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The outsourcing of R&D through acquisitions in the pharmaceutical industry ☆

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Abstract

We examine the performance of 160 pharmaceutical acquisitions from 1994 to 2001 and find evidence that on average acquirers realize significant positive returns. These returns are positively correlated with prior acquirer access to information about the research and development activities at target firms and a superior negotiating position. A unique *Desperation Index* is employed to determine the current status of a firm's internal productivity. We find that firms experiencing declines in internal productivity or which are more desperate are more likely to engage in an outsourcing-type acquisition in an effort to replenish their research pipelines.

JEL classification: G34; D82

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1. Introduction

Researchers have shown that firms generally realize negative returns from acquisitions or, at best, break even. We find that acquirers have been able to avoid the winner's curse by obtaining information about the true underlying value of the target firm prior to acquisition. This information advantage for acquirers enables them to avoid the three major pitfalls that typically characterize unsuccessful acquisitions: (1) overbidding for the target firm, (2) selecting an incorrect target firm, and (3) failing at the post-acquisition integration process.

Instead of investigating a heterogeneous sample of acquisitions, we focus on research and development-directed acquisitions in the biopharmaceutical industry. This kind of examination has two main advantages. First, it allows us to use the extensive publicly available data for both the acquiring and target firms involved in new drug research that are related to informational asymmetries. Second, it provides measures of acquirer firm performance subsequent to an acquisition directly related to research and development (R&D) productivity, specifically product pipeline improvements.

We make four contributions to the literature. First, we find evidence consistent with the proposition that deteriorating R&D productivity could be the motivation underlying the acquisition of research-intensive firms. An integrated data sample of four complementary data sources allows us to test why and which firms engage in outsourcing R&D-type acquisitions. Relatively few studies focus on the motivation behind a firm's acquisition decision. Andrade et al. (2001) point out that "if mergers could be sorted by their true underlying motivations, it may be those which are undertaken for good reasons do benefit acquirers, but in the average statistics, they are canceled out by those with bad reasons." In this paper, we find that firms that are experiencing the greatest deterioration in their R&D productivity are most likely to undertake the acquisition of a research-intensive firm.

Second, we find evidence consistent with the proposition that biopharmaceutical firms can successfully outsource R&D through acquisitions. These acquisitions appear to effectively supplement a firm's internal R&D efforts and R&D-focused alliances. Overall, we find positive announcement period cumulative abnormal returns for the acquiring companies of positive 3.91 percent (significant at the 1% level). This figure is greater than previous results reported in the existing literature.[1] In addition to the significant financial gains to the sample acquirers, we find real measures of success. For example, 71% of acquirers in our sample either maintain or improve their product pipelines or portfolios post-acquisition.

Third, we find that access to information by the acquirer during the pre-acquisition period leads to greater success. Most acquisition research concludes that acquiring companies pay too much for a target and little or no value is created for their shareholders when a significant portion of the target firm's value consists of intangible assets. (See Rodriguez and Higgins, 2003, for a notable exception among software acquisitions.) One reason for such overpayment is the difficulty in valuing intangible assets. To overcome

[1]Andrade et al. (2001) report average announcement period abnormal returns of negative 0.70% for acquiring firms across 3688 different acquisitions from 1973 to 1998. These abnormal returns fell to negative 1.00% when focused on 1864 deals from 1990 to 1998. Bruner (2002) provides a comprehensive review of the current literature on mergers and acquisitions and summarizes the results for acquirer shareholders in Table III, which range from negative 14.2% to positive 3.24% for nontender offer transactions.

these valuation difficulties, we hypothesize that an acquirer can obtain significant additional information through pre-acquisition alliances with the target firm or alliances with firms conducting research that is similar to that of the potential target firm. The acquirer can also obtain additional insights into the underlying value of the target by drawing upon its own internal research experience. We find that pre-acquisition information-gathering activities are positively and significantly correlated with acquirer success.

Fourth, according to Samuelson and Bazerman (1985) acquirers engaged in bilateral negotiations with a target firm that could have superior information regarding the true value of its assets tend to succumb to the winner's curse. We find, though, that acquirers can mitigate overbidding by bidding from an advantageous negotiating position. Our results indicate that acquirer gains are positively correlated with the pre-acquisition strength of the acquirer's new product pipeline and exclusive products portfolio.

The remainder of the paper is organized as follows. Section 2 briefly discusses productivity trends in the pharmaceutical industry; Section 3 provides a brief discussion of the relevant literature; Section 4 discusses the empirical methodology and data used in our analysis; Section 5 presents and discusses our empirical finding; and Section 6 by summarizes the analysis and discusses the implications of our results.

2. Productivity trends in the pharmaceutical industry

Productivity in the pharmaceutical industry (as reflected by the overall industry exclusivity and patent horizon) declined in the late 1990s, because more drugs were coming off exclusivity protection than were being replaced by new Food and Drug Administration (FDA)-approved products.[2] Exclusivity refers to exclusive regulatory marketing rights granted by the FDA under 21 C.F.R. 314.108, which prevents generic products from entering the market.

The pharmaceutical industry had a combined total of approximately 1,100 years of aggregate exclusivity protection in 1998. The exclusivity horizon had fallen to just over eight hundred years by 2001 and the rate of decline has been fairly rapid. Fig. 1 plots the total number of exclusive years for each product currently approved by the FDA. The aging of the overall industry product profile is one reason for this rapid decline. In addition, new products take an average of ten to fifteen years to develop from initial discovery to final FDA approval (DiMasi, 2001). From 1988 to 2001, the average time the FDA took to approve a new drug was approximately 20 months (Federal Trade Commission, 2002). Over the same time period, the cost of developing a new drug product increased from $231 million in 1987 to $802 million in 2000 (DiMasi, 2001). Domestic research and development expenditures have followed the same trend. In 1990, R&D expenditures for US pharmaceutical companies totaled $6.8 billion and grew to over $21.3 billion in 2000. However, as a percentage of sales, R&D expenditures

[2]One explanation put forth by industry representatives for this decline is that the easy drugs have already been developed and that the drugs currently under development are much more sophisticated and target more difficult diseases. A second explanation, described in the Wall Street Journal (2004a), suggests that the heavy reliance on combinatorial chemistry and high-throughput screening did not produce the hits that were initially hoped for when this technology was adopted in the 1990s.

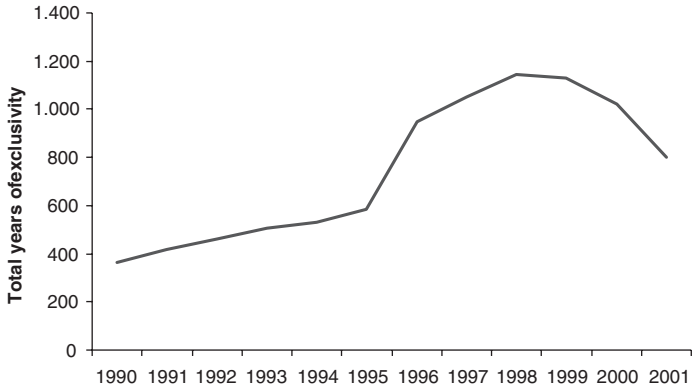

Fig. 1. Total number of exclusivity years remaining for all patented products identified in the Food and Drug Administration Orange Book for the period 1990–2001. This graph accounts for drugs that have been granted additional exclusivity because of reformulations. However, it does not include extensions to exclusivity stemming from litigation.

have remained fairly stable at around 17% from 1990 to 2001, peaking at 20.4% of sales in 1997 (Pharmaceutical Research and Manufacturers of America, 2002).

In response to this decline in R&D productivity, pharmaceutical firms have pursued several options: enhance their internal R&D efforts through the acquisition of smaller pharmaceutical or biotech companies or both; engage in large horizontal mergers to achieve greater economies of scale and scope in their research programs; acquire existing mature products through licensing agreements; increase organic internal R&D efforts independently; increase alliance activity; and change their fundamental business model. These options are by no means mutually exclusive. In reality, companies usually engage in a number of these activities at varying levels. In this paper we explore the first response—the impact that the outsourcing of R&D through acquisition has had on individual firm R&D productivity.

3. Acquisitions and the outsourcing of R&D

3.1. Relevant research on merger and acquisitions

A significant quantity of research has been dedicated to understanding for whom and how value is created through acquisitions. Many theories have emerged, for example, the monopoly theory of mergers (Mueller, 1985; Eckbo, 1992; Ravenscraft and Scherer, 1987) synergies approach (Bradley et al., 1988 economies of scale (Ravenscraft and Scherer, 1989; Houston et al., 2001) gain market power (Anand and Singh, 1997; Baker and Bresnehan, 1985; Barton and Sherman, 1984) redeployment of assets (Capron, 1999) and diversification (Berger and Ofek, 1995).

The conclusion one draws from the bulk of the research focusing on whether value is created or destroyed is that the return to acquiring firm shareholders, on average, is essentially zero. (See Kohlers and Kohlers, 2000; Eckbo and Thorburn, 2000; Lyroudi et al., 1999; Schwert, 1996; and Andrade et al., 2001) The majority of the value flows to the

target firm shareholders (Houston et al., 2001; DeLong, 2001; Eckbo and Thorburn, 2000; Jensen and Ruback, 1983; Jarrell et al., 1988; and Bruner, 2002). Relatively few studies have been able to demonstrate meaningful value gains on behalf of acquiring firms in non tender offer acquisitions. Andrade et al. (2001) suggest that the underlying strategic motivation for a particular transaction could provide a fruitful avenue for identifying how value is created through acquisitions for acquirer shareholders. Because companies merge for multiple reasons, it may be the case that companies engaging in mergers for bad reasons are negating the gains to companies engaging in mergers for good reasons. Mitchell and Lehn (1990) show empirically that there are both good and bad transactions from the viewpoint of the acquiring companies' shareholders. Andrade et al. (2001) offer five motivations for acquisition: (1) efficiency-related reasons that involve economies of scale or other synergies (2) creation of market power (3) market discipline (4) self-serving attempts by acquirer management to over expand and (5) diversification. Each of these strategic motivations, however, has its own distinct set of problems and concerns. It could be the case, then, that by grouping all transactions together we are unable to clearly look at them in any meaningful manner. By classifying acquisitions into appropriate categories of transactions, we could be able to determine which strategic motivation for mergers is flawed, and thereby predisposed to destroy shareholder value. Researchers can then begin to focus on these different underlying motivations and determine why a particular strategy has been successful or unsuccessful.

3.2. *Outsourcing of research and development*

Mergers and acquisitions as a method for outsourcing research and development is one of the justifications for acquisition activity observed during the latter 1990s. Pharmaceutical companies, in particular, begin to supplement internal R&D efforts through acquisition. Chesbrough (2003) discusses the importance of a company's need to address the research gaps in a timely manner. One of the methods he suggests to fill these gaps is through the acquisition of external technologies. In addition, James (2002) discusses the role mergers and acquisitions can play in enhancing a firm's internal capability. For example, in discussing the December 2002 acquisition of Triangle Pharmaceuticals, a Gilead Sciences' spokeswoman said, "We had a need to build our pipeline. This acquisition brings to Gilead not only a late-stage product that could launch next year, but a pipeline of other drugs in development (Smartmoney.com, 2002)." Merck provides another example of this trend. In March 2002 Merck's Chief Executive Officer (CEO) lauded the company's pipeline of products, which numbered 11 potential treatments that were slated to launch over the next few years. However, as of November 2003, only two of the products have launched. A third product was in the process of being filed. Two product's filings have been delayed until 2006 and six products have been either canceled or delayed indefinitely (Wall Street Journal, 2003). These cancellations and failures have caused Merck's pipeline to deteriorate significantly. Subsequently, in February 2004, Merck acquired Aton Pharmaceuticals Inc., a privately held biotechnology company. In describing the acquisition Merck said "The acquisition will enhance its [Merck's] internal research efforts to develop potential new medicines for the treatment of cancer (Wall Street Journal, 2004b).

In addition to having an understanding of what they are purchasing, acquiring companies must have the absorptive capacity to integrate the acquired research into their

own R&D program. Cohen and Levinthal (1989) postulate that a firm's absorptive capacity is based on it's own internal research and development efforts. As a result, regardless of the external R&D activities that an acquiring company could engage in, the firm should continue to pursue a comprehensive internal research program (Chesbrough, 2003).

One challenge that acquirers face in these types of acquisitions is holding on to essential target firm employees who could represent a significant portion of the firm's value. In contrast to the primary findings in the extant literature (for example, Andrade et al., 2001; Myers and Majluf, 1984) equity deals could be preferable to cash deals. Equity deals could be more effective in aligning the interests of employees at the target firm with those at the acquiring firm. This type of moral hazard problem is discussed by Jensen and Thursby (2001) within the context of university licensing agreements. They find that the use of equity to induce scientists to continue to remain committed to a project is an effective measure for reducing the moral hazard problem. In addition, the willingness of the target firm in these transactions to accept equity payment also serves as a signal to the market regarding its on going commitment to research post-acquisition.

3.3. *Information gathering and the winner's curse*

Asymmetric information in acquisitions is potentially a significant problem. For our specific example of acquisitions, this problem is compounded given the knowledge-intensive nature of the industry. Knowledge-based assets, in general, are more difficult to assess than tangible ones. One of the concerns for an acquiring company is its ability to accurately value the target firm. Firms that attempt to make acquisitions outside of their core competencies could have difficulty adding value to the firm (Williamson, 1975). Given this potential difficulty, it makes sense for knowledge-intensive firms to pursue targets with similar competencies. (In fact, 82% of the acquisitions in the current project are ones that involve firms with complementary research.) Chatterjee and Wernerfelt (1991) and Samuelson and Bazerman (1985) suggest that when acquiring firms engage in negotiations with target firms that have superior information regarding the true value of its assets, the acquiring firm tends to succumb to the winner's curse and overpay for the target. The winner's curse arises because of the uncertainty over the value of the target firm's assets.

We propose that firms pursuing knowledge-intensive acquisitions must engage in some pre-acquisition information gathering, besides normal corporate due diligence, to diminish the amount of asymmetric information between the acquirers and the target firms. The pre-acquisition information activities that we consider are alliances prior to an acquisition with the target firm, alliances with other firms within the same therapeutic category as the acquisition, and internal research and prior sales experience within the same therapeutic category as the target firm. These activities function as a feedback mechanism, which allows acquiring companies to generate information on a potential target. The pharmaceutical acquirers in our sample have been and continue to be heavily focused upon research and development. We can presume they are experts in evaluating the future profitability of basic research. As such, if an acquiring firm is engaged in similar research as a target firm, it should be able to place a more accurate value on the target research, potentially avoiding the typical overpayment associated with the winner's curse. In addition, prior contact with the target firm through alliances gives the two firms an opportunity to learn about each other's research and also meet and work with key

scientists and management. (Anand and Khanna, 2000, show that firms can learn to create value as their alliance experience accumulates over time.) In the current analysis, each acquiring firm had, on average, four alliances with the target firm prior to the acquisition. This contact should provide the acquiring firm with sufficient information regarding the human capital of the target firm. Combined, these pre-acquisition activities should provide enough information to the acquirer so that it knows what it is buying. This type of organizational learning perspective is broadly similar to that suggested by Hayward (2002).

In addition to providing information, Rothaermel (2001) finds that alliances with providers of new technologies are positively correlated with new product development for the incumbent firm and, in turn, new product development is positively associated with firm performance. This finding is supported elsewhere in the literature, for example, Shan et al. (1994) and Deeds and Hill (1996).

Acquirers in the pharmaceutical industry are able to negotiate more effectively with the target firm when the exclusivity and patent horizon of their own product portfolios and their product pipelines are strong. We argue that they undertake acquisitions to supplement their slowing R&D productivity as evidenced by an increase in their *Desperation Index* (our unique quantitative measure of firm level productivity). Firms are able to capture value from their acquisition activities by improving their stock of knowledge or information about the target prior to the time of the acquisition. As such, we make the following five predictions: (1) the probability that a given firm undertakes an R&D acquisition is positively related to its level of desperation just prior to an acquisition; (2) given that a firm makes an acquisition, the cumulative abnormal return, *CAR*, realized from the acquisition is positively related to the stock of information accumulated by the acquirer in the period prior to an acquisition; (3) the *CAR* realized from an acquisition is negatively related to the acquirer's level of desperation; (4) post-acquisition improvements in R&D productivity or pipeline health of an acquirer is positively related to acquirer's pre-acquisition information gathering activities; and (5) post-acquisition improvements in pipeline health of an acquirer is positively related to the acquirer's level of desperation prior to an acquisition.

4. Empirical methodology and data sample

4.1. Empirical methodology

We use event study methodology to compute the cumulative abnormal returns around the time of the acquisition announcement. Acquisition dates for the sample are gathered from Securities Data Corporation (SDC) and verified using publicly available media reports from the *Wall Street Journal* and other business publications. We run the event study utilizing an event window of three days. The three-day window includes the day of the announcement as well as the day before and after. As a robustness check, we re-run the event study utilizing a five-day window. The five day window includes the three days prior to an acquisition announcement, the day of the announcement as well as the day after. Finally, we checked for confounding events for each transaction with the *Wall Street Journal*.

One of the challenges in analyzing mergers and acquisitions is to find appropriate measures of transactions success, in addition to the widely accepted cumulative abnormal returns. Healey et al. (1992) use post-acquisition accounting data to test directly for

changes in operating performance that result from mergers. This approach is not appropriate for the current analysis because it overlooks the health of the acquiring company's product pipeline, which represents potential future significant cash flows that are not recorded in available accounting data. We examine two measures of acquisition success in addition to cumulative abnormal returns. First, we look at the post-acquisition change in the research pipeline for the year following the acquisition. We quantitatively measure each company's pipeline using a unique *Score* value. If pipeline products were included in the acquisition, the company's post-acquisition product pipeline *Score* value should increase. This would be one indication that the company was successful in making improvements to its product pipeline as a result of R&D acquisitions. Second, we look at post-acquisition changes in revenues in the year following the acquisition. This measure is less precise for two reasons. First, because many of the acquisitions are smaller in size, even if a company acquired a mature product with existing sales, those added sales may not be enough to counteract the firm's existing loss in sales as a result of current products coming off patent. Second, pipeline products that are acquired by a firm most likely do not have sales in the following year, unless the product has already been submitted for FDA approval.[3] To test our primary predictions, we employ regression analysis controlling for firm characteristics and transaction characteristics expected to affect the value creation resulting from acquisitions in our sample using our standard measure of acquirer success, *CARs*, and two industry-specific measures of success, improved product pipeline and new drug product sales.

4.2. Acquisition identification

We obtain acquisitions data from Thomson Financial's Securities Data Corporation (SDC) database for the years 1994–2001. We identify transactions representative of the new product-focused biotechnology industry acquisitions by the primary acquirer Standard Industry Code (SIC) and by SDC's high-tech search variable. SIC codes 2833-2836 cover the pharmaceutical industry. The high-tech industry classification by SDC identify firms within the biotechnology industry, but with SIC codes other than 2833-2836. This search method also identifies high-tech companies in different sectors. As a result, we filter the data set using SDC's business description and sector variables. Acquisitions that clearly are outside of the biopharmaceutical sector are deleted from the data set. Unrelated acquisitions are considered to be those that include over-the-counter or generic drugs, consumer products, medical devices and products, and manufacturing facilities. In addition to filtering the sample to verify the relevance of the acquisition in question, we collect information from news stories from Factiva. First, we verify the value and method of payment of the acquisition, when disclosed. Second, we note the company's stated reason for entering into the acquisition. Third, the relatedness of the firms is coded. Firms are coded as ''related'' if the target company's research or products are within the same therapeutic category as the acquiring company.[4] The purpose of this classification is to

[3]The inability to extend this beyond one year post-acquisition is a function of our data range. Because our data ends in 2001, we are limited to the number of years we can extend the analysis post-acquisition without losing data points. Our current research project is looking at the status of the acquired pipeline products in the post-acquisition period.

[4]Firms were categorized into broad therapeutic categories based upon the Uniform Standard of Classification. For coding purposes we looked at several sources for therapeutic information about firms. For example, we

determine whether firms were making acquisitions within their current competency or whether they were venturing to build a new competency. This filtering process left approximately 180 transactions spanning 15 countries, with the majority of the acquirers and targets, 76% and 80%, respectively, being based in the United States. We obtain domestic stock market returns data from the Center for Research in Security Prices (CRSP) and international returns data from Data Stream. Twenty transactions are dropped from the final sample because of inadequate data. In some of these cases, both parties are private entities and information about the transaction is severely limited or not available.

4.3. Exclusivity horizon and patent profiles

4.3.1. Implications of Hatch–Waxman

Two types of patent protection exist for pharmaceutical companies. The first are traditional patents granted and processed by the United States Patent and Trademark Office (USPTO). The Uruguay Round Agreements Act of 1994 extended patent lengths from 17 years from the date the patent was granted to 20 years from the date the application was filed. Traditional patents can be filed anywhere along the development lifeline of a drug, and they can encompass a wide range of claims. Most approved pharmaceutical products have several patents attached to them. For example, the Eli Lilly drug Cialis™ has two separate patents associated with its new drug application (NDA).[5]

The second type of protection is regulatory in nature and granted by the FDA upon approval of a new chemical entity (NCE). This type of protection is termed *exclusivity* and could run concurrent with traditional patent protection. For a NCE, exclusivity is granted for a period of five years from the date of FDA approval.[6] Exclusivity came about as an important provision in the Drug Price Competition and Patent Term Act of 1984—more commonly referred to as the Hatch–Waxman Act. The purpose of exclusivity was to provide pharmaceutical companies five years of marketing protection during which other manufacturers were prohibited from filing an application to sell a generic product. Exclusivity does not, however, prevent other manufacturers from seeking approval for a drug that uses the same therapeutic mechanism as an already approved drug. These products are often referred to as "me-too" drugs and are required to undergo the same rigorous clinical testing to garner FDA approval.[7] For example, the erectile dysfunction drugs Cialis™ and Levitra™, direct competitors of the already marketed drug Viagra™, were approved on November 21, 2003 and August 19, 2003, respectively. The exclusivity

(*footnote continued*)
utilized the therapeutic coding available from our proprietary sales data set, the NDA pipeline, company websites, and the news releases about the acquisition itself.

[5]Two patents, numbers 5859006 and 6140329, expiring on January 12, 2016 and July 11, 2016, are attached to the NDA in the FDA Orange Book.

[6]Orphan (for rare diseases and disorders) and pediatric drugs are granted longer exclusivity periods because of their limited use. For example, orphan drugs are granted seven years of exclusivity protection.

[7]This is in contrast to generic drugs, which, according to the Hatch–Waxman Act, only need to demonstrate bioequivalence to an already approved brand-name drug to get FDA approval. Bioequivalence means that the active ingredient in the generic drug is absorbed at the same rate as the brand-name drug. The test required to demonstrate bioequivalence is much less costly than those undertaken by brand-name drugs. This provision in Hatch–Waxman has allowed generics to enter the market quickly and at much lower cost. For example, prior to Hatch–Waxman in 1983, only 35% of top-selling drugs with expired patents faced generic competition. By 1998, that number was close to 100% (Congressional Budget Office, 1998).

provision was designed to help firms that had no patent protection or had little time left under patent when a NCE was approved by the FDA.

Our goal is to construct an exclusivity and patent profile for each pharmaceutical company with an approved product. The purpose of such an exercise is to provide a measure of the health of an individual company's patented product profile. The FDA Orange Book indicates when an NCE is formally approved by the FDA. Along with this approval is the granting of exclusivity by the FDA. According to 21 C.F.R. Section 314.53, upon submission of a new drug application for consideration by the FDA, pharmaceutical firms are required to submit relevant and supporting patent information. For patents issued after the approval of an NDA, firms are required to submit relevant patent information within 30 days.

Unfortunately, several issues arise when trying to use the FDA Orange Book to construct our exclusivity and patent profiles, which must be taken into consideration. First, exclusivity and patent lengths are not static. Companies are allowed to extend the length of both their exclusivity and patent protection. The allowances for both of these extensions flow from the Hatch–Waxman Act. In terms of patent protection, companies that have received approval for a NCE by the FDA can apply to have half the time the drug spent in clinical trials (approximately four to eight years) plus all of the time spent having the FDA review (usually two years) its new drug application added onto its patent length. There are three limitations. First, the extension cannot be longer than five years. Second, the total granted patent length of a drug cannot exceed 14 years after the drug has been approved. Third, companies must apply for the extension within 60 days of FDA approval (Congressional Budget Office, 1998). In addition, only one patent is eligible for the Hatch–Waxman extension. As a result, most firms choose to extend the patent that covers the drug's chemical compound or in the alternative, the patent that covers the use of the drug (Congressional Budget Office, 1998).

The Hatch–Waxman Act also provides for extensions to exclusivity protection. The act allows for the granting of three more years of exclusivity for a supplemental NDA if the application required additional clinical testing. Manufacturers often use this provision to obtain approval for new dosages of previously approved products. Schering used these provisions effectively in the follow-up introductions of Claritin-D™ and Claritin-D 24 Hour™ to there hit allergy medicine Claritin™, which was originally approved on April 4, 1993. The logic behind this provision is to provide manufacturers an incentive to continually improve brand-name products (Congressional Budget Office, 1998).

When a generic manufacturer makes an application (called an abbreviated new drug approval or ANDA) to the FDA, the ANDA must contain a certification regarding each of the patents listed in the Orange Book. Four possible certifications can be made (see Bulow, 2003). Of relevance to the current discussion as it relates to the extension of exclusivity are Paragraph IV Certifications. With this certification a generic manufacturer is challenging that a listed patent is either invalid or will not be infringed upon by the generic drug. The manufacturer making this claim must provide the patent holder with the factual and legal basis for filing. The patent holder then has 45 days in which to file an infringement suit. By filing an infringement suit, the FDA sets aside the approval process for the ANDA until the earliest of the date the NDA patent being challenged expires, a court ruling invalidates the patent, a court ruling of non infringement is made, or 30 months pass after the patent holder was originally notified of the ANDA Paragraph IV certification. The Federal Trade Commission (FTC) estimates that Paragraph IV

challenges, on average, take approximately 25 months to adjudicate (Federal Trade Commission, 2002). In effect, brand-name manufacturers are able to tack on another two and one-half years of exclusivity protection thereby increasing their effective exclusivity period to seven and one-half years.[8]

Unfortunately, these provisions to extend exclusivity and patent protection have been increasingly used in an effort to stave off generic competition by brand-name manufacturers.[9] Bulow (2003) provides a more complete discussion of the type of gaming that has taken place. As a result, the FDA Orange Book, which provides an accurate picture of new drug approvals, could be missing relevant patent data.

4.3.2. *Exclusivity and patent profiles*

Three separate data sources are utilized in generating our firm and industry exclusivity and patent profiles. Because there is the possibility of underreporting in the FDA Orange Book, Thomson Derwent and New England Research Application Center (NERAC) are used in an attempt to identify additional patents that could be used by the firm to extend protections. The goal in utilizing these data sets is to attempt to capture additional, unreported patents that are relevant to a particular approved product. The net result of using this combination of data is that we create a bound for each of our profile measures. A lower bound is created by the use of the FDA Orange Book since there is potential underreporting of patents. An upper bound is created by the combination of Derwent and NERAC. An upper bound is generated because these data sets attempt to identify additional patents tied to a particular approved product that are not identified in the FDA Orange Book. Given that this process of attaching additional patents to a particular approved product is rather subjective, some of the patents identified and attached to a product could be unusable by the firm in efforts to increase patent protection or stave off generic competition.[10]

In addition to these raw patent and exclusivity profiles, a third measure is created. This measure is a sales-weighted exclusivity horizon. Because not all approved products are worth the same in terms of revenues, it makes sense that not all patents are worth the same. By sales weighting our exclusivity measure we are able to discern the status of the most important patents to the firm, in terms of revenues. We construct this by obtaining proprietary sales data from IMS Health for every patented drug in the FDA Orange Book files from 1994 to 2001.[11] We combine the two data sets for each product to obtain a weighted product exclusivity horizon. Each product is weighted according to the proportion of sales represented by the average product life cycle of all drugs in the FDA Orange Book. The average product life cycle is determined as the proportion of sales in each year of exclusivity through three years following loss of exclusivity protection. Over

[8]In its report, the FTC noted that the prevalence of infringement suits increased after 1998 (see Federal Trade Commission, 2002).

[9]This process appears to have been abused in the past. For example, Bristol Meyers Squibb (BMS) announced that it would pay a total of $670 million to settle antitrust suits relating to Buspar and Taxol. One of the allegations made was that the improperly listed a patent in the Orange Book extending their exclusivity (see *In re Busprinoe Patent Litigation*, MDL No. 1410 (S.D.N.Y.).

[10]We thank a patent attorney specializing in biopharmaceutical patents, who requested to remain anonymous, for spending countless hours answering questions relating to these issues.

[11]One hundred fifty patented products identified in the Orange Book files did not have sales data identified in IMS Health's data set; this left 398 patented products with sales data.

the entire Orange Book file, 74.19% of sales occurred during the five-year exclusivity protection period, while an additional 15% of sales were realized in the three years following the loss of exclusivity. We chose this weighting technique in an effort to reflect each product's position correctly within its individual product sales life cycle. This life-cycle measure also provides some empirical insight into potential gaming in the FDA Orange Book. Since 74.19% of sales across the FDA Orange book are occurring within a drug's first five years of sales, this suggests that the impact of gaming is not yet that significant. On average, the vast majority of pharmaceutical sales for a product are still occurring within their first five years of approval.

The exclusivity horizon for the sector, regardless of the measure used, indicates that the cumulative horizon is declining. Fig. 1 plots the cumulative number of years of exclusive marketing rights remaining for all patented products for the years 1991 to 2002. The range is extended beyond our sample length of 1994 to 2001 to demonstrate the longer-run trend. Two potential extensions of the number of exclusive years are discussed; Fig. 1 takes into consideration one of those concerns. When companies apply for a supplemental NDA as a result of a new dosage or use, those products are listed separately and, as a result, are captured in this measure. It is possible that some firms for some products could have a longer exclusivity horizon.

The cumulative patent profile for the sector also follows a similar pattern as the exclusivity profile. The cumulative exclusivity horizon peaked in 1998, while the overall patent profile peaked in 1999. Two possible reasons explain that the cumulative years for the patent profile exceed the cumulative years in the exclusivity profile. First, exclusivity protection is granted only to products that have been approved by the FDA. Many projects in earlier stage testing have received regular patent protection but are ineligible for exclusivity protection. Second, an approved product is granted exclusivity only once, while at the same time an approved product could have a series of patents tied to it that extend back to the early stage discovery process. For example, product X is given five years of exclusivity protection (excluding any possible extensions), but could have several patents associated with it with varying lengths of protected time remaining.

4.3.3. New drug approval pipeline

In an effort to determine what products are in development for acquirer firms, we use the NDA pipeline files from 1994 to 2001. These files contain information relating to the various stages of product development. For purposes of this study we focus on the following phases: pre-clinical, Phase I, Phase II, Phase III, and FDA filed. Phase I involves safety testing, Phase II focuses on small-scale human efficacy trials, and Phase III focuses on large-scale human efficacy trials. We group all pre-Phase I research into the pre-clinical category. We were also able to identify the broad therapeutic categories, through the Uniform Standard of Classification, where this research is focused. For example, over the entire time period, 18.56% of all treatments in various stages of development are related in some way to oncology. While the sheer numbers of potential treatments has grown, the number of treatments being taken to the last stage (filing with the FDA) has remained relatively constant. The ratio of treatments that make it to FDA filing over the number of treatments in Phase III declined from 29% to 17% throughout the 1990s.

Clinical probabilities are subsequently assigned to each of the phases of research. These assigned clinical probabilities, based on existing research, reflect the chance a potential treatment has of receiving FDA approval (Krieger and Ruback, 2001). We subsequently

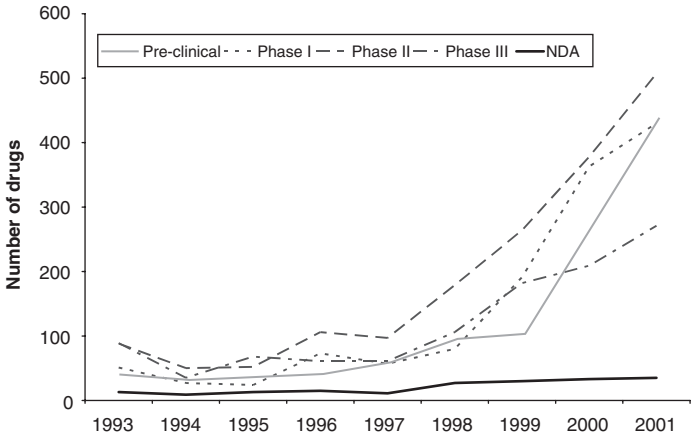

Fig. 2. Total number of drug candidates in the various stages of clinical research identified in the new drug approved (NDA) pipeline for the biopharmaceutical industry over the time period 1993–2001. While a tremendous increase has been evident in the number of drug candidates in the late 1990s, the number of products being submitted to the Food and Drug Administration for approval has remained relatively constant.

employ these values to construct a weighted value of each company's pipeline products, which we refer to as the *Score*. A relatively high *Score* indicates a healthy product pipeline, in that higher *Score* values are reflective of a greater number of later-stage products in the pipeline. For example, a firm with a small number of Phase II or Phase III products would have a higher *Score* value than a firm with a large number of pre-clinical or Phase I products. The more important element, however, is not necessarily the level of the *Score* in any given year, but the trend of the *Score* in the years prior to and after an acquisition. A declining *Score* in the years prior to an acquisition would be indicative of a company whose product pipeline was deteriorating.

The overall industry *Score* value shows a marked increase in the mid-1990s and is reflective of an underlying increase in the number of products in the NDA pipeline. Fig. 2 plots the cumulative number of products in their various stages of pipeline research over our sample period. The number of early stage pipeline products dramatically increased in the late 1990s as did, to a lesser extent, the number of late-stage products. FDA approvals throughout this time period, however, have remained fairly constant at around 50. Reflecting back to Fig. 1, the increase in pipeline products has yet to produce sufficient numbers of new products to stem the decline in industry-wide firm exclusivity horizons.

In the analysis that follows we utilize the raw *Score* values in the two years prior to the acquisition, the year of the acquisition, and the year following an acquisition. In addition, two changes in *Score* value are considered. First, we look at the change in the *Score* value between the year of the acquisition and the year prior. Second, we look at the change between the year after the acquisition and year of the acquisition. By using these different combinations we can look at both levels and changes in the *Score*.

4.4. Alliances

For our analysis we use a proprietary set of alliance data provided by Recombinant Capital. The data identify alliances in the biopharmaceutical industry from 1973 through

2003. They also provide a general description of the nature of these alliances. This information provides two important acquirer firm attributes for our analysis: (1) whether the acquiring company had any alliances with the target company prior to the acquisition; and (2) what type of alliances these were, for example, licensing, research, development, co-development, co-marketing, distribution, or manufacturing. We are also able to determine whether an alliance was for an early- or late-stage product. In addition to alliances between our acquirer and target, we specify two other categories of alliances. The first category is whether or not the acquiring company engaged in any alliances prior to the acquisition with other firms other than the target. The second category is whether the acquiring company engaged in any other alliances within the same therapeutic category as the target, but with a firm other than the target. We believe prior alliance activity with the target provides the most specific opportunity for an acquiring company to learn about the target firm. In fact, 67% of the sample acquirers engaged in, on average, four alliances with the target prior to the acquisition.[12]

4.5. Desperation Index

Through the combination of these data we construct a categorical *Desperation Index*. We place each firm in the sample into one of four categories of desperation based upon whether or not the change in their *Score* value and sales-weighted exclusivity horizon is increasing or decreasing in the year immediately prior ($year_t - year_{t-1}$) to an acquisition. The categories reflect an increasing level of desperation. Category I (strongest position) represents firms that have an increasing *Score* value and an increasing sales-weighted exclusivity horizon. Category II represents firms that have increasing *Score* values, but a declining sales-weighted exclusivity horizon. In contrast, a Category III firm is generating increasing sales but has a declining *Score* value. Finally, Category IV (weakest position) represents firms that have both decreasing *Score* values and a decreasing sales-weighted exclusivity horizon. We place Category II firms ahead of those in Category III because they have greater potential for generating future products and, as a result, future sales. For example, a firm in the second category is one that is experiencing a decline in sales prior to an acquisition, but it is also experiencing an increase in *Score* value. The prospect exists for the firm to be able to replace declining sales products with new ones in the future. In contrast, a Category III firm is generating increasing sales, but its *Score* value is declining. This would be indicative of a firm whose product pipeline is deteriorating. Thus, this firm would have a lower prospect for being able to replace current products with new ones in the near future. Firms were assigned to corresponding *Desperation Index* categories prior to and subsequent to each acquisition. Sixty percent of firms were categorized as either Category III or IV in the period prior to the acquisition. This is in contrast to the post-acquisition period, in which only 32% of firms were categorized as Category III or IV. Approximately 28% of the acquiring firms in our sample were able to remove themselves completely from these lower classifications. Whereas 59% of acquiring firms were able to improve their categorical classification by at least one level, only 12% of these firms remained at their pre-acquisition desperation level.

In addition to our base definition, we consider other variations and combinations of the variables in our *Desperation Index* to test the robustness of our results. First, we parse the

[12]Target firms, on average, had six alliances with firms *other* than the acquiring firm prior to the acquisition.

Desperation Index into its two component parts: the *Score* value and sales-weighted exclusivity horizon. This will allow us to test the levels of these variables versus their change. Next, we replace the sales-weighted exclusivity horizon variable with three other alternatives. First, we test the raw number of exclusivity years remaining in the portfolio. This is a simple summation of exclusivity years as reported in the FDA Orange Book. Second, firms are potentially able to game the number of exclusive years for a product. As a result, the first measure could understate the exclusivity horizon. Assuming that a firm does not engage in a patent infringement suit unless the marginal benefit of doing so exceeds the marginal cost of litigation, we add 30 months of exclusivity protection to drugs that have sales equal to or in excess of $100 million in the year they would lose exclusivity protection.[13] A new summation of the exclusivity variable is then generated based on this extension. While not a perfect measure, it should mimic more closely the response of companies. Finally, we replace the sales-weighted exclusivity horizon with a summation of regular patent years. Again, because of potential gaming of patents in the FDA Orange Book, we use our second patent measure generated from NERAC and Thomson Derwent. These data attempt to identify relevant data not identified in the FDA Orange Book. As a result, this variable could possibly be overstated. As such, the measure serves as an upper-bound, while the exclusivity horizon will serve as a lower bound.

5. Empirical analysis

5.1. Assessing acquirer desperation and propensity to engage in acquisitions

Pharmaceutical firms experiencing declines in either their research pipeline or patented product portfolio can respond in several ways. We focus our analysis on the propensity of firms to engage in outsourcing acquisitions using probit regressions. Our sample for this analysis includes firms contained in Recombinant Capital's alliance data set from 1994 to 2001 and that have both sales and pipeline data available. This allows for a homogenous sample of firms engaged in similar activities and facing potentially similar constraints. The dependent variable is an indicator variable, $y_{it,}$ that assumes a value of one for a given firm, i, in a specific year, t, if that firm undertakes an acquisition in a given year and is zero otherwise. For independent variables we use the change in *Score*, R&D intensity, the log of market capitalization, a count variable identifying the number of alliances undertaken prior to the current year (includes all firms, not just target firms), indicator variables corresponding to each category of our potential acquirer *Desperation Index*, and a time trend. As a robustness check, we include the three other definitions and constructions of the components of the *Desperation Index*. We also refine the variable *Count* to include only alliances with the target firm. See Table 1 for variable definitions; Table 2 summarizes the variables; and Table 3 presents the variable correlations.

We present the results of our probit regressions with White and Huber heteroskedasticity consistent standard errors in Table 4.[14] Consistent with our hypothesis, we find that

[13]This process was repeated for drugs with $50 million and $75 million in revenues in the final year of exclusivity.

[14]The same analyses were performed with logit regressions. Unreported results are consistent with the probit analyses reported in the paper. A Hausman test was run and rejected the hypothesis that the individual-level effects were adequately modeled using a random effects approach. As such, a fixed effects model is utilized.

Table 1
Definition and description of regression-model independent variables

Different dependent variables are utilized. Cumulative abnormal returns (CAR_j) are used in Table 7 and Δ *Score* and Δ *Sales* are used in additional cross section analyses presented in Table 9.

Variable	Description
Score	Weighted value (non monetary) of company research pipeline
Δ *Score pre-acquisition*	Pre-acquisition change in weighted value of research pipeline ($score_t - score_{t-1}$)
Δ *Score post-acquisition*	Post acquisition change in pipeline weighted value ($score_{t+1} - score_t$)
Log sales level	Log value of real life-cycle-weighted pharmaceutical sales
Δ *Sales pre-acquisition*	Pre-acquisition change in weighted sales ($log\ sales\ level_t - logsaleslevel_{t-1}$)
Δ *Sales post-acquisition*	Post acquisition change in weighted sales ($log\ sales\ level_{t+1} - logsaleslevel_t$)
R&D intensity	Research and development expenses/sales (real 1999 dollars)
Pipeline experience	Dummy equals 1 if acquiring company has pipeline research in the same therapeutic category as the target firm
Sales experience	Dummy equals 1 if acquiring company has patented pharmaceutical product sales in the same therapeutic category as the target firm
Alliance	Dummy equals 1 if acquiring company has alliance with target firm *prior* to the acquisition
Royalty	Dummy equals 1 if acquiring company was paying a royalty to the target firm prior to the acquisition
Early stage alliance	Dummy equals 1 if acquiring company has early stage product alliance with target firm prior to acquisition
Desperation Index (pre-acquisition)	Dummy equals 1 if acquiring company was assigned to desperation Categories III or IV
Δ *Desperation Index* post-acquisition	Dummy equals 1if acquiring company improved level of desperation post-acquisition
Prior acquisition	Dummy equals 1 if acquiring company has prior acquisition experience in the three years before the latest acquisition
Stock deal	Dummy equals 1 if acquisition was stock financed
Cash deal	Dummy equals 1 if acquisition was cash financed
Contingent contract	Dummy equals 1 if contingent contract was present
Related	Dummy equals 1 if acquiring and target firms operate within the same therapeutic category or categories
Sales force	Dummy equals 1 if sales force personnel were part of acquisition
Free-cash flow	Free-cash flow
Tobin	Tobin's *Q*
Log market cap	Log of market capitalization
International	Dummy equals 1 if acquiring firm was an international firm

firms that are more desperate are more likely to engage in acquisitions. The *Desperation Index* has two components: the change in *Score* value (representing progress in the firm's new product pipeline) and the change in the sales-weighted exclusivity horizon (representing the state of the firm's current product portfolio). Model 1 takes just one of the component values, the change in *Score*, and uses it as an independent variable. We report a negative and significant correlation between the change in *Score* value and the probability that a firm engaged in an acquisition. This result suggests that firms with improving product pipelines are less likely to undertake an outsourcing acquisition. In Models 2 and 3, we incorporate each of our four classifications of the *Desperation Index*. Category III and IV firms, our most desperate firms, are experiencing a declining

Table 2
Descriptive statistics for firms making 160 research and development related acquisitions in the 1994 to 2001 period

These variables are used in probit results analyzing the characteristics that impact the probability a firm engages in an acquisition (Table 4), analysis of the event study results (Table 5), cross-section results that utilize the cumulative abnormal return as the dependent variable (Table 7), and cross-section results that utilize two separate measures of success as the dependent variable (Table 9).

Variable	Mean	Standard deviation	Minimum value	Maximum value
Free-cash flow	438.03	943.77	−250.87	4669.00
Tobin	3.69	3.53	−0.96	32.25
Log market cap	7.26	2.42	2.15	12.58
Score (in year of acquisition)	4.49	8.66	0	51.54
Δ *Score pre-acquisition*	1.39	5.06	−9.95	28.15
Δ *Score post-acquisition*	0.51	191.4	−10.6	114.4
Log sales level	3.51	5.67	0	15.58
Change Sales Level	0.30	1.72	−9.71	12.15
R&D intensity	3.06	26.05	0	324.98
Pipeline experience	0.36	0.48	0	1
Sales experience	0.23	0.42	0	1
Alliance	0.67	0.29	0	1
Royalty	0.03	0.17	0	1
Desperation Index	0.60	0.26	0	1
Prior acquisition	0.28	0.45	0	1
Stock deal	0.36	0.48	0	1
Cash deal	0.18	0.39	0	1
Contingent contract	0.21	0.41	0	1
Related	0.81	0.39	0	1
Sales force	0.13	0.34	0	1
International	0.24	0.43	0	1

sales-weighted exclusivity horizon. Category IV firms are also experiencing a declining pipeline *Score* value. Of significant interest are the coefficient estimates on x_7 and x_8, which correspond to Categories III and IV of the *Desperation Index*. In Model 2, both Category III and Category IV firms were more likely than Category I firms to engage in an acquisition. Category III firms were 11.41% and Category IV firms were 16.01% more likely to engage in acquisitions. This result suggests that as firms fall from Category III to IV, their probability of engaging in an acquisition increases by approximately 4.6%. In Model 3, when the number of previous alliances indicator variable (*Count*) is removed, the coefficients and resulting probabilities remain fairly stable. Again, Category III and IV firms were more likely than Category I firms to engage in acquisitions. Category III firms were 11.77% more likely and Category IV firms were 16.38% more likely. Model 4 takes two of the desperation categories and combines them into a single indicator variable, *Desperation Index*, which equals one if the firm is either a Category III or IV firm. Using this specification, desperate firms were 13.86 percent more likely to engage in an acquisition than Category I and II firms. These findings support recent work by Danzon et al. (2004). They find a positive relationship between the motivation to merge and a percentage of a firm's drugs that are old and at risk of losing patent protection.

Table 3
Correlation matrix for relevant variables utilized in the following analyses: probit estimation (Table 4); cumulative abnormal return cross-sectional regressions (Table 7); and, post-acquisition cross-sectional regressions (Table 9)

The numbers listed horizontally across the top row correspond to the numbers and variables listed vertically on the table. See Table 1 for variable definitions.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Pipeline experience	1.0000														
2. Sales experience	0.1292	1.0000													
3. Royalty	−0.0669	−0.0260	1.0000												
4. Early stage alliance	−0.0474	0.0306	−0.0007	1.0000											
5. Equity stake	0.0428	0.1841	0.1921	0.2491	1.0000										
6. Desperation Index	0.1373	0.3467	0.0264	0.1888	0.1258	1.0000									
7. R&D intensity	−0.0494	−0.0641	−0.0010	−0.0580	−0.0109	−0.0512	1.0000								
8. Prior acquisition	0.1238	0.2685	−0.0484	0.0824	0.0292	0.2744	−0.0797	1.0000							
9. Stock deal	0.0861	0.0254	0.0017	0.1438	0.1692	0.0284	−0.0821	−0.0446	1.0000						
10. Cash deal	−0.0318	0.1644	0.1162	−0.0871	−0.0896	0.0199	−0.0517	0.0574	−0.3697	1.0000					
11. Free cash flow	0.1975	0.1786	0.0217	0.0689	−0.0064	0.2630	−0.0632	0.2848	−0.0440	0.0527	1.0000				
12. Tobin	−0.0077	−0.0661	−0.0663	−0.0511	−0.0575	0.0763	−0.0224	0.0103	−0.1106	−0.0490	0.1642	1.0000			
13. Log market cap	0.0637	0.2251	−0.0730	0.1195	0.0531	0.4156	−0.1420	0.3667	−0.0447	0.1032	0.5913	0.1421	1.0000		
14. Contingent contract	0.1865	−0.1283	−0.0139	−0.0616	0.1009	−0.1353	0.1784	−0.0415	0.0468	−0.0237	−0.1558	−0.1099	−0.2093	1.0000	
15. International	−0.0318	0.2948	−0.0882	0.0079	0.0369	0.2325	−0.0563	0.1802	−0.0582	0.0431	−0.0024	−0.0058	0.2003	−0.2046	1.0000

Table 4
Probit estimates for our data regress an acquisition indicator (equals 1 if an acquisition took place) on a series of independent variables expected to impact a firm's probability of engaging in an acquisition

The period for this analysis runs from 1994 to 2001. The universe of firms for this analysis includes all firms contained in the Recombinant Capital alliance data set that have pipeline and patented product information available. *Count* is defined as the total number of alliances that the acquiring firm is engaged in on a year-by-year basis. *Desperation Index* Categories III and IV are the most severe levels of firm desperation. The variable *Desperation Index* is an aggregated indicator variable that assumes a value of one if the acquirer is in Category III or IV and is zero otherwise. Φ is the standard cumulative normal distribution. See Table 1 for all other variable definitions. Firm and time effects were included. We use the White (1980) heteroskedasticity-consistent standard errors to compute the appropriate test statistics included in parentheses below the coefficient estimates. We test the model:

$$P(y_{i,t} \neq 0 \mid x_{i,t}) = \Phi(x^1_{i,t} + x^2_{i,t} + x^3_{i,t} + x^4_{i,t} + x^5_{i,t} + x^6_{i,t} + x^7_{i,t} + x^8_{i,t} + x^9_{i,t} + FE + c),$$
$$\partial\Phi/\partial x_i = \phi(\mathbf{xb})b_i.$$

The dependent variable is *Acquisition Indicator*. *** denotes significance at the 1% level; ** denotes significance at the 5% level; and * denotes significance at the 10% level.

Independent variable	Model 1		Model 2		Model 3		Model 4	
	Model 1	$\partial\Phi/\partial x$	Model 2	$\partial\Phi/\partial x$	Model 3	$\partial\Phi/\partial x$	Model 4	$\partial\Phi/\partial x$
x^1: *Change score (pre-acquisition)*	−0.0545	−0.0111						
	(1.91)*							
x^2: *R&D intensity*	0.0016	0.0003	0.0014	0.0003	0.0016	0.0003	0.0012	0.0002
	(1.84)*		(1.98)**		(2.34)**		(1.89)*	
x^3: *Log market cap*	−0.0457		−0.0965	−0.0214	−0.0881	−0.0196	−0.0894	−0.0201
	(1.09)		(2.77)***		(2.83)***		(2.62)***	
x^4: *Count*	0.0086		0.0033				0.0019	
	(0.80)		(0.37)				(0.22)	
x^5: *Desperation Index (Category* I)								
x^6: *Desperation Index (Category* II)			−0.4640		−0.4497			
			(1.44)		(1.39)			
x^7: *Desperation Index (Category* III)			0.4416	0.1141	0.4537	0.1177		
			(2.14)**		(2.24)**			
x^8: *Desperation Index (Category* IV)			0.5668	0.1601	0.5776	0.1638		
			(1.83)*		(1.86)*			
x^9: *Desperation Index*							0.5314	0.1386
							(2.96)***	
c: *Constant*	−0.8285		−0.3479		−0.3874		−0.3867	
	(2.02)**		(1.08)		(1.21)		(1.21)	
Fixed effects	Yes		Yes		Yes		Yes	
N	424		424		424		424	
Pseudo R^2	0.04		0.04		0.05		0.05	
Log likelihood	−122.96		−172.09		−172.17		−173.23	

The results suggest that we might anticipate lower or even negative abnormal returns for acquiring firms at higher levels of desperation. However, we do not find that target firms are able to extract all of the acquiring firm gains, even when the acquirer is particularly desperate to supplement its R&D program.

In unreported regressions we test the robustness of the results to a change in definition of the *Desperation Index*. First, we parse the *Desperation Index* into its two essential component parts (the *Score* and sales-weighted exclusivity horizon). We then use the levels of these variables in the year prior to the acquisition to test whether a firm was more or less likely to engage in an acquisition. In a series of regressions, using the same independent variables as Table 4, we consistently find a negative and significant relationship between our *Score* and *Acquisition* variables. These findings suggest that firms with large *Score* values (or relatively healthy research pipelines) are less likely to engage in an acquisition. Likewise, firms with low *Score* values—or relatively unhealthy research pipelines—were more likely to engage in an acquisition in the following calendar year. The sales-weighted exclusivity horizon variable did not produce the same result. The variable was consistently not significant across the additional specifications. This finding could suggest that the decision to engage in a research-type acquisition is mainly driven by what is happening with a firm's research pipeline and not their sales or revenues. This is consistent with the findings of Danzon et al. (2004).

When we replace the sales-weighted exclusivity horizon with our patent horizon generated from our combination of NERAC and Thomson Derwent data sources we find results similar to those reported in Table 4. Category II was not significant across any specification. Categories III and IV were both negative and significant. Marginal probabilities were slightly larger, on average, than the results we report. Category III firms were around 13% more likely to engage in an acquisition than Category I firms while Category IV firms were around 19% more likely. When we combine Category III and IV firms together in Model 4 the marginal probability increases slightly to 15%. All results using this modified definition of the *Desperation Index* are significant at least at the 5% level.

The analysis produced several other results of note. Firms with greater R&D intensity have a greater propensity to undertake R&D outsourcing acquisitions. This result is consistent with the notion that higher levels of absorptive capacity on the part of research-focused firms are necessary for those firms to incorporate new research into their R&D programs effectively (Cohen and Levinthal, 1989). This view is supported by Chesbrough (2003), who stresses the importance of maintaining internal competencies even while considering the use of outsourced research and development. In addition, we find that smaller firms have a greater tendency to undertake acquisitions. This is demonstrated by the consistently negative and significant coefficient estimates for our log of market capitalization variable in Table 4. This result is consistent with the notion that pharmaceutical R&D programs require increasing economies of scale (Cockburn and Henderson, 1996). For smaller firms to improve the productivity of their research programs, they can engage in R&D acquisitions to increase their scale. Finally, Andrade and Stafford (2004) find that firms with a high Tobin's Q are significantly more likely to undertake both merger and non merger investment. In unreported regressions, we do not find, for the current sample, any statistically significant relation between Tobin's Q and the probability that a firm engaged in an acquisition. High Q firms could engage in non merger investment. However, that question is beyond the scope of the present study.

5.2. Assessing stock market returns

We present univariate *CAR*s against various independent variables in Table 5. We focus on five specific independent variables: the relatedness of the transaction, financing method, alliance activity, sales experience, and research experience. The relatedness of the transaction measures if both the acquirer and target operate within the same therapeutic category. Next, we focus on whether the deal was financed with stock or cash. Mixed

Table 5
Event study estimates evaluating the cumulative abnormal return versus the presence of various independent variables

Type I transactions involve the acquisition of biotechnology research and development; Type II transactions involve the acquisition of general research and development; and Type III transactions involve the acquisition of a mature product along with research and development. *T*-test measures whether each of the subcategories (for the overall sample) is statistically different from each other (difference of the means). *t*-statistics are reported in parentheses. See Table 1 for definitions of variables. *** denotes significance at the 1% level; ** denotes significance at the 5% level; and * denotes significance at the 10% level.

	Overall	*t*-test	Type I	Type II	Type III
Acquirer CAR	3.91%		2.81%	4.29%	5.29%
	(4.95)***		(2.61)***	(2.41)**	(3.27)***
	$N = 160$		$N = 91$	$N = 27$	$N = 42$
Relatedness	3.51%		2.49%	4.00%	4.32%
	(4.24)***		(2.25)**	(2.01)**	(2.88)***
	$N = 130$		$N = 68$	$N = 24$	$N = 36$
Financing		2.19**			
Stock payment	3.87%		3.22%	3.36%	3.71%
	(2.92)***		(2.13)**	(0.68)	(1.67)***
	$N = 58$		$N = 35$	$N = 8$	$N = 14$
Cash payment	2.38%		2.35%	2.24%	4.08%
	(2.47)**		(1.36)	(1.71)*	(1.47)
	$N = 29$		$N = 13$	$N = 7$	$N = 9$
Alliances		2.58***			
Prior alliances	4.30%		4.58%	2.11%	4.22%
	(4.14)***		(3.25)***	(1.39)	(1.82)
	$N = 94$		$N = 54$	$N = 18$	$N = 21$
No prior alliances	3.36%		0.17%	8.65%	6.37%
	(2.73)***		(0.13)	(2.07)**	(2.77)***
	$N = 66$		$N = 35$	$N = 9$	$N = 21$
Sales experience		2.12**			
Prior sales	6.99%		4.28%	4.50%	10.56%
	(3.29)***		(2.19)**	(1.49)	(1.91)*
	$N = 128$		$N = 75$	$N = 17$	$N = 31$
No prior sales	3.08%		2.58%	4.17%	3.43%
	(4.85)***		(2.46)**	(4.36)***	(3.32)***
	$N = 34$		$N = 14$	$N = 10$	$N = 11$
Research experience		2.10***			
Prior experience	5.08%		2.40%	9.08%	12.35%
	(3.71)***		(2.46)**	(4.36)***	(3.32)***
	$N = 103$		$N = 61$	$N = 15$	$N = 25$
No prior experience	3.24%		3.03%	6.95%	0.50%
	(4.52)***		(2.19)**	(1.49)	(1.91)***
	$N = 57$		$N = 28$	$N = 12$	$N = 17$

Table 6
The dispersion of cumulative abnormal returns (*CAR*s) are presented

Following Dodd and Warner (1983), standardized abnormal returns (*SAR*s) are computed by dividing the abnormal return (AR) by its standard deviation. These standardized abnormal returns (*SAR*s) are then aggregated over the number of the days in the event window, k, to generate a cumulative abnormal return.

Magnitude	Number of observed abnormal returns
$CAR \leqslant -15.0\%$	4
$-15.0\% < CAR < -10.0\%$	3
$-10.0\% \leqslant CAR < -5.0\%$	12
$-5.0\% \leqslant CAR < 0.0\%$	41
$0.0\% \leqslant CAR < 5.0\%$	38
$5.0\% \leqslant CAR < 10.0\%$	29
$10.0\% \leqslant CAR < 15.0\%$	17
$15.0\% \leqslant CAR$	16

financing deals were included in the overall sample, but not in this specific analysis, given the inability to attribute any potential *CAR* to a specific financing method. The alliance variable is an indicator that equals one if the acquiring firm had an alliance with the target prior to the acquisition. The sales experience variable is an indicator that equals one if the acquiring firm has patented product sales within the same therapeutic category as the target firm prior to the acquisition. If an acquiring company has a patented product that meets this criterion—we argue that the firm has to have some internal capabilities with respect to products in that therapeutic category because it had to successfully complete clinical testing and the FDA approval process to begin to sell the product. Finally, we include research experience. The research experience variable is an indicator that equals one if the acquiring firm has products in its own pipeline within the same therapeutic category as the target firm. We anticipate that with the presence of prior alliances, sales and research experience should generate greater *CAR*s for acquiring firms. We present four separate specifications: univariate results for the entire sample as well as results for three smaller sub samples. We break the sample into three types. Type I transactions are deals in which a biotechnology firm or technology was acquired. Type II transactions are those deals in which non biotechnology related research and development firms were purchased. Type III transactions are those involving a mature product along with research and development capabilities.

The overall average abnormal return for acquiring firms, using a three-day window, is 3.91% and is significant at the 1% level.[15] Average abnormal returns to target firms were around 16.0%. The returns to the target firms are consistent with previous research. We find similar results across the various sub types of acquisitions. Average abnormal returns for these sub types were 2.81%, 4.29% and 5.29%, respectively. All are significant at the 1% or 5% level. We provide the distribution of the overall average abnormal returns in Table 6. We include several controls to ensure that our results are not being driven by outliers. Table 6 breaks down the individual abnormal returns into magnitude ranges. From this panel, we find that only four *CAR*s are below negative 15.0% while sixteen

[15]Abnormal returns for our robustness measure for acquiring firms was 4.38% and significant at the 1% level. This *CAR* was a combination of results from a three- and five-day window, as discussed in Section 4.2.

*CAR*s are greater than positive 15%. In an unreported plot of the *CAR*s against their frequency, the sample appears to be skewed slightly to the right of zero. No large outliers appear to exist. In addition to Table 6, we performed non parametric tests to determine the sensitivity to outliers.[16]

The extant literature finds that cash-financed transactions generate superior returns than those financed with stock (Andrade et al., 2001). Our findings contradict this result. While cash transactions, on average, produce average cumulative abnormal returns of 2.38%, those transactions financed with equity yielded returns of 3.87%. Both results are significant at least at the 5% level and are also significantly different from each other at the 5% level. Equity payments in these acquisitions could help alleviate the moral hazard problem and align the interests of target-firm employees with those of the acquiring firm. As there is generally a large disparity in size between acquirer and target in terms of market capitalization, acquiring firms need to ensure that target firm managers or scientists remain committed to the overall success of a particular research project as they move from being owners of the firm's research output to employees of the acquirer.

Our next three results examine different types of pre-acquisition information-gathering activities on the part of acquirers: prior alliances, sales experience, and research experience. We find that the presence of each of these activities generates greater abnormal returns for the acquirer. Acquirers that engaged in alliances with the target firm prior to the acquisition generated average abnormal returns of 4.30% versus returns of 3.36% for those firms that did not engage in these types of alliances. Both are significant at the 1% level and are notably different from each other at the 1% level. Acquiring firms that had prior sales experience within the same therapeutic category as the acquisition had substantially greater average abnormal returns than those firms that did not. Firms that had prior sales experienced average abnormal returns of 6.99% while those that did not experienced average abnormal returns of only 3.08%. Both are significant at the 1% level and are significantly different from each other at the 5% level.[17] Finally, acquiring firms that have existing research experience within the same therapeutic category as the target generate greater average abnormal returns, 5.08% versus 3.24%. This result suggests that firms are rewarded for making acquisitions within their existing areas of expertise. Again, both are significant at the 1% level and are measurably different from each other at the 1% level. The presence of each of these activities allows the acquiring firm to learn about the true underlying value of the target. As a result, acquiring firms are able to place a more accurate value on the target firm and generate greater positive abnormal returns for their shareholders. It is also likely that these pre-acquisition information-gathering activities lead to more successful post-acquisition integration.

Cockburn and Henderson (2003) in their study of drug development performance find a strong correlation between the scope of a firm's development efforts and the success

[16]We perform a Wilcoxon signed rank test, which considers both the sign and magnitude of each transaction's cumulative abnormal return. We reject the null hypothesis of zero *CAR* with a *z*-value of 5.692.

[17]A robustness check on a slight change in definition was performed. Currently, the variable includes sales of a patented product for which a firm could only be distributing the product and could have had limited or no involvement in the development of the product. Our alliance data set was utilized in an effort to identify only marketing deals. The relevant therapeutic category for these sales was removed from the acquiring company's list if it had no other sales experience for products that it internally or co-developed within that therapeutic category. We were unable to identify any situations for which this would be necessary. As a result, we are confident in our original measure.

probability of individual projects. Scope is defined by the number of therapeutic categories in which a particular company operated. Our *pipeline experience* and *sales experience* variables are not scope measures. Instead they are a measure of the complementarity between the acquiring and target firm's research and product portfolios. As such, firms undertaking these types of outsourcing of research and development acquisitions are choosing to deepen their existing capabilities versus broadening their overall research scope. The results for our *relatedness* variable support this claim. We find positive average cumulative abnormal returns of 3.51% for acquirers that operate within the same broad therapeutic category as the target firm, as opposed to average cumulative abnormal returns of 2.57% for those firms that do not. In addition to the scope findings, Cockburn and Henderson (2003) conclude that past successes in a therapeutic category were positively associated with successful outcomes of a project. These results were robust across all of their specifications. Our *sales experience* variable is a measure of exactly this. It measures whether a firm has sales of a patented product, which serves an indicator that the firm has experience taking a product in that therapeutic category through the various research phases, within the same therapeutic category as the research being acquired from the target firm. Their finding of a greater likelihood of development success could also provide an alternative explanation for the magnitude of the positive abnormal return on the *sales experience* variable.

5.3. Cross-sectional analysis of abnormal returns

5.3.1. Information-gathering activities

Firms that engage in one of the three pre-acquisition information-gathering activities (alliances, prior sales of patented products and research experience within the same therapeutic category as the target) generate positive abnormal returns for their shareholders. In addition, each of these significantly impacts the overall magnitude of the *CAR*. We report our cross-sectional regression estimates in Table 7. Table 7 presents results for six separate specifications that test a series of independent variables hypothesized to have an impact on the magnitude of the *CAR*, while various attributes of the firm and acquisition deals are controlled. The dependent variable for these regressions is the acquirer three-day *CAR* for each acquisition in our sample. We include three groups of independent variables in our analysis. The first three variables are our pre-acquisition information-gathering activities: prior research and sales experience and alliance activity. Next we have our *Desperation Index* measure and a measure of R&D intensity, defined as research and development expenditures divided by sales. We also include an indicator of whether or not the firm had engaged in any acquisitions in the previous three years. We include two financing variables indicators for cash and equity deals. Three other variables control for various financial characteristics of the acquiring firm: a measure of free-cash flow, Tobin's Q, and the log value of the market capitalization of the acquiring firm. Finally, dummies are included if the acquiring firm was based outside of the United States and if there was a contingent contract present in the deal.

Across the first four specifications we find mixed support for the pipeline experience variable. The coefficient ranges between 0.0184 and 0.0249 and is significant only once at the 10% level. Prior pipeline research (firms with products identified in the NDA pipeline) within the same therapeutic category as target firm positively impacts the overall

Table 7
Cross-sectional regression estimates and independent variables from regressing the cumulative abnormal return (*CAR*) on selected independent variables for 160 announcements of acquisitions relating to the outsourcing of research and development

*CAR*s are from the three-day event window. The period for this analysis runs from 1994 to 2001. Year fixed effects are included in all specifications. The White (1980) heteroskedasticity-consistent t-statistics are reported in parentheses. See Table 1 for variable definitions. *** denotes significance at the 1% level; ** denotes significance at the 5% level; and * denotes significance at the 10% level.

The dependent variable is *Acquirer CAR*

Independent variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Pipeline experience	0.0249	0.0227	0.0184	0.0211		
	(1.73)*	(1.11)	(1.24)	(1.14)		
Sales experience	0.0565	0.0527	0.0544	0.0529	0.0557	0.0408
	(3.01)***	(2.89)***	(3.12)***	(2.93)***	(3.12)***	(2.65)***
Alliance	0.0348	0.0374	0.0396	0.0347	0.0321	0.0355
	(3.21)***	(3.28)***	(3.11)***	(3.59)***	(2.99)***	(2.67)***
Desperation Index	−0.0442	−0.0428	−0.0436	−0.0406	−0.0362	
	(2.41)**	(2.34)**	(2.42)**	(2.24)**	(2.26)**	
R&D intensity	0.0003		0.0004			
	(0.91)		(0.95)			
Prior acquisition	−0.0211	−0.0204	−0.0185	−0.0204	−0.0174	−0.0219
	(2.34)**	(2.31)**	(2.17)**	(2.31)**	(2.12)**	(2.41)**
Stock deal	−0.0117	−0.0069				
	(0.65)	(0.42)				
Cash deal	−0.0202					
	(0.99)					
Free-cash flow	−0.0005	−0.0041		−0.0040		
	(0.41)	(0.39)		(0.45)		
Tobin	0.0003	0.0002		0.0002		−0.0002
	(1.14)	(0.11)		(0.11)		(0.11)
Log market cap	−0.0024	−0.0031	−0.0035	−0.0028	−0.0041	−0.0057
	(0.45)	(0.62)	(0.98)	(0.56)	(1.22)	(1.73)*
Contingent contract	0.0036					
	(0.16)					
International	0.0108	0.0085	0.0159			
	(0.66)	(0.54)	(0.75)			
Constant	0.0576	0.0591	0.0528	0.0535	0.0711	0.0816
	(1.39)	(1.58)	(1.77)*	(1.38)	(2.43)**	(2.86)***
N	155	155	160	155	160	155
R^2	0.26	0.25	0.22	0.24	0.22	0.22
F-statistic	2.78	2.64	2.91	2.87	3.12	2.58

magnitude of the *CAR*. In this case, firms are positively rewarded for buying what they know.

Having prior sales experience, our proxy for FDA approved products, within the same therapeutic category as the target firm also positively impacts the magnitude of the *CAR*. We find strong evidence for this result across all six model specifications. Furthermore, the coefficient remains fairly stable and is significant at the 1% level. In addition to having the research capabilities for a specific therapeutic category, having sales experience and as a result having a product approved by the FDA demonstrates that the particular acquiring

pharmaceutical firm has experience in taking that specific category of product through the formal FDA approval process. Phase III testing (human clinical trials) and the FDA approval process are expensive and time-consuming. Firms have a clear advantage in taking new products into this process for which they already hold some experience. In addition, the introduction of a new product within an existing therapeutic category would require less time to train sales professionals and generate a new market than would a new class of products. Again, these results imply that acquiring firm shareholders are being rewarded for staying within areas in which they are already experts.

Alliance experience with the target firm prior to an acquisition positively impacts the magnitude of our *CAR* values across all specifications considered. Results ranged from 0.0321 to 0.0396 and were significant at the 1% level. On average, there were four alliances between the firms prior to the acquisition. Presumably this prior contact should provide learning opportunities for the acquiring firm resulting in a more appropriate valuation being placed on the target firm. These positive impacts are consistent with Chan et al. (1997) and Porrini (2004).

Next, we look at the impact that the level of desperation has on the *CAR*. We find, across five of the six model specifications, a negative impact on the overall magnitude of the *CAR*. Results are significant at the 5% level. More important, while the presence of firm level desperation negatively impacts the magnitude of the *CAR*, the overall *CAR* for these desperate firms remains positive. The overall average abnormal return for the entire sample is 3.91%. Performing a univariate analysis similar to those in Table 5, the average abnormal return for the most desperate firms was 1.73%, significant at the 10% level. This suggests that even the most desperate firms are still able to employ pre-acquisition information-gathering activities to generate positive value for their firm's shareholders. The lower abnormal returns for these firms could be attributable to such factors as a lower internal required rate of return for the acquiring firm in addition to the less favorable negotiating position vis-à-vis target firms.

Of the remaining independent variables, R&D intensity, stock deal, cash deal, free-cash flow, Tobin's *Q*, contingent contracts, and an international indicator, none is significant at any reasonable level across six specifications. However, acquiring firms experience a negative impact on their *CAR* if they engage in an acquisition within the three years prior to the current acquisition. This result is negative and significant at the 5% level across all six specifications. This finding is in contrast to Fuller et al. (2002). One reason for the difference could be that the market is penalizing companies that engage in either multiple acquisitions or a program of acquisitions in an effort to grow their R&D business. The market could perceive this type of firm as having a weak internal research and development program that is unable to develop new projects independently. Because new product development is the life-blood of any pharmaceutical firm, companies that are unable to produce potential products internally could be at a competitive disadvantage. Another reason for the difference may be the selection of firms analyzed. Whereas this study focuses solely on the pharmaceutical sector, the same sector only totaled 1.3% of the total firms analyzed in their study.

In additional unreported regression specifications, the public status of the target firm had no significant statistical impact on the magnitude of the cumulative abnormal return. This finding, in contrast to the extant literature, suggests that a private company discount does not exist in the current study. One of the justifications for the private company discount is the difficulty in valuing a company. This lends support to our argument that

acquiring firms are able to use pre-acquisition information-gathering activities to lessen the uncertainty as to the underlying value of the target firm.

5.3.2. Sensitivity analysis

Additional specifications were tested to ensure the robustness of our main findings to changes in definitions. Repeating our procedure we parse the *Desperation Index* into its two main components, the *Score* and sales-weighted exclusivity horizon. In the first series of regressions we tested the levels of these two variables in the year prior to the acquisition. *Score*, the weighted measure of the health of a firm's research pipeline, while positive was not significant in the additional specifications. This would seem to suggest that a firm's pipeline status in the year prior to an acquisition has little impact on the abnormal returns generated over the three-day event window. We found previously, however, that *Score* played a significant role in the probability that a firm actually engaged in an acquisition. In contrast, we found both positive and significant results for our sales-weighted exclusivity horizon. We removed the exclusivity weighting and tested real sales and found similar results. Finally, we removed the sales data completely and used just a straight measure of the number of exclusivity years remaining in a firm's portfolio. Again, we found positive and significant results. These findings are all consistent with our findings on *Desperation Index* in Table 7. The desperation level of a firm negatively impacts the magnitude of its *CAR*.

Given the potential pitfalls of using exclusivity as an adequate measure of the health of a firms patented product portfolio we employ additional measures. First, in an attempt to control for some of the gaming that could take place to garner additional years of exclusivity, for example, by engaging in patent litigation, we add 30 months of exclusivity onto each product in their last year of exclusivity if the drug had at least \$100 million in revenues.[18] Arguably a company would not engage in the expense of patent litigation if the marginal benefit of doing so was less than the marginal cost. We find across various specifications a positive and significant (at the 5% level) impact on the magnitude of the *CAR*. Again, this finding is consistent with our reported *Desperation Index* findings in Table 7.

We next remove the exclusivity variable and replace it with our patent data variable constructed from NERAC and Thomson Derwent to test robustness of our results across differing legal protections. Our findings are mixed. The coefficient remains positive, consistent with the exclusivity findings; however, the variable is only significant at the 10% level in a limited number of specifications. This finding only suggests a real potential difference between the impact a firm's patent profile and a firm's exclusivity profile has on the magnitude of the *CAR*. Because this variable serves as an upper-bound measure, these results could be a function of the way the variable is constructed.

5.4. Cross-sectional analysis of post-acquisition success measures

In addition to the abnormal returns result, we find positive changes to the acquiring firm's *Score* value and product sales figures in the year following the acquisition. The *Score* value for a firm is a weighted measure of the health of a firm's research pipeline. An

[18]This process was repeated for drugs with \$50 million and \$75 million in revenues in the final year of exclusivity.

Table 8

Panel A: *distribution of acquiring firms across desperation categories*
Changes in *Desperation Index* pre- and post-acquisition. Classifications are as follows: Category I indicates firms with increasing or constant score values and increasing weighted sales; Category II indicates firms with increasing or constant score values and decreasing weighted sales; Category III indicates firms with decreasing score values and increasing or constant weighted sales; and, Category IV indicates firms with decreasing score values and decreasing weighted sales. Category I firms are less desperate than those firms in Category IV. 94 firms (59%) improved their level of desperation. 19 firms (12%) had their level of desperation remain constant. 47 firms (29%) had a worsening of their level of desperation.

Pre-acquisition			Post-acquisition		
Category	Frequency	Percent (%)	Category	Frequency	Percent (%)
Category I (least desperate)	17	10.63	Category I	36	22.50
Category II	47	29.38	Category II	72	45.00
Category III	24	15.00	Category III	33	20.63
Category IV (most desperate)	72	45.00	Category IV	19	11.88

Panel B: *distribution of acquiring firms across various post-acquisition measures*
Changes in sales and pipeline score values in the calendar year following the acquisition. The *Score* value is a proxy for the overall health of a firm's research pipeline. An increase in score value would signal that the firm's pipeline has strengthened. Δ *Score* is defined as $score_{t+1} - score_t$,. Δ *Sales* is defined as $sales_{t+1} - sales_t$.
Classifications are as follows: Category I indicates firms with increasing or constant score values and increasing weighted sales; Category II indicates firms with increasing or constant score values and decreasing weighted sales; Category III indicates firms with decreasing score values and increasing or constant weighted sales; and Category IV indicates firms with decreasing score values and decreasing weighted sales. Weighted sales values are log values of 1999 constant dollars.

Variable and category	Number of firms	Mean	Standard Deviation	Minimum	Maximum
Δ *Score*					
Category I	36	116.91	167.14	0	636.2
Category II	72	40.83	142.34	0	1143.8
Category III	33	−173.10	228.06	−1059.6	−3
Category IV	19	−71.34	66.07	−273.6	−3
Δ *Sales*					
Category I	36	1.0966	2.4109	0.2436	10.82
Category II	72	−0.2784	1.4465	−9.7067	−0.0067
Category III	33	0.4872	1.5877	0	6.5853
Category IV	19	−0.8373	3.2896	−14.345	−1.5194

increase in the *Score* value of a firm after an acquisition is suggestive of improvements to the underlying pipeline. We show the distribution of firms across the various levels of desperation, both pre- and post-acquisition, in Table 8. As presented in Panel A of Table 8, 94 firms or 59% of the firms in our sample improved their level of desperation through the use of acquisitions. This means that in the year following an acquisition, acquiring firms moved from one of the four levels of desperation to a less desperate level. In other words, through the use of acquisitions, firms are able to increase either their score value or weighted sales or both. Another 19 firms or 12% of firms maintained their level of

desperation. In total, 71% of firms either improved or maintained their level of desperation.

Panel B presents the average change in sales and score values for the distribution of desperation categories post-acquisition. This panel suggests that firms that were able to improve their level of desperation in Category I (least desperate) or Category II were most successful in adding to their underlying research score value. As shown in Panel A, 67.50% of firms fell into one of these two categories post-acquisition. The average change in *Score* value for a Category I firm (least desperate) post acquisition is positive, while the average change in *Score* value for a Category IV firm (most desperate) is negative. Moreover, the average change in sales for Category I firms was positive, while the average change in sales for Category IV firms was negative. The post-acquisition change in product sales needs to be viewed cautiously. As most research is acquired while still in phase testing, the sales impact is not felt until some time in the future. The more important result, we feel, is the post-acquisition change in the *Score* value given that this is a direct measure of the health of a firm's research portfolio.

Pisano (1991) suggests that acquisition of biotechnology firms can be a dangerous strategy particularly when acquisitions are used to overcome a weakness in internal capabilities. We find consistent with Chesbrough (2003) that this is not always the case. Table 9 presents cross-sectional regression results for these post-acquisition measures. The change in *Score* value ($score_{t+1}-score_t$) and change in product sales ($sales_{t+1}-sales_t$), respectively, are used as dependent variables. For both regression models we present five separate specifications. We include and test a variety of independent variables that we feel have an impact on the two dependent variables. We find in the first regression model (Δ*Score post-acquisition* is the dependent variable) that the coefficient on the variable *Desperation Index* is positive and significant at least at the 5% level. This result suggests that desperate firms are experiencing positive post-acquisition changes to their *Score* value through the use of acquisitions. As the *Score* value is a measure of pipeline health, these improvements justify the use of acquisition activity as a tool to help improve the research portfolio of the firm. The next regression model (Δ *Sales post-acquisition* is the dependent variable) focuses on the post-acquisition changes in product sales. Again, these results need to be viewed with caution because many of the acquisitions contained products are still in various stages of phase testing. As a result, the financial impacts of their presence may not be realized until some period in the future, likely greater than one year after an acquisition. Some acquiring firms, however, did purchase either mature products along with research capabilities or products in late-stage or FDA approval process. Again, the coefficient on the variable *Desperation Index* is positive and significant. Desperate firms that included these types of products in their acquisition were able to positively impact their post-acquisition change in product sales. Firms that acquired a sales force as part of the acquisition showed positive changes to their post-acquisition change in sales. This result implies that target firms that had a sales force present also had products generating some type of revenue. As such, it is not surprising that the acquiring firm experienced a positive change in post-acquisition sales.

6. Conclusion

The pharmaceutical industry is characterized by large amounts of research and development. It is also an industry dependent upon that research to be productive and

Table 9
Cross-sectional regression estimates and independent variables from two separate regressions are reported

First, Δ *Score*, defined as $score_{t+1} - score_t$, is regressed on a series of independent variables thought to have an impact on the firm's underlying research portfolio. Second, Δ *Sales*, defined as $sales_{t+1} - sales_t$, is regressed on a series of independent variables thought to have an impact on the firm's underlying weighted sales. The period for this analysis runs from 1994 to 2001. The White (1980) heteroskedasticity-consistent *t*-statistics are reported in parentheses. See Table 1 for variable definitions. *** denotes significance at the 1% level; ** denotes significance at the 5% level; and * denotes significance at the 10% level.

Dependent variable	Independent variables	Mode 1	Model 2	Model 3	Model 4	Model 5
Δ *Score post-acquisition*	*R&D intensity*	−0.0357	−0.1566	−0.1910	−0.2131	−0.0041
		(0.35)	(1.63)	(2.02)**	(2.38)**	(0.40)
	Pipeline experience	40.883	32.041	38.200		
		(1.41)	(1.09)	(1.23)		
	Sales experience	57.169	73.316			
		(1.14)	(1.44)			
	Desperation Index	68.592	58.326	64.637	64.857	77.116
		(2.10)**	(1.80)*	(1.94)*	(1.94)*	(2.42)**
	Free-cash flow	−0.0641	−0.0373	−0.0301	−0.0262	−0.0574
		(1.65)*	(1.10)	(0.84)	(0.71)	(1.40)
	Tobin	−2.476		−2.104	−2.339	
		(0.73)		(0.83)	(0.98)	
	Log market cap	19.784				20.356
		(2.46)**				(2.51)**
	Constant	−176.25	−46.119	−30.651	−18.081	−169.80
		(3.14)***	(1.70)*	(0.96)	(0.64)	(3.06)*
N		155	155	155	155	155
R^2		0.12	0.08	0.06	0.05	0.09
F-statistic		13.41	17.76	16.10	20.37	23.02
Δ *Sales post-acquisition*	*R&D intensity*	0.0011				
		(1.08)				
	Pipeline experience	0.7572	0.7596	0.7257	0.5264	0.5098
		(2.18)**	(2.19)**	(2.10)**	(1.32)	(1.32)
	Sales experience	−0.2547	−0.2303			
		(0.57)	(0.52)			
	Desperation Index	0.6012	0.6143	0.5713	0.5742	0.5841
		(1.67)*	(1.71)*	(1.78)*	(1.73)*	(1.80)*
	Free-cash flow	−0.0059	−0.0006	−0.0005		
		(1.43)	(1.51)	(1.59)		
	Tobin	−0.0322			−0.0435	
		(0.72)			(1.06)	
	Log market cap	−0.0456	−0.0397		−0.1003	−0.1041
		(1.32)	(0.35)		(1.32)	(1.42)
	Sales force	1.4304	1.3800	1.3027	1.4068	1.3618
		(2.11)**	(2.11)**	(2.13)**	(2.10)**	(2.09)**
	Constant	−0.5992	−0.6622	−0.3994	−0.3017	−0.1675
		(1.24)	(1.41)	(1.36)	(0.60)	(0.36)
N		155	155	155	155	160
R^2		0.15	0.15	0.15	0.11	0.10
F-statistic		1.74	1.86	2.31	1.65	2.04

generate revenues to finance future research. As such, the protection and health of a firm's research pipeline is of paramount importance. Managers are faced with several options on how to go about replenishing that research pipeline. In this paper, we have sought to understand how pharmaceutical companies have employed acquisitions in an effort to combat deteriorating research pipelines and declining patented product portfolios. For acquisitions characterized by information asymmetries, we find evidence consistent with the proposition that acquirers are able to avoid the winner's curse. Specifically, we find a positive and significant correlation between acquirer returns and pre-acquisition information-gathering activities. We also find, on average, that companies experiencing a deterioration of their research pipeline and product sales were more likely to engage in an acquisition. Moreover, these firms were either able to stabilize or to reverse the pipeline declines that they were experiencing.

We believe considerable opportunities exist for further empirical research into these issues. It would be of interest to see if these results generalize across other high-tech industries; for example, the software industry. In this project, we employed a broad view of firm level research activities being undertaken by pharmaceutical firms. Extensions of the current analysis such as tracking research further into the future post-acquisition should yield additional important insights. Finally, exploring more fully how firms employ alliances to complement internal research programs should be a rewarding area for future research.

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