed in house biotechnology research capabilities before undertaking integration of external biotechnologies (Leonard-Barton, Dorothy & Pisano, 1993). As a result, in order for a firm to value the resources and technologies of its alliance partner, "it must possess some amount of prior knowledge basic to the new knowledge" (Lane and Lubatkin, 1998, pg 464). Hence, even though strategic alliances can provide access to valuable and complementary resources, firms can fail to take advantage of alliance gains because their prior knowledge is insufficient in determining their value. As a result, a firm with greater experience is better able to learn from their past experiences and can draw on past experiences to make inferences on the value of partnering firms. For instance, firms with greater experience and thus absorptive capacity benefit from learning

curve effects (Zahra and George, 2002). This includes not only improvements in operational efficiencies (Levinthal and March, 1993; Pennings and Harianto, 1992) but past experiences constrains a firm's search to information that is close or proximally related to the firm's experiences (Zahra and George, 2002). As a result, firms with greater experiences will tend to form alliances that build upon the firm's existing knowledge base. A firm's absorptive capacity leverages the resources of its' alliance partners by identifying complementary[2] yet similar partners (Lane and Lubatkin, 1998; Pennings and Harianto, 1992; Nerkar and Roberts, 2004; Zahra and George, 2002) who can advance products that builds upon the firm's core experiences. As a result, a firm's prior experiences can be used to not only select better fit partners but can use their prior experience to integrate the resources of partnering firms in ways that advance its core experiences. As a result, this increases the firm's ability to introduce products to the market. Such an absorptive capacity argument is absent in prior strategic alliance studies. Hence, the following is hypothesized:

*H3a : A firm's accumulated experience has a positive moderating effect on the firm's strategic alliances.*

A second criterion is: the transfer and understanding of knowledge among alliance increases with the diversity of prior knowledge experiences held by aligning partiers (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Nerkar and Roberts, 2004; Zahra and George, 2002). In that, firms with diverse research and marketing experience are more likely to understand the value of the

[2] Zahra and George (2002) notes "Lofstrom (2000) reports that knowledge complementarity, defined as the extent to which knowledge is related to and at the same time different from the knowledge of contacts in their information networks" (p. 193)

resources and information of alliance partners. This is because the diversity in a firm's prior knowledge has been suggested to strengthen the assimilation of external information and development of new innovations (Bosch et al, 1999; Cohen & Levinthal, 1990; Nerkar and Roberts, 2004; Zahra & George, 2002). As Cohen and Levinthal (1990) note,

> "a diverse background [knowledge] provides a more robust basis for learning because it increases the prospect that incoming information will relate to what is known.' (Cohen and Levinthal, 1990,131).

Further, Bosch et al (1999) also argue firms with broader knowledge experiences - knowledge scope- are more able to explore and assimilate diverse knowledge sources. In addition in drawing on Nicholls-Nixon (1993), Lane and Lubatkin (1998) comment,

> *"*She found that firms with high levels of absorptive capacity invest more in their own R&D, utilized alliance, had more in house expertise with relevant technologies, and managed communications with alliance partners more effectively" (pg 463)

This is, however, distinct from argument raised in hypothesis 3a. A firm's absorptive capacity is a multi-dimensional construct (see Zahra and George, 2002; Nerkar and Roberts, 2004) that yield different advantages to a firm's ability to absorb external information. In particular, a firm with a diversity of prior knowledge experiences –as opposed to cumulative experiences- can draw on its' broader base of experiences to make inferences of new technologies and resources held by its' alliance partners (Nerkar and Roberts, 2004; Pennings and Harianto, 1992). Such diversity of prior knowledge is similarly described by

Nerkar and Roberts' (2004) notion of a firm's proximal and distal experiences. In that, the greater the diversity of firms' prior knowledge experiences, the greater the degree to which firms share proximally similar experiences. For instance, firms involved in different research programs such as cancer therapies, protein engineering, medical diagnostics, screening for molecular compounds etc are more likely to understand and recombine the technologies and resources held by their aligning partners, than those firms with more specialized research programs. Although a firm's cumulative experiences are correlated with its prior knowledge diversity, the distinction is: knowledge diversity increase the degree to which a firm's experiences can relate to external sources. A firm's knowledge diversity broadens its' search and thus exposes the firm to greater diversity of alliance resources. This allows for a greater exchange and recombination of partner resources to bring about the development of new research. Since Schumpeterian innovation (1934) is a process of novel recombination of knowledge experiences, a firm's diversity of prior knowledge experiences enables a greater absorption of varied alliance resources and thus should positively impact a firm's product performance[3]. This is consistent with Ng's (2003) study of strategic change, where a firm's internal knowledge diversity increases the firm's ability to relate to varied external information sources. As a result, a firm's prior knowledge diversity should, thus, promote the absorption of the knowledge and expertise of its' alliance partners and in turn increase the firm's product performance. The following is hypothesized:

[3]As Lane and Lubatkin (1998) notes transfers of knowledge among aligning partners are a one-way form of communicative learning, however, they contend 'the factors that influence one-way learning also effect two-way learning'(p. 464).

*H4: A firm's prior knowledge diversity is positively related to its' product performance.*

*H4a : A firm's prior knowledge diversity has a positive moderating effect on the firm's strategic alliances.*

More over, since the biotechnology industry has experienced significant mergers and acquisition activities (Thayer, 2001), the cumulative experiences gained from a firm's merger and acquisitions should impact it's prior knowledge and thus absorptive capacity. In particular, mergers and acquisition can involve changes in firm's boundary of operations into different product markets. For example, Monsanto was formerly a chemical company and through the acquisition of Searle –a pharmaceutical company, Monsanto had acquired research expertise in the pharmaceutical domain (see Leonard-Barton et al., 1993). As a result, a firm's mergers and acquisition can increase or decrease (i.e. Divestitures) the diversity of knowledge base through such merger and acquisition activities. Hence, from an absorptive capacity perspective, mergers and acquisitions involve not only the control and ownership of another firm's physical assets, but it also provides direct access to the merged and acquired firm's knowledge and experiences. This can broaden a firm's prior knowledge and thus absorptive capacity. Increases in a firm's absorptive capacity increase the firm's ability to integrate the resources of its alliance partners in advancing a firm's product performance. The following addendum to hypothesis 4 is provided.

*H4b: A firm's history of mergers and acquisitions has positive effect on a firm's product performance.*

*H4c : A firm's history of mergers and acquisition has a positive moderating effect on the firm's strategic alliances.*

## METHOD

### Data

Data from public biotechnology, pharmaceutical, and related agricultural companies was examined from a BioScan Database (April, 2004). BioScan (2004) (American Health Consultants, 2003) is one of the most comprehensive databases on strategic alliances in the biotechnology industry. BioScan has been used by network researchers to examine strategic alliances in the biotechnology industry (Deeds and Hill, 1996; Lane and Lubatkin, 1998; Powell et al., 1996; Rothaermel, 2001 a,b; Rothaermel and Deeds, 2004). Consistent with prior cross sectional studies (Deed and Hill, 1996; Rothaermel, 2001a,b; Rothaermel and Deeds, 2004), a cross sectional analysis is conducted such that comparisons can be made to these earlier studies. As a biotechnology firm can be involved in an array of agricultural and pharmaceutical related products and services, biotechnology is used as an over-arching term that encompasses such products.

### Data Sample

From the BioScan database (2004), an initial sample of 559 public biotechnology firms was available for econometric analysis. This sample includes biotechnology firms producing pharmaceutical and agricultural related products and services. Table 1 shows the distribution of firms among 6 product categories.

[Insert Table 1 here]

Products in the agricultural category were from firms producing only agricultural related products (e.g. fertilizer, chemicals, genetically modified seed, animal medicine, and livestock genetics). Biotechnology includes products and services such as production of monoclonal and polyclonal antibodies, diagnostic services -DNA sequencing, analysis of gene functions, biological software (bioinformatics), and or research equipment. Products designed for human health or use, for example human therapeutics, is defined as pharmaceutical. For example: insulin for the treatment of diabetes and growth hormones for the treatment of growth hormone deficiencies. Since the majority of the biotechnology firms consist largely of pharmaceutical products followed by biotechnology and the combination thereof, the analysis is conducted on a sample of these firms. Our sample of biotechnology firms are, therefore, inclusive of firms that produce and market biotechnology and pharmaceutical products. Such a sample is adopted because it also allows for comparison to Deeds and Hill (1996) and Rothaermel and Deeds (2004).

As the dependent variable of interest is a firm's product performance, the number of a firm's products that has completed all phases of product development –preclinical, phase I, phase II and phase III, received FDA approval- and are currently being marketed are recorded (see also Deeds and Hill, 1996; Rothaermel and Deeds, 2004). Biotechnology firms with no products are removed. In addition, outlying firms with extremely large numbers of marketed products were eliminated from the sample. For example, one firm had reported 8,800 products and fell outside the range of product numbers for the rest of the dataset. More over, firms with an IPO at the time of this data collection

2004 and firms with no employees were removed. The final data set used for econometric analyses contained 241 firm observations for the year 2004 (N=241).

**Measures**

**Dependent variable:** A biotechnology firm's products, (PMR), is a count of each firm's product that has successfully completed all stages of the product development process –preclinical, phase I, phase II and phase III, received FDA approval- and are now being commercialized. This measure was also used by Deeds and Hill (1996) and Rothaermel and Deeds (2004). Their product market variable was on an earlier BioScan data base (1991).

**Independent variables:** Strategic alliances: A biotechnology firm's strategic alliances, A, is a count variable of the cumulative alliances formed by the firm, since its founding. This strategic alliance variable, A, consists of the aggregation of non-equity alliances. This includes Licensing, (LI), Research and Development (RD), Marketing, (MK), Manufacturing, (MN) and Distribution, (DI) agreements. These forms of non-equity alliances are commonly found in strategic alliance studies in high technology industries (Chan et al., 1997; Deeds and Hill, 1996; Lane and Lubatkin, 1998; Powell et al., 1996; Rothaermel and Deeds, 2004). To test for the non-monotonic influences of strategic alliances, the quadratic form of this strategic alliance variable, $A^2$, is included.

**Absorptive capacity**: Absorptive capacity is a multi-dimensional construct and thus a variety of measures have been used in absorptive capacity research (Lane and Lubatkin, 1998; Nerkar and Roberts, 2004; see Zahra and George, 2002 for a review of measures). Measures of the absorptive capacity construct

have been based on a firm's accumulated experiences (Zahra and George 2002). Hence based on a firm's accumulated experiences, three measures of absorptive capacity are introduced. This enables one to capture the multi-dimensional dimensions of absorptive capacity. First, a firm's age, (G) is used as a proxy for a firm's absorptive capacity. This measure follows from Pennings and Harianto (1992)[4]. Second, to capture the diverse element of the absorptive capacity construct, a firm's knowledge diversity is measured by the research diversity variable, (DIV). Research diversity is a count of the firm's number of distinct areas of research development, (DIV). A firm's research diversity, (DIV), is a count of distinct technological and/or research areas of specialization. This diversity measure reflects the number of subfields in which the firm has participated in. BioScan (2004) provides a description of the distinct areas of research application and focus pursued by each company[5]. This diversity

[4]Cohen and Levinthal (1990) and Lane and Lubatkin (1998) have used the ratio of R&D expenditures to sales.

[5] As an example of a representative firm in the BioScan database: "Cancer diagnostics and therapeutics: oncogenes, including c-abl oncogene in chronic myelogenous leukemia, transforming growth factor beta 3 (TGF-B3), tumor inhibitory factor (TIF), DNA probes, more than 200 MAbs, oncogenes, tumor suppressor genes, AIDS diagnostic, TGF-alpha MAb-based diagnostic, A representative biotechnology firm would involve in the following research development activities: "in vivo radioisotopic MAb-based diagnostics for neu, P53, EGF-R, EGF, TGF, and GCSF

Therapeutics: tyrosine-specific protein kinase inhibitors, tumor growth inhibitors (TGIs)

Automated screening systems for chemicals that modulate gene expression of specific targets in various disease areas

Automated oncogene-based drug screens for inflammation, anemia, and other human therapeutics

TGF-beta 3 for wound healing

Chromosomal translocation technology

Drugs to specifically inhibit functional activities associated with oncogene-encoded proteins

Application of technology for the development of pharmaceuticals outside the field of cancer

measure has been used by (Rothaermel and Deeds, 2004; Shan, Walker & Kogut, 1994). This diversity measure is correlated with the number of products in development (Rothaermel and Deeds, 2004). Nicholls-Nixon (1993) uses the number of products in research development as a measure of absorptive capacity. Hence to capture the diverse element of absorptive capacity, the research diversity measure also includes number of products in development. Third, as absorptive capacity is subject to path dependent processes (Zahra and George, 2002), a firm's history of acquisitions and mergers is used to capture the diversity of firm experiences that occur from the acquisition or loss of knowledge through changes in a firm's boundary of operations. Mergers and acquisitions involve not only the control and ownership of another firm's physical assets, but it also provides direct access to the merged and acquired firm's knowledge and experiences. Since the biotechnology industry had experienced significant mergers and acquisitions (Thayer, 2001), the cumulative experiences gained from a firm's merger and acquisition history is used as another diversity measure of a firm's absorptive capacity. It is computed as the difference in the cumulative number of firm mergers less divestitures, (NETM). This count variable, however, does assume merger and divestiture activities are equally weighted.

***Control Variables:*** In order to distinguish scale efficiency effects from absorptive capacity influences, estimated models are controlled for firm size. In knowledge intensive industries, size is measured by the number of employees (Rothaermel and Deeds, 2004; Shan et al., 1994). As a result, firm size is measured by the number of firm employees, (E). In addition, the location of the firm is coded as a

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Regulation of gene transcription"

dummy variable (0= U.S. based, 1 non-US based) to account for institutional differences (Rothaermel and Deeds, 2004). The number of subsidiaries held by a firm is included because they provide access to either foreign markets and or provide entrance into new product-markets. Lastly, the number of institutional investors (i.e. investors from major banks, fund agencies) is also included. Investors provide sources of funding necessary to bringing products to markets. Since significant investments are tied up in R&D commitments, such external investors should positively impact the number of products on the market.

**Estimation Procedure**

To test hypotheses 1-4, Nested Hierarchical Weighted Least Squares (WLS) method is applied to six econometric models shown in table 4. Models 1-6 were estimated with the Shazam econometrics software (version 9.0). In estimating these models, tests for heteroscedacity, multicollinearity, as their presence can lead to problems of statistical inference and OLS estimates that are not BLUE (Greene, 2000; Wooldridge, 2003). Heteroscedastic (ARCH test) indicate the presence of significant heteroscedacity in all models. To correct for heteroscedacity, the estimated parameters in all models were weighted by the squared values of the size variable, employees, (E). As firm size exhibits very significant variation (see table 1: descriptive statistics), it is a significant source of heteroscedacity. Heteroscedacity tests are then re-tested on this WLS linear model and ARCH tests were not significant at the 90% significance. Low correlations among variables were observed (also shown in table 2) and multicollinearity does not appear to be a problem (Greene, 2000; Wooldridge, 2003).

## RESULTS

The descriptive statistics for the theoretical variables of interests and their correlations are shown in tables 2 and 3. The WLS regression results for models 1-6 are shown in table 4. Standardized coefficient estimates are reported.

[INSERT TABLES 2, 3, & 4, HERE]

In model 1, all control variables were not significant. However, in model 2, a firm's subsidiaries (S) variable is positive and significant. This is consistent with Rothaermel and Deeds (2004). The alliance variables, A and $A^2$, are also significant and show an inverted U shape relationship to the firm's product performance (PMR). This was also evident in all remaining models, this supports hypothesis 1. Prior studies, Deeds and Hill (1996) have also found empirical support for this relationship. However, unlike Deeds and Hill (1996), this study's data was collected at a much later stage of industry maturity. Hence, this study reinforces the findings of Deeds and Hill (1996) and goes on to further suggest that this inverted U shaped relationship is robust to different stages of industry development. This performance relationship may reflect an intrinsic structural feature of alliance relationships. In model 2a, the partial effects of each strategic alliance agreement was estimated. Licensing (LI), Marketing (MK) and Distribution (DI) were significant and positive. However Research and Development (RD) was not significant, but later significant in model 2b. In model 2b, the interactions between a firm's R&D (RD) and marketing (MK) are estimated. In model 2b, Research and Development (RD) and Marketing (MK) are significant and positive and yield the greatest impact to a firm's product performance, relative to other alliances. This supports hypothesis 2. However,

the interaction between these variables is significant but negative. Hypothesis 2a is not supported. This finding is contrary to prior research findings where research expertise and marketing competence mutually complement the advancement of a firm's products to market (Danneels, 2002; Nerkar and Roberts, 2004). Model 2b results may suggest marketing and research and development alliances may be viewed as competing trade offs, especially given the finite and limited financial resources of firms.

In model 3, the inverted U shape relationship is still maintained, however, a firm's age, (G), was not significant. Hypothesis 3 is thus not supported in this model. However, in model 4, when the interactions between a firm's age, G, and the number of alliances, A, was included, a firm's age, G, was positive and significant. Rothaermel and Deeds (2004) also finds similar support for firm age. Thus, like Rothaermel and Deeds (2004), hypothesis 3 is supported in model 4. In addition, the interaction between age and alliances was significant and positive. Although Rothaermel and Deeds (2004) finds positive interactions between a firm's age and exploration alliances, our results are similar. Model 4 shows comparable results of a positive interaction between the total firm alliances, A and a firm's age, G. This supports the argument that a firm's absorptive capacity –cumulative experiences- can be used to value and leverage the resources of its' alliance partners in ways that builds upon the firm's core experiences. As a result, this increases the firm's ability to introduce products to the market. Stated differently, this result suggests a firm's experience positively impacts its ability to leverage its' past experiences to absorb the resources of its

alliance partners. In doing so, this increases the firm's product performance. Hypothesis 3a is supported.

In model 5, the diverse aspect of a firm's absorptive capacity is estimated by the research diversity variable, (DIV). This coefficient is positive and significant. This supports hypothesis 4. In model 5a, the interaction between a firm's diversity and alliance is significant and positive at *p*=11.2%). Hypothesis 4a is supported. This is consistent with Cohen and Levinthal (1990) and Lane and Lubatkin (1998) arguments that a firm's ability to relate to external information is dependent on the diversity of the firm's prior knowledge and expertise. Our results are also consistent with Nerkar and Roberts (2004) who found that a firm's "proximal distant" – or diversity- positively assists its ability to gain access to complementary assets and advance a firm's products to market. However, this study further adds: the coefficient on the squared interaction of these terms was also found to be negative and significant. Thus, a firm's absorptive capacity to internalize external information sources is subject to diminishing effects. Research in absorptive capacity tends to focus on the mechanisms that explain for the absorption of external information (i.e., combinatorial routines, organizational search, learning, etc) (Zahra and George, 2002). These results suggest there may be limits imposed on these absorptive mechanisms. Lastly, in model 6, a firm's Net mergers, (NETM), is significant and positive. This supports hypothesis 4b. Similar to earlier results, model 6a shows the interaction estimates of a firm's net mergers, (NETM) and alliances. The interactions are significant and exhibit a non-monotonic or diminishing curve effect. This supports hypothesis 4b. Hence, although a firm's net mergers has a positive moderating

effect on the firm's strategic alliances in bringing a firm's product to the market, this effect is subject to diminishing returns.

## CONCLUSIONS AND DISCUSSIONS

The study asks the question of what are the determinants of firm's ability to launch products in the biotechnology industry. Prior studies have examined firm and inter-firm level causal factors to understand the determinants of a firm product performance. However, no studies to date have examined their interactive influences. Three contributions are made with this study. First, a theoretical and empirical framework is developed and tested that integrates firm level construct of absorptive capacity with the construct of strategic alliances. Our empirical results suggest that there are interactive influences between a firm absorptive capacity – in terms of its age and diversity of prior experiences- on its ability to absorb information and resources of its network partners. This interaction has positive influences on a firm's product performance. To date, no studies have examined these firm and inter-firm level interactions. Second, our results also observe that such gains from absorptive capacity exhibit diminishing effects. This appears to be supported in the age and diversity measures of absorptive capacity. Hence, as there are diminishing effects from strategic alliance relationships, our results also suggest there may also be diminishing effects from a firm's absorptive capacity. Third, various researchers have identified research and development and marketing alliance activities mutually complement the commercialization of biotechnology products (Teece, 2000). Our results suggest this is not the case and in particular, marketing and commercially related alliances appear to more greatly affect a firm's product performance.

In light of these contributions, there are, however, some limitations. First, panel data analysis is called for in future research. As the development of new products involves a temporal component, dynamic studies of product introductions would be fruitful area of investigation. Second, our proxy measures for absorptive capacity could be improved by developing measures used by Cohen and Levinthal (1990).

## REFERENCES


American Health Consultants, BioScan 2004.

Barney, J. B. 2002. Gaining and sustaining competitive advantage. Prentice Hall, Upper Saddle River, NJ.

Bettis, R., & Hitt, M. 1995. Technological transformation and the new competitive landscape. Strategic Management Journal, 16:7-19.

Bosch, F., Volberda, H., & Boer, M. (1999). "Coevolution of firm absorptive capacity and knowledge environment: organizational forms and combinative capabilities". Organization Science, 10, 5: 551-568.

Chan, S.H., Kesinger, J.W., Keown, A.J. & Martin, J.D. Do strategic alliances create value? Journal of Financial Economics 46 199-221.

Cohen, W.M., & Levinthal, D.A. 1990. Absorptive capacity: a new perspective on learning and innovation. Administrative Sciences Quarterly, 35: 128-152.

Danneels, E. 2002. The dynamics of product innovation and firm competences. Strategic Management Journal, 23: 1095-1121.

Deeds, D.L. and C. Hill. 1996. Strategic Alliances and the Rate of New Product Development: An Empirical Study of Entrepreneurial Biotechnology Firms. Journal of Business Venturing 11: 41-55.

Dyer, J. and Singh, H. 1998. The relational view: cooperative strategy and sources of inter-organizational competitive advantage. Academy of Management Review, 23, 4, 660-679.

Greene, W.H. (2000). Econometric Analysis: 4th Edition. Upper Saddle River, New Jersey: Prentice Hall.

Gulati, R., Nohria, N., & Zaheer, A. 2000. Strategic networks. Strategic Management Journal, 21: 203-215.

Helfat, C.E. & Raubitschek, R.S. 2001. Product sequencing: co-evolution of knowledge, capabilities, and products. Strategic Management Journal, 21:961-980.

Helfat, C.E., & Peteraf, M.A. 2003. The dynamic resource-based view: capabilities lifecycles. Strategic Management Journal, 24:997-1010.
Hill, C.W.L. and G.R. Jones. 1995. Strategic Management Theory. Boston: Houghton-Mifflin.

Hulse, Joseph H. (2004). “Biotechnologies: past history, present state and future prospects,” Trends in Food Science & Technology, 15, 3–18.

Harrison, J.S., Hitt, M.A., Hoskisson, R.E. and Ireland, R.D. (2001) 'Resource complementarity in business combinations: extending the logic to organizational alliances', Journal of Management, Vol. 27, pp. 679-690.

Helfat, C.E. & Raubitschek, R.S. 2001. Product sequencing: co-evolution of knowledge, capabilities, and products. Strategic Management Journal, 21:961-980.

Helfat, C.E. & Peteraf, M.A. 2003. The dynamic resource-based view: capabilities lifecycles. Strategic Management Journal, 24:997-1010.

Koza, M.P and Lewin, A.Y. 1998. The Co-Evolution of Strategic Alliances, Organization Science, Vol. 9, No. 3, 255-264

Jones, C., Hesterly, W.S. & Borgatti, S.P. 1997. A general theory of network governance: exchange conditions and social mechanisms. Academy of Management Review, 22, 4: 911-945.

Lane, P.J., & Lubatkin, M. 1998. Relative absorptive capacity and interorganizational learning. Strategic Management Journal, 19: 461-477.

Leonard-Barton, Dorothy & Pisano, Gary P. 1993. Monsanto's march into biotechnology (A) (case study). Harvard Business School Publishing. Product Number: 9-690-009: 19pg.

Levinthal, D.A., March, J.G. 1993. The myopia of learning. Strategic Management Journal 14 95-112.

Liebeskind, J.P., Oliver, A.L., Zucker, L. and Brewer, M. (1996) 'Social networks, learning, and flexibility: scientific knowledge in new biotechnology firms', Organization Science, Vol. 7, No. 4, pp. 428-443.

Mowery, D., Oxley, J, & Silverman, B. 1996. Strategic alliances and Inter-firm Knowledge Transfer. Strategic Management Journal, 17: 77-91.

Ng, D. 2003. The social structure of organizational change and performance. Emergence: a Journal of Complex Issues in Organization and Management, 5, (1): 79-101.

Osborn, R.N. & Hagedoorn, J. 1997. The institutionalization and evolutionary dynamics of interorganizational alliances and networks. Academy of Management Journal, 40, 2: 261-278.

Nicholls-Nixon, C. 1993. "Absorptive capacity and technological sources: implications for the responsiveness of established firms', unpublished Ph.D. Dissertation, Purdue University.

Parkhe, A. 1991. Interfirm Diversity, Organizational learning, and Longevity in Global strategic alliance, Journal of International Business Studies, 22, 4, 579-601.

Penrose, E. 1959. The theory of the growth of the firm. New York: Oxford University Press.

Pennings, J.M. and Harianto, F. 1992. Technological networking and innovation implementation, Organization Science, 3,2: 356-382.

Peteraf, M.A. & Bergen, M.E. 2003. Scanning dynamic competitive landscapes: a market-based and resource-based framework. Strategic Management Journal, 24: 1027-1041.

Pisano, G. 1990. The R&D boundaries of the firm: An empirical analysis. Administrative science quarterly, 35(1): 153-176.

Powell, W. W., K.W. Koput and L. Smith-Doerr. 1996. Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology. Administrative Science Quarterly 41 (1): 116-145.

Prahalad, C.K., & Hamel, G. 1990. The core competence of the corporation. Harvard Business Review, 68 (3): 71-91.

Rothaermel, F. 2001a. Complementary assets, strategic alliances, and the incumbent's advantage: an empirical study of industry and firm effects in the biopharmaceutical industry. Research Policy 30: 1235-1251.

Rothaermel, F. 2001b. Research Note: incumbent's advantage through exploiting complementary assets via interfirm cooperation. Strategic Management Journal, 22: 687-699.

Rothaermel, F.T and Deeds, D.L. 2004. Exploration and exploitation alliances in biotechnology: a system of new product development. Strategic Management Journal, 25: 201-221.

Rowley, T., D. Behrens, and D. Krackhardt. 2000. Redundant governance structures: an analysis of structural and relational embeddedness in the steel and semiconductor Industries. Strategic Management Journal, 21:369-386.
Schoonhoven, C.B., K.M. Eisenhardt, and K. Lymman. 1990. Speeding products to market: waiting time to first product introduction in new firms. Administrative Science Quarterly 35: 177-207.

Stalk, G. and T.M. Hout. 1990. Competing Against Time. New York: Free Press.
Schumpeter, J. A. 1934. The Theory of Economic Development (R. Opic, Trans.). Harvard University Press, Cambridge, MA, (original work published in 1912)

Shan, W., Walkter, G., & Kogut, B. 1994. Interfirm cooperation and startup innovation in the biotechnology industry, Strategic Management Journal 15 (5): 387-394.

Teece, D.J. 2000. Managing intellectual capital: Organizational, strategic, and policy dimensions. Oxford University Press. New York.

Thayer, A.M. 2001. Life Sciences. Business April 23, 79, (17) : 25-36.

Tripsas, M. & Gavetti, G. 2000. Capabilities, cognition, and inertia: evidence from digital imaging. Strategic Management Journal, 21: 1147-1161.

Werther, W.B., & Kerr, Jeffrey L. 1995. The shifting sands of competitive advantage.

Wernerfelt, B. 1984. A resource-based view of the firm. Strategy Management Journal, 5 (2): 171-180.

Wooldridge, J.M. 2003. Introductory Econometrics: A Modern Approach 2nd edition. South Western, Ohio.

Zahra, S.A. & George, G. (2002)."Absorptive capacity: a review, reconceptualization, and extension". Academy of Management Review, 27,2:185-203.

Table 1: Distribution of Biotechnology companies by product / service type marketed

| Type | Occurrence | Probability | |
|---|---|---|---|
| **Agricultural** | 22 | 0.0394 | 3.94% |
| **Agricultural & Biotechnology** | 11 | 0.0197 | 1.97% |
| **Agricultural & Pharmaceutical** | 49 | 0.0877 | 8.77% |
| **Biotechnological** | 149 | 0.2665 | 26.65% |
| **Pharmaceutical** | 263 | 0.4705 | 47.05% |
| **Pharmaceutical & Biotechnological** | 65 | 0.1163 | 11.63% |
| **TOTAL** | 559 | 1.0000 | 100.00% |

Table 2: Descriptive Statistics

| VARIABLE | N | MEAN | STD. DEV. | VARIANCE | MINIMUM | MAXIMUM |
|---|---|---|---|---|---|---|
| PMR | 241 | 0.74274 | 0.96188 | 0.925210 | 0 | 3 |
| G | 241 | 14.64300 | 9.57060 | 91.597000 | 0 | 78 |
| L | 241 | 0.71369 | 0.45298 | 0.205190 | 0 | 1 |
| I | 241 | 2.06640 | 3.18000 | 10.112000 | 0 | 18 |
| S | 241 | 0.79668 | 1.37090 | 1.879300 | 0 | 9 |
| E | 241 | 439.35000 | 2,871.40000 | 8,244,900.000000 | 3 | 43,000 |
| RD | 241 | 3.50210 | 4.13230 | 17.076000 | 0 | 30 |
| LI | 241 | 1.61830 | 2.82610 | 7.987000 | 0 | 26 |
| MK | 241 | 0.61826 | 1.15630 | 1.337000 | 0 | 8 |
| DI | 241 | 0.29876 | 0.80231 | 0.643710 | 0 | 5 |
| MN | 241 | 0.23237 | 0.60204 | 0.362450 | 0 | 4 |
| A | 241 | 6.26970 | 6.17500 | 38.131000 | 0 | 37 |
| A2 | 241 | 77.28200 | 148.93000 | 22,180.000000 | 0 | 1,369 |
| M | 241 | 0.68465 | 1.22140 | 1.491800 | 0 | 10 |
| D | 241 | 0.12033 | 0.39534 | 0.156290 | 0 | 2 |
| NETM | 241 | 0.56432 | 1.20980 | 1.463600 | -2 | 9 |
| DIV | 241 | 2.86310 | 2.48030 | 6.152000 | 0 | 16 |

Table 3: Correlation Matrix of Model Variables (N=241)

| VARIABLE | PMR | G | L | I | S | E | RD | LI | MK | DI | MN | A | $A^2$ | M | D | NETM | DIV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PMR | 1.000000 | | | | | | | | | | | | | | | | |
| G | 0.119430 | 1.000000 | | | | | | | | | | | | | | | |
| L | 0.011944 | -0.066915 | 1.000000 | | | | | | | | | | | | | | |
| I | -0.046157 | -0.035635 | 0.056640 | 1.000000 | | | | | | | | | | | | | |
| S | -0.046152 | 0.239930 | -0.228330 | -0.031299 | 1.000000 | | | | | | | | | | | | |
| E | 0.022366 | 0.146760 | 0.004370 | -0.038560 | 0.314450 | 1.000000 | | | | | | | | | | | |
| RD | -0.027120 | 0.024566 | 0.114960 | 0.176600 | 0.042367 | 0.009955 | 1.000000 | | | | | | | | | | |
| LI | 0.097073 | 0.039925 | 0.060733 | 0.083504 | -0.114760 | -0.009822 | 0.257660 | 1.000000 | | | | | | | | | |
| MK | 0.188560 | 0.078756 | 0.132530 | 0.127040 | -0.062312 | 0.007911 | 0.231250 | 0.032998 | 1.000000 | | | | | | | | |
| DI | 0.180990 | 0.032391 | 0.041435 | -0.007807 | -0.088498 | 0.039240 | -0.017782 | -0.019322 | 0.132430 | 1.000000 | | | | | | | |
| MN | 0.060488 | 0.060732 | 0.076902 | 0.018025 | -0.033392 | 0.167750 | 0.184040 | 0.165000 | 0.439200 | 0.157600 | 1.000000 | | | | | | |
| A | 0.091000 | 0.059589 | 0.142420 | 0.180930 | -0.050591 | 0.025101 | 0.846060 | 0.649850 | 0.417130 | 0.149350 | 0.398890 | 1.000000 | | | | | |
| $A^2$ | 0.077268 | 0.043703 | 0.118800 | 0.150680 | -0.058922 | 0.008478 | 0.782960 | 0.626140 | 0.308160 | 0.060699 | 0.335490 | 0.908820 | 1.000000 | | | | |
| M | 0.068975 | 0.097623 | 0.046999 | 0.010777 | 0.232790 | 0.214790 | 0.226330 | 0.084482 | 0.058969 | -0.043772 | 0.015071 | 0.196950 | 0.137420 | 1.000000 | | | |
| D | 0.092704 | 0.058749 | -0.062754 | -0.105810 | 0.137590 | 0.166790 | 0.108240 | 0.086037 | -0.044932 | -0.061267 | 0.057095 | 0.101000 | 0.062405 | 0.191090 | 1.000000 | | |
| NETM | 0.039343 | 0.079362 | 0.067958 | 0.045458 | 0.190060 | 0.162350 | 0.193130 | 0.057177 | 0.074219 | -0.024171 | -0.003442 | 0.165830 | 0.118350 | 0.947160 | -0.133860 | 1.000000 | |
| DIV | 0.065511 | 0.033565 | -0.42456E-0 | 0.033180 | 0.115540 | 0.063302 | 0.231140 | -0.006894 | 0.077585 | -0.058922 | 0.102320 | 0.168370 | 0.089452 | 0.101220 | 0.084861 | 0.074460 | 1.000000 |

Table 4: WLS Estimations

| | Model 1 | Model 2 | Model 2a | Model 2b | Model 3 | Model 4 | Model 5 | Model 5a | Model 6 | Model 6a |
|---|---|---|---|---|---|---|---|---|---|---|
| **Adjusted R-Squared** | 0.0126 | 0.2014 | 0.2185 | 0.2503 | 0.2035 | 0.2146 | 0.2912 | 0.304 | 0.3425 | 0.3638 |
| **P-Value of the F-Statistic** | | | | | | | | | | |
| ANOVA from the Mean | 0 | 0 | 0 | 0 | 0.000 | 0 | 0 | 0 | 0 | 0 |
| ANOVA from zero | 0 | 0 | 0 | 0 | 0.001 | 0 | 0 | 0 | 0 | 0 |
| **Durbin-Watson Statistic** | 0.398 | 0.6432 | 0.6286 | 0.6441 | 0.6990 | 0.7783 | 0.8168 | 0.8457 | 0.883 | 0.9137 |
| **Standardized Coefficients** | | | | | | | | | | |
| Constant | 0.0000* | 0.0000 | 0.000 | 0.000 | 0.0000 | 0 | 0 | 0 | 0 | 0 |
| L | -0.0945 | -0.0449 | -0.0003 | 0.0331 | -0.0657 | -0.0457 | -0.0776 | -0.0843 | -0.0401 | -0.0404 |
| I | -0.0510 | 0.0011 | 0.1765 | 0.0062 | 0.0072 | 0.0158 | -0.0087 | -0.0165 | -0.0239 | -0.012 |
| S | 0.1043 | 0.1665** | -0.0152 | 0.1771* | 0.1973* | 0.1548** | 0.1831** | 0.1886** | 0.1769** | 0.1715** |
| E | 0.0856 | -0.0435 | 0.0929 | -0.2051 | -0.0396 | -0.059 | -0.0673 | -0.045 | -0.0573 | -0.0407 |
| RD | | | 0.2082** | 0.2051* | | | | | | |
| LI | | | 0.3691** | 0.1998* | | | | | | |
| MK | | | 0.1405** | 0.5599* | | | | | | |
| DI | | | -0.1022 | 0.1168** | | | | | | |
| MN | | | | 0.0049 | | | | | | |
| A | | 0.8087* | | | 0.8365* | 0.9944* | 0.5791* | 0.419* | 0.5113* | 0.4233* |
| A2 | | -0.4382* | | | -0.4652* | -0.5851* | -0.303** | -0.2101 | -0.2726** | -0.2381*** |
| G | | | | | 0.0837 | 0.1405** | 0.1697** | 0.1779** | 0.1419** | 0.1307** |
| DIV | | | | | | | 0.3459* | 0.282** | 0.2596* | 0.2596* |
| RD*MK | | | | -0.3465* | | | | | | |
| RD*A | | | | | | 0.1643** | | | | |
| DIV*A | | | | | | | | 0.3477 | | |
| $(DIV*A)^2$ | | | | | | | | -0.3097** | | |
| NETM | | | | | | | | | 0.2559* | 0.0035 |
| NETM*A | | | | | | | | | | 0.5174** |
| $(NETM*A)^2$ | | | | | | | | | | -0.3154** |

* = $p$<1%, ** = $p$<5%, *** = $p$ < 10%