Mergers and Acquisitions in the Pharmaceutical and Biotech Industries

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Abstract:

This paper examines the determinants of M&A activity in the pharmaceutical-biotechnology industry and the effects of mergers using propensity scores to control for merger endogeneity. Among large firms, we find that mergers are a response to excess capacity due to anticipated patent expirations and gaps in a company's product pipeline. For small firms, mergers are primarily an exit strategy for firms in financial trouble, as indicated by low Tobin's q, few marketed products, and low cash-sales ratios. Conversely, small firms with a relatively high Tobin's q, a large number of marketed products, and high cash/sales ratios are less likely to engage in any M&A activity.

We find that it is important to control for a firm's prior propensity to merge. Firms with relatively high propensity scores experienced slower growth of sales, employees and R&D regardless of whether they actually merged, which is consistent with mergers being a response to distress. Controlling for a firm's merger propensity, large firms that merged experienced similar changes in enterprise value, sales, employees, and R&D relative to similar firms that did not merge. Merged firms had slower growth in operating profit in the third year following a merger. Thus mergers may be a response to trouble, but they are not an effective solution for large firms. Neither mergers nor propensity scores have any effect on subsequent growth in enterprise value. This confirms that market valuations on average yield unbiased predictions of the effects of mergers. Small firms that merged experienced slower R&D growth relative to similar firms that did not merge, suggesting that post-merger integration may divert cash from R&D.

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I. Introduction

The pharmaceutical-biotechnology industry has become increasingly concentrated over the past 15 years; in 1985 the 10 largest firms accounted for about 20 percent of worldwide sales, whereas in 2002 the 10 largest firms accounted for 48 of sales. Much of this consolidation is the result of mergers. The value of M&A activity in this industry exceeded $500 billion during the 1988 to 2000 period. A commonly cited rationale for this consolidation by proponents of these mergers is the existence of economies of scale in research and development (R&D) and in sales and marketing. However, despite rising R&D spending the productivity of the pharmaceutical industry, as measured by the number of compounds approved by the Food and Drug Administration (FDA) has deteriorated since 1996. Furthermore, the number of new drugs entering clinical trials has declined since 1998, which calls into question the effectiveness of mergers and the economies of scale hypothesis more generally. Moreover, several of the largest pharmaceutical firms have been trading at significantly lower price-to-earning ratios than many of their smaller rivals, indicating investors believe the larger firms will experience lower growth rates.

In this paper, we first examine the determinants of merger and acquisition (M&A) activity in the pharmaceutical- biotechnology industry during 1988-2001. We then examine the impact of merger on growth in two major cost categories -- employment and R&D investment – and on several measures of firm performance: growth in sales, operating profit and market value. In the first stage of our model, we test several reasons why firms would merge based on existing literature (Jensen, 1986; Holmstrom and Kaplan, 2001): economies of scale or scope; specific assets or capacities (for example, new technologies or foreign subsidiaries) that can be acquired more efficiently than through internal growth; self-serving expansion by managers with excess cash and imperfect agency controls; and the market for corporate control, in which acquisition is a mechanism to transfer assets to more efficient uses and/or management.

Our analysis of determinants and effects of mergers distinguishes between small biotech firms and large pharmaceutical firms, since they face very different production and cost functions. In particular, we test a variant of the excess capacity theory of mergers that is most relevant to mergers involving large

firms, specifically, that patent expirations and gaps in a firm's pipeline of new drugs makes current levels of human and physical capital potentially excessive. Previous literature has suggested that excess capacity may be a rationale for merger to restructure asset bases in industries that experience shocks due to technological change or deregulation. In the pharmaceutical industry, this capacity-adjustment motive for merging occurs because of the patent-driven nature of a research-based pharmaceutical firm's sales. Essentially, a fully-integrated pharmaceutical firm has two production activities. The first is R&D, which uses inputs of labor, capital, and various technologies to develop new drugs and perform the clinical trials that are required for regulatory approval.[1] R&D investment is substantial but by itself generates no revenue, and is characterized by a high degree of ex ante uncertainty regarding the ultimate safety, efficacy, and market potential of individual compounds. The second activity is production, marketing and sales, for which approved compounds, obtained from internal R&D, in-licensing or acquisition, are an essential input. Patent protection on new drugs on average lasts for roughly 12 years after market approval. Once the patent expires, generic competitors usually enter and rapidly erode the originator firm's sales.[2] Since a few blockbuster drugs often account for 50 percent or more of a firm's revenues, patent expiration on one or more of these compounds can decimate the firm's revenues within a few months, unless the firm can replace the patent-expired compounds with new compounds. Thus if a firm is faced with patent expirations and has failed to generate or in-license new compounds to replace them, its investment in specialized labor and capital in the sales and marketing functions becomes unproductive. Since large firms finance their R&D almost exclusive from current earnings (Vernon, 2002), patent expirations can also disrupt the funding of R&D.

For an integrated company that faces patent expirations and gaps in its pipeline of follow-on products, merging with a firm that has a pipeline but lacks adequate marketing and sales capacity to

[1] Compounds must demonstrate safety and efficacy in human clinical trials, in order to obtain marketing approval from the FDA in the US or similar regulatory agencies in other countries. In the US, roughly 4 out of 5 drugs fail in clinical trials, and some are withdrawn post launch if adverse events occur once on the market. Taking a compound through discovery, development and regulatory approval takes on average 12 years.

[2] Recent experience is that generics take over 80% of prescription volume within the first year of patent expiration, due to their much lower prices and strong incentives of patients and pharmacists to substitute generics.

optimally launch its own drugs may create value. Merger may also offer the potential for cost reductions in administration and possibly other duplicative functions, thereby offsetting the negative effect of declining revenues on net profits and generating economies of scale in the longer run. Although a pharmaceutical firm that faces excess capacity due to lack of compounds could reduce staff and sell assets without merging, we hypothesize that this would entail loss of quasi-rents on investments in firm-specific human and physical capital, if this capital has specialized skills and the compound shortfall is expected to be transitory (Oi, 1962). The loss of quasi-rents may be relatively small if the cuts are made in the context of a merger that brings in some new compounds and facilitates restructuring that permits the elimination of some duplicative functions and selection of the best people for those jobs remain.[3]

The excess capacity motive for mergers is less relevant for small firms that have yet to establish a substantial sales and marketing function and typically have no patented drugs to sell. Since the 1980s, new drug discovery technologies have led to the emergence of hundreds of new biotechnology firms, mostly specializing in drug discovery or associated technologies. The most successful have evolved to become fully integrated firms that compete with traditional pharmaceutical firms. Most traditional pharmaceutical firms were initially slow to adopt the new technologies, but have since adopted them through a range of different mechanisms: outright acquisition, purchase of a majority equity stake in biotech firms, and more limited product and platform-specific alliances for drug development and marketing. In addition, biotech firms engage in significant biotech-biotech mergers and alliances. We hypothesize that for these smaller, R&D-focused firms, merger is more likely to be motivated by growth motives. Since the relevant products and technologies are usually patent-protected and the human capital is highly specialized, acquiring a firm that owns complementary assets may be cheaper than trying to develop needed assets in-house. Conversely, being acquired can be an attractive exit strategy for a small firm. Since these smaller firms represent almost half of our sample, we separately examine the

[3] According to a survey of U.S. pharmaceutical firms conducted in 2000, 35 percent of personnel were in marketing, 22 percent in production and quality control, 21 percent in R&D, 12 percent in administration, and 10 percent in other functions (Pharmaceutical Industry Profile, PhRMA, 2002).

determinants of mergers and the impact of mergers for large and small firms, measuring size by sales and market value.

In the second stage of our model, we examine the impact of mergers on subsequent corporate performance. Most event studies of mergers, based on abnormal returns around the announcement date, conclude that mergers create shareholder value, with most of the gains being captured by the target firm (Andrade, Mitchell, and Stafford, 2001; Pautler, 2003; Ravenscraft and Long, 2000). However, there is no consensus regarding how this value is created or on whether the expectations are actually realized in the longer term. Estimating the effect of mergers simply by comparing performance of merged firms to an industry mean for non-merged firms may be biased if a firm's decision to engage in an acquisition is not random, but is related to expected future performance, as confirmed by our first-stage results. In particular, if firms that anticipate poor earnings growth, due to patent expirations or other pipeline shocks, are more likely to merge than firms with strong growth prospects, then the subsequent performance of the merged firms may be inferior to that of the non-merged firms, but still better than it would have been in the absence of merger. We therefore use a propensity score method to control for ex ante observable firm characteristics in estimating the effects of merger.[4]

We find evidence supporting our hypothesis that for large firms mergers are, in part, a response to expectations of excess capacity that will decrease labor productivity. Large firms with a relatively low Tobin's q (the ratio of the market to book value of a firm's assets), and thus firms with a low expected growth rate of cash flows, are more likely to acquire other firms. When we also include a variable measuring the percentage of a firm's drugs that are old and at risk of losing patent protection, which is a more direct measure of expected excess capacity than the Tobin's q, the coefficient on the "drug age" variable is positive and significant and the Tobin's q coefficient remains negative but is insignificant. This confirms that the anticipation of patent expirations and the associated shock to revenues and excess labor capacity is a significant motive for acquisition. Relatively large firms, as measured by market value, are more likely to acquire another firm, be acquired, and be involved in a pooling merger. This suggests

that if achieving economies of scale is a rationale for merging, firms perceive that optimum firm size is larger than the mean size in our large-firm sample. Firms that experienced a relatively large increase in operating expenses between t-3 and t-1 were more likely to be involved in a pooling merger. This is consistent with the hypothesis that merging may be a useful context for eliminating excess costs. It might also be consistent with the hypothesis that mergers transfer assets to firms with (more) competent management. In theory, acquisition rather than pooling would be a more effective mechanism for transferring control, since an acquisition leaves no doubt as to who is in charge. However, given the perceived accounting advantages of the pooling approach to merger, it may still be optimal to implement such acquisitions through a pooling merger rather than an outright acquisition.

For relatively small firms (firms with at least $20 million in sales for at least one year between 1988 and 2000 but with an enterprise value less than $1 billion), our results suggest that firms that are financially weak are at risk of being acquired. Financially strong firms (as measured by relatively high Tobin's q, number of marketed drugs and high ratio of cash to sales), on the other hand, are more likely not to engage in M&A at all.

Our results strongly confirm the importance of controlling for the likelihood that firms will merge when measuring the impact of a merger on a firm's subsequent performance. If we assume mergers are exogenous, we would conclude that merged firms have low growth rates of sales and R&D expenditures in the first year following a merger, relative to firms that do not merge. However, firms with a high propensity of merging experience low growth rates of sales, employees, and R&D expenditures in the subsequent one, two, and three years, regardless of whether they actually merge. When we control for the propensity to merge, mergers have very little effect on a firm's growth in sales, employees, R&D expenditures, and enterprise value for large firms. For a firm with the mean propensity to merge, a merger is predicted to reduce the operating profit by 52.3 percent in the third year following a merger relative to an otherwise similar firm that did not merge. This suggests that post-merger integration may absorb more resources and managerial effort than anticipated by most managers.

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[4] See Dranove and Lindrooth (2003) for a similar approach to measuring effects of hospital mergers.

We find that small firms with high propensity scores experienced relatively low growth in employees and R&D regardless of whether they merged, consistent with the earlier finding that strong firms tend not to engage in M&A. Mergers were not an effective growth strategy for firms with the mean propensity of merging. For such a firm, we predict that a merger would result in a 29 percent reduction in R&D in the first full year following a merger relative to an otherwise similar firm that did not merge. This indicates that resources may be diverted from R&D immediately post-merger. Conversely, a merger is predicted to increase employees and R&D by 21 percent and 30 percent, respectively, in the first full year following a merger for a firm with a very high propensity score relative to an otherwise similar firm that did not merge. Thus, firms that faced the greatest distress appeared to grow following a merger, possibly because the merger provided access to financial resources that these small firms lacked.

II. Existing M&A Literature and Pharmaceutical Biotech Experience

A significant body of economic research has examined the reasons for mergers and their effects -- whether mergers add, destroy or merely redistribute value. Economic theory suggests several, not mutually exclusive reasons for mergers, including economies of scale and scope, acquisition of specific assets, and the market for corporate control. These general theories have difficulty explaining the fact that mergers have historically occurred in waves, with a particular wave often concentrated in specific industries. To explain these waves, several authors have suggested shocks, due to such factors as technological advances or deregulation, that are often industry specific and create excess capacity or other inefficiencies in the current configuration of resources, which can account for within-industry correlations in timing of merger activity (for example, Hall, 1999; Andrade, Mitchell and Stafford, 2001). These studies shed some light on causes of cross-industry variation in merger activity but they do not address within-industry variation.

Assuming that mergers are intended to create value, there is no consensus regarding how this value is created or on whether the expectations are actually realized in the longer term. In a recent review of empirical evidence on mergers, Andrade, Mitchell and Stafford (2001) report a quasi difference-in-

differences estimate of operating margin before and after merger, for merged firms versus the industry average. They conclude that "mergers improve efficiency and that the gains to shareholders at announcement accurately reflect improved expectations of future cash flow performance. …. (But) The underlying sources of gains from mergers have not been identified."

Hall (1999) analyzes a sample drawn from all manufacturing firms that exited between 1957 and 1995. She uses a Cox proportional hazards model, treating merger, going private and bankruptcy as competing risks for methods of exit and separate logit models for probability of acquiring or being acquired. She finds that in general firms that were acquired by other public firms do not differ significantly from firms that remained independent. For the sample as a whole, there is no significant effect of mergers on R&D investment, but for firms with the highest propensity to merge, those that did merge experienced more rapid post-merger growth than those that did not merge.[5] In previous work on an earlier sample without controlling for pre-merger characteristics (propensity to merge), Hall found little effect of mergers on R&D; however, leverage was negatively related to R&D, even if no merger was involved (Hall, 1988). She interprets this as evidence against economies of scale in R&D and in favor of some substitution between leverage and R&D.

Like many other industries, the pharmaceutical industry experienced a high rate of M&A activity in the 1980s and 1990s. Most of the leading firms in 2003 are the result or one or more horizontal mergers -- for example, Glaxo-SmithKline's antecedents include Glaxo, Welcome, SmithKline French and Beecham; Aventis is the cross-national consolidation of Hoechst (German), Rhone-Poulenc (French), Rorer, Marion, Merrill, Dow (all US); Pfizer is the combination of Pfizer, Warner-Lambert, and Pharmacia, which included Upjohn. Only three of the top US companies have been not been involved in major horizontal acquisitions in the last 15 years. The 10-firm concentration ratio based on global sales has increased from 20 percent in 1985 to 48 percent in 2000. Hall (1999) cites the pharmaceutical

[5] Hall (1999), following Rosenbaum and Rubin (1983), constructs a cohort of merged firms and a matched cohort of firms that did not merge but that were similar in their predicted probability of merging, based on a logit regression (other forms of exit are included in the non-merger group?) The difference in differences in R&D growth of these two cohorts is used to estimate the effects of merger. The test is based on medians and other distribution-free tests.

industry as an exception to the norm of restructuring driven by excess capacity and low market value-to-book value ratios (Tobin's q).

Horizontal pharmaceutical mergers are often rationalized by claims of economies of scale and scope in R&D and in marketing. The pharmaceutical industry is research-intensive, with an average R&D to sales ratio of 18 percent, compared to 4 percent for US manufacturing industry overall (PhRMA). The growth in market share of large firms offers survivor evidence consistent with the hypothesis of scale economies in at least some functions. Understanding the effects of merger on firm performance and on R&D intensity and productivity is thus of particular interest. Ravenscraft and Long (2000) performed an event study of 65 pharmaceutical mergers that occurred between 1985 and 1996 and found abnormal stock returns around the announcement date of 13.3 percent for the target firm, -2.1 percent for the bidding firm, but not significantly different from zero for the combined firm, averaging over all mergers. However, for large horizontal mergers and cross-border mergers, the combined abnormal returns were positive, indicating that shareholders expected these mergers to create value.[6] Ravenscraft and Long show that target firms experienced negative cumulative stock return in the 18 months prior to merger, compared to an index of non-merging pharmaceutical firms; however, they do not examine in detail the determinants of mergers or the actual post-merger performance of the firms in their study.

Most prior studies of M&A have focused on outright acquisitions that result in the exit of the target firm. However, outright acquisition or merger is one extreme variant of the range of acquisition activity in the pharmaceutical industry. Since the 1980s, new drug discovery technologies have spawned a range of different pharmaceutical-biotech and biotech-biotech relationships from outright acquisition to purchase of a majority stake (e.g,, Roche-Genentech) to product-specific drug development and marketing alliances (e.g., Bayer-Millenium). This continuum of activity makes the definition of a merger/acquisition somewhat arbitrary. Here we focus on "transforming mergers", defined as acquisitions that would require significant reorganization by the acquirer in order to integrate the target.

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[6] The remaining categories were partial, hostile and vertical acquisition.

Empirically, we define a transforming merger as an acquisition where the value either exceeds $500 million or exceeds 20 percent of the market value of the buying and/or selling firm.[7]

Table 1 reports the number of unique transforming mergers by year between 1988 and 2000 for our sample of biotech and pharmaceutical firms.[8] There were a total of 165 transforming mergers during this period, accounting for cumulative acquisitions of over $500 billion dollars (in 1999 dollars). The number of transforming mergers and the market value of the mergers increased throughout the 1990s. Six percent of firms were involved in a merger in a year, on average, and the price of a merger represented 33 percent of the buying firm's market value.

Several standard economic hypotheses appear relevant to understanding the pharmaceutical-biotech merger experience. Pharmaceutical acquisitions of biotech companies are consistent with an asset-specific motive, while the cross-national acquisitions reflect geographic growth, assuming that it is cheaper, quicker and more effective to buy a local company with established connections than to attempt to build a foreign subsidiary. The horizontal mergers between large pharmaceutical companies are often rationalized by economies of scale and scope. However, large size is clearly neither necessary nor sufficient for high productivity in R&D, as evidenced by the growing share of new compounds produced by biotech and some mid-sized companies and the recent relatively high valuations of these smaller firms compared to large pharmaceutical companies. The market power hypothesis is implausible, given the low overall level of concentration in this industry; although concentration is higher at the therapeutic category level (e.g. cardiovascular), the Department of Justice and European Union competition authorities frequently require divestiture of compounds in therapeutic areas where the merger might significantly lessen competition. Thus these theories seem inadequate to explain the horizontal mergers between large pharmaceutical firms.

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[7] If firm A acquires 20 percent or more firm B, firm A is required to incorporate firm 's results into its financial reporting. By our definitions, if a large firm buys a 50% share in a smaller firm, this could be a transforming acquisition for the small firm but not for the large firm. Thus our analysis does not necessarily include both parties to a transaction.

An alternative hypothesis to explain these larger pharmaceutical mergers is the threat of excess capacity due to patent expirations and gaps in the firm's pipeline of compounds, which makes current levels of human and physical capital potentially excessive. This hypothesis is analogous to the excess capacity hypothesis proposed by Hall (1999, citing Blair, Shary and others), except that the causes of excess capacity in the pharmaceutical industry are firm-specific and reflect the atypically large role of patents in defining product life-cycles and particularly end of economic life of a product in this industry. Hall argues that firms in the 1980s engaged in various forms of restructuring as a response to finding their existing capital stock excessive relative to the returns it could generate, as measured by values of Tobin's q less than one. In the industries studied by Hall, the precipitating factors were increased foreign competition and high real interest rates.

The problem of patent expirations is less relevant for small biotech firms, which usually start out specializing in R&D devoted to either drug discovery or discovery-related technologies that may be of value to larger firms. The small firms raise capital through external offerings of private or public equity or alliances with larger companies, since they have no products to generate retained earnings. For those firms that do not aspire to become fully integrated pharmaceutical companies, selling the firm and its technologies to another firm may be an attractive exit strategy for the seller and an efficient growth strategy for the acquirer. By the mid 1990s, the more mature biotech firms no longer specialized in discovery but had become fully integrated, manufacturing and marketing their own products, hence they faced the same pipeline issues as large pharmaceutical companies.

III. Data

This analysis draws on a number of different data sets. We define an initial universe of pharmaceutical and biotech firms as any company in the Standard & Poor's Compustat or GlobalVantage databases with a primary biotechnology or pharmaceutical SIC code (2834, 2835, or 2836). We then

[8] To be included in our sample a firm had to have sales in excess of $20 million or a market value in excess of $1 billion for at least one year between 1988 and 2000. If two pharmaceutical/biotech firms in our sample merge, we

added firms listed in the Merrill Lynch Pharma Industry Report, which tracks the largest pharmaceutical and biotech firms, in order to include pharmaceutical divisions of conglomerate companies where the company's primary SIC code is outside of the pharmaceutical and biotech industries.[9] After removing firms with missing financial information, we were left with a universe of 896 pharmaceutical and biotech firms.

Information on the number of drugs a firm is selling and the year the drugs were approved come from five sources: the Food and Drug Administration (FDA), the First DataBank National Drug Data File, the Electronic Product Catalog, the Lehman Brother's Pipeline reports, and Chemdex. We collected financial data from the Standard & Poor's Compustat Industrial file and Global Vantage Industrial/Commercial file for 1985 through 2001.[10]

To limit our sample to firms with significant economic value, we eliminated from the sample firms that never had net sales of at least $20 million (1999 dollars) in any year during the sample period and never had an enterprise value of at least $1 billion. This restriction reduced our universe of firms to 383. We then split these firms into two sub-samples. "Large" firms are those that reached the $1 billion enterprise value threshold (n=213) in at least one year during our study period, whereas "small" firms had sales of at least $20 million in at least one year but never had an enterprise value in excess of $1 billion (n=170). Sample means and standard deviation are reported in Table 2, separately for the large-firm and small-firm sub-samples.

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record this in Table 1 as a single unique merger.

[9] We added four additional firms not identified in the two steps described in the text but known to be in the pharmaceutical or biotech sector: American Cyanamid, Warner-Lambert, Pharmacopeia, and Affymetrix, and excluded four firms more appropriately described as outside the pharmaceutical/biotech industry: Dupont, 3M, Procter & Gamble and BASF. Twenty more firms were excluded because they were old entries, pro forma entries, Indian subsidiaries, or duplicates.

[10] Foreign currency values from the Global Vantage files were converted to U.S. dollars, using monthly exchange rates from Global Vantage. All monetary values were then adjusted for inflation using the U.S. domestic manufacturing Producer Price Index (index year is 1999). To maximize our sample size, we imputed some financial data, but only for observations where other key financial variables were non-missing in order to be certain that the firm was active in that year. Because some firms were listed in both the Compustat and Global Vantage files, we extracted financial data on a firm-by-firm basis from the source that reported more years for a given firm, and we filled in missing data from the otherwise unused source.

We extracted merger transactions data for 1988-2001 from the Securities and Data Corp.'s (SDC) Worldwide Mergers and Acquisitions database. We use information from the SDC database to classify the role that a firm played in a transforming event as one of the following: (1) acquirer: the firm purchased part or all of another firm; (2) target: the firm sold a substantial portion or all of itself to another firm; or (3) partner in a pooling merger: the firm pooled its assets with another firm or merged with another firm of approximately equal size.[11] Since financial data are collected by fiscal year and fiscal years sometimes differ from calendar years, we linked the transaction to the firm's fiscal year based on the transaction announcement date and the firm's fiscal year calendar.

We restrict our formal analysis to "transforming" mergers -- transactions that are sufficiently large that post-merger integration will require reorganization of a firm's research, development, marketing and/or sales processes. We consider a transaction to be transforming if the transaction value was $500 million or more, or if the transaction value represents 20 percent or more of a firm's pre-merger enterprise value (the value of the firm at the conclusion of the prior fiscal year). In the handful of cases where firms engaged in multiple transforming mergers in the same fiscal year, we recorded the largest transaction only. Of the 202 transforming mergers, 97 were classified as acquisitions, 59 as targets, and 46 as pooling.

Some mergers are recorded as a transforming event for both the seller and the buyer if both firms are in our sample. In a few cases a transaction was not recorded as a transforming merger for the buyer because the transaction represented less than 20 percent of its enterprise value, but was recorded as transforming event for the seller because it represented more than 20 percent of its enterprise value. In other cases, it was a transforming event for the buyer but the seller is simply not in our database, because it is either a privately held (usually small) firm or a foreign firm that in not traded in the US and not listed

[11] The SDC database tracks up to three firms on the acquirer side of the transaction and up to three firms on the selling side. Each merger was credited to all of the relevant firms in our sample. Most transactions were credited to a single firm on the acquirer side. For transactions that involve the acquisition of a relatively small firm that is not listed in Compustat, we lack financial data on the target firm. However, for some transactions we were able to match both acquirer- and seller-side firms, and for others only seller-side firms. We excluded all divestiture transactions where the pharmaceutical-biotech firm in our sample was selling a division.

in Global Vantage. This underscores our assumption that an event is "transforming" with respect to a specific participant; what is transforming to the seller may not necessarily be transforming to the buyer. Thus in our empirical analysis the number of acquirer and target observations is not identical.

IV. Methodology

Our analysis proceeds in two stages. First we analyze the determinants of a firm's decision to engage in a transforming merger in each year between 1988 and 2001. The unit of observation is a firm-year and the sample size for the first-stage analysis is 3,083 firm-years, of which 1,591 are in the large-firm sample and 1,492 are in the (relatively) small-firm sample. Using multinomial logistic regression, we model the probability that a firm will engage in each of the three types of merger activity in year t as a function of firm characteristics in years t-3, t-2, and t-1.[12]

Our explanatory variables are selected to test a number of hypotheses regarding reasons for merger. We now describe the right-hand side variables associated with each hypothesis.

Excess Capacity due to Pipeline Gaps

Our first hypothesis is that for large integrated pharmaceutical/biotech firms, mergers are motivated by the expectation of a gap in the product pipeline. Such gaps cause a decline in the expected growth rate of future revenue and create expected excess capacity in the firm's marketing, sales, and possibly manufacturing departments in the future. The excess capacity motivation for mergers should be less relevant for small firms that have yet to create large sales, marketing, and manufacturing departments that depend on a steady stream of product revenues.

We use four variables to measure a firm's expected excess capacity: Tobin's q, the lagged percent change in sales, and the percentage of a firm's marketed drugs that are old and therefore likely to lose

[12] In a preliminary analysis not reported here, we tested whether the 4-outcome model, which treats pooling mergers as a separate category, is superior to a 3-outcome model, which includes only being an acquirer, a target and no M&A activity. We rejected the 3-outcome model in favor of the 4-outcome model because the pooling mergers vector of coefficients was significantly different from the other outcomes. Since the sample of pooling mergers is so small, our estimation does not distinguish acquirers and targets within this category, although SDC does designate one firm in a pooling as the acquirer and another as the target.

patent protection in the near future. Tobin's q is the ratio of the market value to book value of a firm's assets, where the former is the sum of the book value of long-term debt and the market value of equity at the conclusion of a fiscal year.[13] The market value of a firm's equity will be a function of its current as well as expected future cash flows, while the book value of assets is a contemporaneous measure. Since the balance sheet records the book value a firm's physical assets, whereas arguably most of a pharmaceutical-biotech firm's assets are associated with patents and other intangible capital, Tobin's q is likely to be very sensitive to fluctuations in the value of this intangible capital. Specifically, a firm with large expected growth opportunities due to a promising pipeline of products will have a large Tobin's q. Conversely, a firm that will soon lose patent protection on key products and/or has few promising products in products in late-stage clinical trials will have lower expected future cash flows and a lower Tobin's q. Tobin's q captures differences in expected growth rates between firms at a point in time, and within a firm over time. The excess capacity hypothesis predicts that acquisitions and pooling mergers are negatively related to (lagged) Tobin's q.

On the other hand, firms with a high Tobin's q should be able to finance an acquisition relatively easily due to their relatively high stock price. If the financing effect of an abnormally high share value is important to the timing of acquisitions, we expect Tobin's q to be positively associated with being an acquirer. Thus, since Tobin's q may reflect both excess capacity effects and financing effects, the net effect for acquirers (and possibly pooling) will be negative if the excess capacity effect dominates the financing effect. Tobin's q is predicted to be negatively associated with being a target if firms tend to be acquired when the market undervalues them, at least relative to some subjective estimates.

We also include the percentage change in sales between year t-3 and year t-1 since a relatively slow sales growth rate implies the productivity of quasi-fixed factors is or soon will be declining. Sales grew by 25 percent, on average, over a two-year period for both the large and small firms (Table 2). There is considerable variation across firms in the growth of sales, as indicated by the high standard deviations. Our final variable for measuring expected excess capacity is the percentage of a firm's drugs

[13] Book value of long-term debt should be close to its market value.

that were approved by the FDA between nine and 14 years ago, which is a proxy for the percent of the firm's product portfolio that is approaching patent expiration. Although the normal patent term for drugs marketed during our analysis period was 17-20 years, years of sales under patent protection is usually 9-14, because many years of patent life are typically lost due to clinical trials and regulatory approval.[14] Among the large firms, 13 percent of their drugs had been approved between nine and 14 years ago (Table 2), and as before the standard deviation is almost twice as large as the mean. The excess capacity motivation for mergers predicts that acquisitions will be negative related to lagged sales growth and positively related to the percent of a firm's drugs approved 9-14 years ago. Both these measures are less inclusive than Tobin's q because they do not reflect the value of products in the pipeline but not yet launched.

Finally, we include the percentage change in operating expenses between years t-3 and t-1. Under the excess capacity hypothesis, a firm that anticipates patent expirations or experiences a pipeline shock may respond initially by reducing costs, in order to maintain net revenue growth. If this strategy is exhausted before the firm's pipeline produces new products, the firm may consider an acquisition as a means to obtain further expense reductions. If so, pharmaceutical firms with relatively low lagged expense growth rates would be more likely to acquire another firm or engage in a pooling merger.

Economies of Scale

If achieving economies of scale is a significant motive for merger in the pharmaceutical/biotech industry, we would expect smaller firms to be more active as acquirers than larger firms that are operating at the minimum efficient scale. We measure a firm's size by the logarithm of its enterprise value and by the number of approved drugs that it markets. As reported in Table 2, firms in the large-firm sample were not marketing any drugs in 56 percent of the firm years, and the mean number of marketed drugs is only 3.5. This count only reflects new chemical entities (excluding reformulations, combinations etc.) and assigns each product to a single firm, whereas in fact many products are shared through licensing agreements. However, it is possible for a firm to have a high market value despite no approved drugs,

[14] Firms file for patent protection during the pre-clinical stage, well before the FDA approves a drug.

since investors value compounds in a company's pipeline that have not yet been approved. Small firms were marketing an approved drug in only five percent of the firm years, although they may still be generating revenue through out-licensed products or technologies and/or other services performed for other firms.

Note that the excess capacity and economies of scale motives for mergers are not mutually exclusive and ideally they should be complementary. That is, if a firm faced with pipeline gaps were to engage in acquisition in order to achieve short run cost savings, this would be an extremely short-sighted strategy if in the long run the post-merger scale of operations were less efficient than the pre-merger scale.

The Market for Corporate Control

Another function of M&A is to transfer assets from ineffective to effective managers. A low value of Tobin's q could indicate that a firm's value is below its potential value. This would predict that firms with a low value of Tobin's q are more likely to be targets. As an alternative measure of managerial performance we include the percentage change in operating expenses and sales, respectively, between year t-3 and year t-1. According to the "corporate control" hypothesis, firms with relatively high lagged operating expense growth rates and relatively low sales growth rates will be more likely to be acquired. As discussed above, the excess capacity hypothesis predicts that firms with relatively low lagged expense growth rates would be more likely to acquire another firm or merge through pooling. The mean two-year change in operating expenses is about 25 percent in both samples, approximately equal to the percentage change in sales (Table 2).

Specific Asset Acquisition

Another explanation for mergers is they are the most sensible way for firms to acquire specific assets. For example, a foreign pharmaceutical firm that wants to establish a presence in the U.S. market may acquire a U.S. firm that already has an established sales force and relationships, including with the FDA. We include an indicator variable for foreign firms in order to test the hypothesis that foreign-domiciled firms are more likely to merge to improve their access to the US market. One-third of the large

firms and one-fifth of the small firms are foreign (Table 2); however, this is far from the universe of foreign pharmaceutical and biotech firms, because many are not listed in our datasets.

Financing/agency issues

Some have argued that mergers occur when managers have aspirations to run a larger company, they have considerable cash, and agency controls are imperfect. We include a variable measuring the ratio of cash to sales. We expect a high ratio of cash to sales to be positively related to acquisitions if either imperfect agency concerns are significant or availability of financing is a significant constraint on mergers that are undertaken for other reasons.

In Table 3 we report the means of the firm characteristics separately for firms that did and did not merge, as well as two-sample t-statistics of the differences in the means. Among the 1,049 firm-years in the large-firm sample, firms that actually merged were marketing more drugs, were less likely to have no approved drugs, had a greater percentage of drugs at risk of patent expiration, had a larger enterprise value, a lower cash-to-sales ratio, and were less likely to have a top-coded Tobin's q and missing sales data relative to firms that did not merge.[15] Among the 1,000 firm-years in the small-firm sample (panel B of Table 3), firms that merged had a lower Tobin's q, had fewer drugs at risk of patent expiration, experienced a relatively large increase in operating expenses in the prior two years, and were less likely to have a top-coded Tobin's q, missing sales data, and missing expense data relative to firms that did not merge.

In the second stage we examine the effect of transforming mergers on several measures of firm performance between 1989 and 2000[16]: the annual percentage change in sales, operating profit, and enterprise value one, two, and three years after the merger.[17] In order to understand the mechanism

[15] In Table 5 we include only the firm-year observations that are included in the second stage regressions. Observations may be included in the multinomial logit regressions of Table 3 and Table 4 but not in the second stage regressions if they occurred in 2000 or 2001 (because we cannot observe the post-merger performance) or if there are missing values for the second stage dependent variables.

[16] Since 2001 is the last year of available financial data, 2000 is the last year for which we can calculate an annual percent change.

[17] We calculate percentage changes using an ARC formula. Operating profit is defined as sales – cost of goods sold – selling/general and administrative expenses. We exclude R&D expenses since increases in R&D expenses are often perceived to increase the future value of biotech and pharmaceutical firms.

whereby mergers may affect value, we also examine the effects on annual percentage change in employees and R&D investment. Since post-merger integration takes time and results may not be evident immediately, we examine the impact of a merger in year t on the change in outcomes from t+1 to t+2, t+2 to t+3, and t+3 to t+4. Some studies estimate the impact of mergers by examining abnormal returns in stock prices around the merger announcement date, under the assumption that the expected impact of the merger is incorporated quickly into stock prices (e.g., Moeller, Schlingemann, and Stulz, 2003; Andrade, Mitchell, and Stafford, 2001; Ravenscraft and Long, 2000; and Jensen and Ruback, 1983). Examining actual changes in a firm's financial and operating performance following a merger, on the other hand, provides insights into whether investors' expectations at the time of the announcement are actually realized in the longer term, and evidence on inputs provides evidence on the mechanism for any change in the expected value of a merged entity.

Before discussing how we control for the potential endogeneity of a merger, we first discuss hypotheses regarding the impact of a merger. If firms that merge experience a relatively large (small) subsequent increase in enterprise value, this would imply that the market underestimates (overestimates) the impact of mergers on performance. However, in this case, we would not know whether mergers actually changed profitability or merely changed profitability relative to the expectations at the time of the merger announcement, nor the means by which profitability was changed.

Under the excess capacity hypothesis, mergers are expected to facilitate restructuring and cost reductions. This would predict that employees (and possibly R&D) should grow less at firms that merged than at firms that did not merge and, assuming that the strategy is successful, operating profit should grow more rapidly than would have been predicted based on the acquiring firm's pre-merger condition. Similarly, if mergers are a means of achieving economies of scale or scope, merged firms should experience relatively slow growth in employees and/or R&D, and improved operating profit. Thus empirically the predicted outcomes of the excess capacity and economies of scale hypotheses are similar, which is not surprising because, as noted earlier, these two motives for mergers are not mutually exclusive and ideally they should be complementary, that is, a merger could yield both short and long run

cost savings if the post-merger scale of operations is more efficient than the pre-merger scale. As discussed earlier, the first stage estimates may enable us to distinguish between these hypotheses, in particular, if Tobin's q is inversely related to the probability of acquisition, this is consistent with the excess capacity motive but not with simple economies of scale. Both hypotheses would also be consistent with a relatively large growth in sales due to increased productivity of the combined sales forces and/or acquisition of new compounds for the sales force to market. Hall (1999) suggests that merger may actually reduce R&D, due to short-term management distraction and because the funds used to finance an acquisition may be diverted from R&D. This hypothesis predicts that R&D growth will be relatively low for firms that merge. However, this hypothesis is empirically indistinguishable from the economies of scale hypothesis.

Both the specific asset acquisition hypothesis and the market for corporate control predict that merged firms should experience relatively rapid growth of sales and/or operating profit. These two hypotheses are thus indistinguishable at the second stage but not at the first stage.

Accounting for the Endogeneity of a Merger

Our goal is to estimate the effect of a merger on various measures of post-merger performance and input levels for the firms in our sample. Specifically, let Y_{i1} be the percentage change from year t+1 to year t+2 for one of the five variables of interest if firm i participated in a transforming merger in year t, and let Y_{i0} be the percentage change if the firm did not merge in year t. The treatment effect for the firms that merge is:

$$(1) \qquad E(Y_{i1} \mid M_{it}=1) - E(Y_{i0} \mid M_{it}=0),$$

where $M_{it}=1$ if firm i merged in year t. Since we only observe Y_{i0} for firms that do not merge, the estimated treatment effect from equation (1) will be biased if Y_{i0} differs systematically for firms that do and do not merge. For example, if firms that anticipate poor earnings growth due to pipeline shocks or upcoming patent expirations are more likely to merge than firms with strong growth prospects, then the subsequent performance of the merged firms may be inferior to that of the non-merged firms even if there were no mergers. Failure to account for this type of selection would bias downward the estimated effect

of a merger on the subsequent change in sales and operating profit. The descriptive data in Table 3 for firms that did merge and firms that did not merge in Table 3 strongly suggest significant differences in observed characteristics between firms that were involved in M&A and those that were not.

Our analysis of effects of mergers controls for selection based on observed characteristics using a propensity score method. The propensity of merging, $p(M_i)$, is the probability firm i will merge in year t conditional on observed characteristics **X**:

$$(2) \qquad p(M_{it}) = \Pr(M_{it} = 1 \mid \mathbf{X}_{i,t-1})$$

Rosenbaum and Rubin (1983) have shown that if the outcomes (Y_{i1} and Y_{i0}) are independent of the assignment to the treatment (merging firm) and control (non-merging firm) groups, conditional on the observed covariates, then classifying observations by their propensity score balances the observed covariates (**X**); within a subclass with a similar p(M), the distribution of **X** is the same between the treatment and control groups. The treatment effect of a merger for firms with a specific propensity score is the difference in the mean outcomes between the treatment and control groups:

$$(3) \qquad E(Y_{i1} \mid p(M_{it}), M_{it}=1) - E(Y_{i0} \mid p(M_{it}), M_{it}=0),$$

where the expectation is taken with respect to the distribution of p(M). Consider two firms with the same probability of merging in a particular year where one firm merged and the other did not. The firm that did not merge can serve as a control for the firm that did merge since the expected difference in their response is equal to the average treatment effect of a merger.[18]

In the first stage analysis of determinants of mergers, we estimate equation (2) using a multinomial logit regression that distinguishes situations where a firm acquires another, a firm is acquired, a firm is involved in a pooling merger, and a firm is not involved in any M&A activity. In the second stage analysis of the effect of a merger, we sum the predicted probabilities that a firm will be an acquirer and be involved in a pooling merger in order to derive the firm's estimated merger propensity

[18] See Imbens (2004) for a review of methods for estimating the treatment effect of a binary treatment when there is selection on observable characteristics.

score for a particular year.[19] We then regress Y_i, the percentage change in a firm performance measure from t+1 to t+2, on a firm's propensity score for year t, an indicator that equals one if the firm merged in year t, year indicators, and an indicator for foreign firms.[20] We also include an interaction between the propensity score and the merger indicator to test whether the effect of a merger differs according to likelihood that the firm would engage in M&A activity. A firm facing a substantial loss of sales due to patent expiration, for example, may have a high propensity score and may reduce employees substantially if it were to acquire another firm, whereas a firm that was less distressed might alter staffing less aggressively if it were to merge. Since post-merger integration takes time and results may not be evident immediately, we run three separate second-stage regressions to measure the impact of mergers on firm performance one, two, and three years following a merger. That is, we define Y_i as the percentage change in a firm's performance from t+1 to t+2, from t+2 to t+3, and from t+3 to t+4 (where the merger of interest occurred in year t).

The propensity score method controls for selection based on observed firm characteristics. If there is selection into mergers based on unobserved characteristics, our estimate of the impact of a merger may be biased. For example, if firms with capable managers are more likely to merge because such managers can exploit the benefits of a merger, then our estimate of mergers will be upward biased.

As a robustness check, we also estimate a second-stage model based on the approach suggested by Hirano, Imbens, and Ridder (2000). Rather than including the propensity score as a regressor in the second stage regression, we perform weighted ordinary least squares where the weights for firms that merged are $1/p_i$, and the weights for firms that did not merge are $1/(1-p_i)$.[21] Therefore, firms that did not merge are given a greater weight if they had a high propensity score (i.e., they appeared similar to firms

[19] We omit the predicted probability the firm will be acquired because firms that are acquired generally are not included in the second-stage regression.

[20] We cannot compare performance of merged firms, pre- and post-merger, with a matched sample of non-merging firms over the same time period, because we lack pre-merger accounting data for one component of the merged entity for a significant fraction of our mergers. This occurs primarily due to partial acquisitions (where reported data pertains to the entire corporate entity, not just the division acquired), and acquisitions involving foreign firms and private companies that are not covered by Compustat or Global Vantage. We include the acquiring firm's propensity score in the second stage rather than averaging the propensity scores of the two merging firms because often the target firm is not included in the first stage regression (due to missing accounting data).

that did merge based on observables), and firms that did merge are given a greater weight if they have a low propensity score (i.e., they appear similar to firms that did not merge). The results using this method are qualitatively similar to those that we report in Table 6 and Table 7.[22]

V. Results

Determinants of M&A Activity

We estimate equation (2) using a multinomial logit model with four possible outcomes: the firm acquires another firm in a transforming merger, is acquired by another firm, is involved in a pooling merger, or does not undertake any merger activity. We pool observations from 1988 to 2001. The unit of observation is a firm-year and we report robust standard errors, to adjust for clustering within firm over time. In Tables 4 and 5, we report marginal effects of the four distinct outcomes for the large-firm sample and the small-firm sample, respectively. The marginal effects, which are the change in the probability of an event (e.g., the probability a firm acquires another) associated with a unit increase in the independent variable, sum to zero for each independent variable across all four possible outcomes**.**

The results in Table 4 provide some support for the hypothesis that large pharmaceutical-biotech firms that expect to have relatively high excess productive capacity are more likely to engage in acquisition. Recall that we use four different variables to measure expected excess capacity: Tobin's q, which is the most comprehensive; the percentage of a firm's drugs that were launched 9 to 14 years ago (and are thus likely to lose patent protection soon); the lagged change in sales; and lagged change in operating expense. In regressions not reported here, when we omit the number and age profile of a firm's marketed drugs, firms with a relatively low Tobin's q (the ratio of the firm's market to book value of its assets) are more likely to acquire other firms. This is consistent with the hypothesis that firms with relatively low expected earnings growth rates (as reflected in a low market value of its assets) use

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[21] Finkelstein (2003) also uses this method in her study of vaccine development.

[22] Results of the weighted-OLS regressions are available upon request. In these specifications we do not include an interaction term between the merger indicator variable and the propensity score.

acquisition as a source of either short run cost reductions until their pipeline can be strengthened and/or new compounds to apply to their pipeline.

In Table 4 when we include explicit measures of the firm's products and their age profile, which provides a more direct measure of expected excess capacity, the marginal effect of a change in Tobin's q on the likelihood of acquiring another firm is still negative but is no longer significant. However, firms with a relatively old portfolio of drugs are more likely to acquire another firm, as predicted, and this marginal effect is concave. A one standard deviation increase in the percentage of a firm's drugs that are between 9 and 14 years old (from 13.3 to 37.7) is associated with a 1.8 percentage point increase in the probability a firm will acquire another company.[23] Since the probability a firm acquires another in a particular year is 0.0465 (bottom row of Table 4), this represents a 38 percent increase in the likelihood of acquiring another firm. The lagged percent change in sales is negative but insignificant.

Firms with a relatively low Tobin's q are more likely to be acquired, suggesting that the acquirer values the firm's assets more highly than the market does, which is consistent with acquisition being a mechanism to transfer assets to more effective managers. Also consistent with this hypothesis is the finding that firms that experienced relatively rapid growth of operating expenses are more likely to be involved in pooling, possibly to transfer the assets to more effective managers. However, since this variable is insignificant in the target equation, this interpretation is tentative.

If firms merged in part to achieve economies of scale, smaller firms would be more likely to merge. We measure a firm's size by the logarithm of its enterprise value and the total number of drugs it has brought to the market. Contrary to expectations, larger firms, as measured by enterprise value, are more likely to be involved in all three types of merger activity. This suggests that, if economies of scale are motive for merger, even the firms at the sample mean perceive advantages in growing larger. A 100 percent increase in a firm's enterprise value (or an increase of one in the log of its enterprise value, which is about one-half of a standard deviation) is associated with a 1.0 and 0.32 percentage point increase in the likelihood of acquiring another firm and being involved in a pooling merger, respectively, which is

approximately a 20 percent increase in the probabilities. Firms with larger enterprise values are also more likely to be targets. The marginal effects of the number of marketed drugs are not significant.

The coefficient on the indicator for foreign firms is positive in the acquisition equation but insignificant, suggesting that foreign firms do not disproportionately engage in merger as means to enter the US market. Our estimates suggest that foreign firms are less likely to be acquired than domestic firms, however this may simply reflect a US-bias in our dataset, which may not capture all the acquisitions of foreign firms by other foreign firms. The coefficient on the ratio of cash to sales is insignificant. Thus there is no evidence of imperfect agency, that is, that managers acquire companies merely because they have the means to do so. There is also no evidence that financing is a constraint on M&A.

Table 5 reports the marginal effects from the multinomial regression analysis of determinants of mergers for relatively small firms, defined as firms with at least $20 million in sales for at least one year between 1988 and 2000 but with an enterprise value less than $1 billion.[24] For this sample, we have more success predicting the probability of being a target than an acquirer. The results are more consistent with merger being an exit strategy for firms in financial trouble in general, not specifically a response to expected excess capacity associated with patent expirations. This is as expected, since the great majority of these small firms had no marketed drugs, hence were not exposed to patent expirations and had fewer assets at risk of becoming underutilized in the event of pipeline failures. Nevertheless, most of these firms would be engaged in R&D, hence would be heavily dependent on external financing through public or private equity. If such firms experience R&D setbacks that result in a decline in their Tobin's q and have run out of cash, they may face little alternative other than to sell out.

We find that firms with a relatively low Tobin's q, implying a relatively low expected growth rate of earnings, are more likely to be acquired, as in the large firm sample. This is consistent with transfer of underperforming assets to other managers. A one-standard deviation increase in a firm's Tobin's q is

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[23] $24.4(.104) + (24.4)^2 (-0.0013) = 1.8$

[24] The standard errors for four of the coefficients in the pooling merger arm of the multinomial logit are so small that the Stata software program reports them as zero. We have omitted the standard errors in Table 4 for these

associated with a 0.19 percentage point decrease in the predicted probability a firm will be acquired. The mean probability that a small firm will be acquired in a particular year is 0.021 (bottom row of Table 5), so this represents a 9 percent reduction in the predicted probability. By contrast, small firms with a relatively high value of Tobin's q, large number of drugs, and high ratio of cash to sales are less likely to engage any type of M&A activity. As further evidence that the causes of financial distress are different for small firms, we find that small firms with a large percentage of drugs at risk of losing patent protection are less likely to be involved in M&A activity, whereas the opposite effect was found for larger firms (Table 4).[25]

Firms with relatively large enterprise values are more likely to be acquired and be involved in a pooling merger, whereas firm size has no effect on the probability of being an acquirer, in contrast to the large firm sample. A 100 percent increase in a firm's enterprise value (which is slightly smaller than one standard deviation) is associated with a 0.19 percentage point, or 9 percent, increase in the predicted probability of being acquired. These results are consistent with larger firms being relatively attractive targets, presumably as a means whereby the acquiring firm can achieve economies of scale in an existing capability (e.g., research) or to acquire new technologies and/or expertise in a new functions (e.g., drug development).

Although being in financial trouble puts a firm at risk for acquisition, there is no evidence that having the ability to finance a merger tends to precipitate acquisition. Firms with a relatively high cash-to-sales ratio are less likely to be involved in any M&A activity. Further evidence that financing is neither a constraint on acquisition nor a precipitating factor is suggested by the finding that firms with relatively high Tobin's q (ability to finance an acquisition through equity) are less likely to engage in M&A. In summary, for small firms the results suggest that financial weakness puts a firm at risk as a target, but

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coefficients. The point estimates of these four coefficients are also very small, as is the frequency of pooling mergers in the small-firm sample.

[25] The number of marketed drugs is positive for only 4.9 percent of the firm-year observations in the small-firm sample. However, among these firm-years, there is considerable variation in the number of marketed drugs (ranges from one to four), and the percentage of drugs that were approved 9 to 14 years ago (ranges from zero to 100, with a mean of 22).

financially strong firms (as measured by relatively high Tobin's q, number of marketed drugs and high ratio of cash to sales) are more likely not to engage in M&A at all.

Effect of a Merger on a Firm's Subsequent Performance

The evidence of means in Table 3 and the analysis of determinants of merger in Tables 4 and 5 demonstrate that merger in the pharmaceutical-biotech industry is not a random event but is related to observable firm characteristics. If the post-merger performance of these firms is also a function of these prior observed characteristics, then a method that assumes mergers are exogenous may produce a biased estimate of the causal effects of a merger.

The goal of the propensity score method is to identify firms that are expected to have similar outcomes regardless of whether or not they actually merged. The propensity score is a summary measure of the likelihood of merging based on a vector of firm characteristics. One way to evaluate if the propensity score method is working is to see if the covariates for firms that did and did not merge are similar among firms with similar propensity scores. We estimate the multinomial logit model of equation (2) with all the variables listed in Table 4 (and Table 5) as well as year indicators, additional lagged measures of employees, the ratio of R&D expenses to sales, the ratio of operating profit to sales, interaction terms between many pairs of variables, and quadratic terms of the continuous variables. We sum the predicted probability that a firm will acquire another company and the probability a firm will be involved in a pooling merger to derive the M&A propensity score. We omit the predicted probability that a firm will be acquired because firms that are acquired generally do not appear in our second-stage sample. We then sort firm-years by the propensity score and assign them to three separate groups, or tertiles: low, medium, and high propensity score.[26]

[26] Cochrane (1968) shows that grouping observations into five subclasses according to their propensity score often removes over 90 percent of the bias due to the covariates. Since mergers are infrequent in our sample (about five percent of the firms merge in a particular year), we would have a small number of mergers in each quintile and therefore use tertiles.

We use a two-way analysis of variance model to determine if the propensity score balances each covariate between the treatment (merged) and control (did not merge) groups. Each covariate that appears in the multinomial logit model is regressed on indicator variables for the three propensity tertiles, an indicator for whether or not the firm actually merged in that year, and interactions between the propensity and merged indicator variables. We then calculate F-statistics to determine whether the covariates differ between merging and non-merging firms -- overall and within each tertile -- once we control for the firms' propensity to merge using the tertile indicator variables. In fact, once we control for a firm's propensity to merge, none of the covariates from Table 3 differ significantly between firms that do and do not merge. For example, although firms in the large-firm sample that merge have considerably more marketed drugs than firms that do not merge, within each of the three propensity tertiles there is no statistical difference in this variable between merging and non-merging firms.

Estimates from 30 separate second-stage regressions are reported in Table 6 for the large-firm sample. In the first three rows we regress the percentage change from t+1 to t+2 for each of the five firm performance measures on an indicator variable that equals one if a firm merged in year t, year indicators, and an indicator for foreign firms.[27] The coefficient on the merger indicator is the impact of a merger if one assumes mergers are exogenous. For each of the five dependent variables, we then report a second regression that includes the propensity score for the firm-year and an interaction between the merger indicator and the propensity score to test whether any merger effects are significant after controlling for the propensity to merge and to see if any effects of a merger differ according to the firm's prior likelihood of engaging in M&A activity. Finally, we repeat these two regressions for each dependent variable, using the percentage changes between t+2 and t+3 (rows 4 through 6 of Table 6) and t+3 and t+4 (rows 7 through 9) to examine how the impact of a merger varies over the time horizon. In these latter two sets of regressions, the merger indicator is still one if a firm merged in year t.

[27] Some of the year indicators were significant, suggesting industry-wide growth trends, but these coefficients are not reported here.

For large firms, in the first year post-merger, the merger has no significant effect on operating profit or enterprise value. The latter result is consistent with unbiased investor expectations, on average. It is also consistent with Ravenscraft and Long's finding of no significant abnormal returns to pharmaceutical mergers overall.[28] If one were to assume that mergers are exogenous, one would conclude that merger results in slower growth in sales and in R&D expenditures in the first full year after a merger (the first equation for each dependent variable in Table 6). However, the negative and frequently significant coefficient on the propensity score variable in the regressions for growth in sales, employees, and R&D highlights the importance using the propensity score method as a control for prior characteristics that are likely to be associated with future performance. Firms with a relatively high likelihood of merging in a particular year experience relatively small growth in sales, employees, and R&D, on average, over the next three years, regardless of whether or not they actually merge. This supports our hypothesis that many large firms merge to try to improve a bad situation. Firms that don't merge but share similar characteristics as firms that do merge, also perform relatively poorly on the three aforementioned dimensions. It is not surprising that the propensity score coefficients are insignificant in the enterprise value regressions because a company's current stock price should incorporate expectations of its future performance, and those expectations should be based on the same firm characteristics as the propensity score.

Including a firm's propensity to merge increases the coefficient on the merger indicator variable in 12 of the 15 regressions in Table 6 and eliminates the finding of significant difference in the growth in sales and R&D expenses between merging and non-merging firms in the first full year following a merger.

The results for the second and third full years following a merger (rows 4-6 and rows 7-9 of Table 6, respectively) are similar to those for the first full year for all of the dependent variables except for employees and operating profit. In the second year post-merger, employee growth appears to be more

[28] Their analysis spans 1985-1996, and should include most of the mergers in our large firm sample, excluding the 1996-2000 mergers. Unlike Ravenscraft and Long, we find no positive differential for cross-border mergers.

negative for firms that merged, as expected if cost reductions through restructuring are an important objective of mergers. However, once we control for the propensity to merge, employee growth is not significantly different between firms that did and did not merge. Thus, firms that were in trouble either cut or slowed the growth of employees within the next two years, regardless of whether or not they merged.

Mergers are associated with relatively low growth in operating profit in the third year after a merger. Controlling for a firm's propensity to merge, a firm with the sample average propensity (0.038) is predicted to experience a 52.3 percent reduction in operating profit in the third year following a merger relative to an otherwise similar firm that did not merge.[29] This reduction is significantly different from zero at a six percent level. This suggests that post-merger integration may absorb more resources and managerial effort than anticipated by most managers, although not relative to market expectations given the insignificant result for the forward-looking enterprise value measure. However, the positive and significant coefficient of 219 on the merged-propensity score interaction indicates that mergers had a more beneficial effect on operating profit for firms with a relatively high probability of merging. A merger is predicted to increase the operating profit for a firm with a very high propensity score by 10.2 percent in the third year following a merger relative to an otherwise similar firm that did not merge, although this effect is not significantly different from zero at conventional levels.[30]

Estimates from the same set of second-stage regressions are reported in Table 7 for the sample of small firms. In Table 5 we found that merging is an exit strategy for relatively small biotech firms in financial trouble, whereas strong firms, as measured by high Tobin's q, number of marketed drugs and high ratio of cash to sales, are more likely not to engage in M&A at all. Firms that merged had significantly lower growth in operating profit in the year following the merger, and controlling for the propensity to merge makes this effect more, not less negative. In subsequent years there was no

[29] -60.7 + (0.038)(219) = -52.3.

[30] The 10.2 percent predicted increase in operating profit is based on a firm with a propensity score of 0.323, which is one-standard deviation higher than the mean propensity score for firms that actually merged. The predicted

significant difference in operating profit between firms that did and did not merge, suggesting that post-merger integration is easier for small firms than for large firms, which is not surprising.

Small firms with high propensity scores experienced relatively low growth in employees and R&D regardless of whether they merged, consistent with the earlier finding that strong firms tend not to engage in M&A. As with the large-firm sample, this highlights the importance of controlling for the likelihood of a firm's expected performance when estimating the impact of mergers. Relative to an otherwise similar firm that did not merge, we predict that a merger reduces the growth rate of sales, employees, and R&D by 10.2 percent, 10.6 percent, and 29.1 percent, respectively, in the first full year following a merger for a firm with the mean propensity (0.031). Only the change in R&D is statistically significant, which indicates resources may be diverted from R&D immediately post-merger.

As in the operating profit regression discussed above, the positive coefficients on the merged-propensity score interactions for these three regressions indicate that mergers may be a more effective growth strategy for firms with high propensity scores. A merger is predicted to increase sales, employees, and R&D by 12.8 percent, 21.2 percent, and 30.3 percent, respectively, in the first full year following a merger for a firm with a very high propensity score relative to an otherwise similar firm that did not merge.[31] The results for employees and R&D are significantly different from zero at a 10-percent level, and the predicted effect of a merger is significantly larger for firms with very high propensity scores relative to those with the sample mean propensity score for all three of these dependent variables. Thus, firms that face the greatest distress appear to grow following a merger, possibly because the merger provided access to financial resources that these small firms lacked.

With two exceptions, the insignificant coefficients in most of the second-and third-year regressions indicate that the impact of a merger for small firms appears to be concentrated in the first full year following a merger. For a firm with the sample mean propensity, a merger is predicted to have no

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impact of a merger on the operating profit of a firm with the mean propensity versus a firm with a very high propensity is statistically different from one another at a 5 percent level.

[31] These predictions are based on a firm with a propensity score of 0.223, which is one-standard deviation higher than the mean propensity score for firms that actually merged.

statistically significant effect on its employees two years following a merger or its enterprise value three years following a merger. By contrast, for a firm with a very high propensity score, we predict that a merger increases its employees by 16.5 percent in the second year and reduces its enterprise value by 48.7 percent in the third year relative to an otherwise similar firm that did not merge. [32] Apparently the long-run impact of a merger for these distressed firms fell short of investors' expectations.

VI. Conclusion

The pharmaceutical-biotechnology industry has experienced a high rate of M&A activity in the last two decades, and this has contributed to increased consolidation of the industry. Several of the largest firms today are the result of a series of large mergers, including cross-national mergers. At the same time, other firms in the industry have avoided major M&A activity and have elected to grow through internal R&D and more modest acquisitions, including in-licensing of products and technologies. Our analysis of this M&A activity over the period 1988-2000 has focused on cross-sectional variation across firms within the industry rather than time-series trends in pharmaceuticals relative to other industries.

Among large firms (over $20 million in sales and $1 billion in market value), we find that firms with a low Tobin's q, which implies low expected earnings growth and hence low market relative to book value of assets, are more likely to acquire another firm. This effect remains negative but becomes insignificant when we control for the percent of their product portfolio that is approaching patent expiration. Thus for large firms this evidence supports the hypothesis that mergers are frequently the response to expected excess capacity that is triggered by patent expirations and gaps in the pipeline of follow-on products, which depresses expected future earnings growth. Mergers are in fact often rationalized as offering an opportunity to reduce overhead and other costs, implying expectations of economies of scale. Thus a gap in the flow of revenue-generating patented products leads to excess capacity and creates a motive for merger and restructuring in the research-based pharmaceutical industry

[32] Both of the predicted effects for firms with very high propensity scores are significantly different from zero at a 5-percent level. The predictions are based on a firm with a propensity score that is one-standard deviation higher than

that is somewhat analogous to the role of technological and regulatory shocks that create a motive for merger and restructuring in other industries. We find that firms with high enterprise value are more likely to engage in merger, confirming that there is a perception of economies of scale in this industry.

For small firms mergers appear to be primarily an exit strategy for firms that are in financial trouble, as indicated by low Tobin's q, few products and low cash-sales ratio. This financial trouble may be caused by R&D shocks that we do not observe, but the motive for merger appears to be financing, not excess capacity due to gaps in the pipeline of marketed products, which is expected since most of these firms do not have marketed products. Conversely, small firms with a relatively high Tobin's q, marketed products and cash/sales ratios are more likely not to engage in any M&A activity. We find no evidence that the availability of financing, either cash or relatively high value of equity, raises the probability of acquisitions for large or small firms; thus at least by this measure, we find no evidence that mergers are the result of imperfect agency by managers with cash available.

The evidence on effects of mergers strongly confirms the importance of controlling for a firm's prior characteristics, as reflected in the merger propensity. For both the large- and small-firm samples, firms with relatively high propensity scores tend to have slower growth of sales, employees and R&D, consistent with merger being a response to distress. Controlling for merger propensity, we find that for large firms merger had no effect on the change in enterprise value, sales, employees, and R&D expenses in the three years following a merger. Firms that merged experienced slower operating profit growth in the third year after merger. Thus although merger is a response to being in trouble for large firms, there is no evidence that it is a solution. For small firms, those that merged experienced relatively slow growth of R&D in the first year compared to similar firms that did not merge, suggesting that post-merger integration may absorb the cash that is necessary to finance R&D among small firms. Changes in enterprise value are unaffected by mergers and propensity scores, consistent with the hypothesis that stock market valuations incorporate all the observable information and on average yield unbiased predictions of merger effects.

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the mean propensity score for firms that actually merged.

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Table 1: Merger and Acquisition Activity by Year

Year	Number of firms in sample	Number of unique transforming mergers	Percent of firms involved in transforming merger[33]	Total market value of mergers ($ million)	Merger value as a percent of industry's market value	Mean merger value as percent of acquiring firm's value	Mean merger value as percent of target firm's value
1988	121	3	2.5%	1,309	0.6%	33.2%	n/a
1989	125	12	7.2%	27,971	11.8%	44.7%	121.0%
1990	134	9	5.2%	15,843	5.1%	28.8%	60.6%
1991	190	6	4.2%	1,924	0.4%	16.7%	112.0%
1992	196	3	2.6%	1,325	0.2%	32.5%	92.2%
1993	212	5	1.9%	8,385	1.2%	16.7%	n/a
1994	216	18	9.7%	37,174	5.9%	22.8%	110.0%
1995	243	12	6.2%	36,732	5.2%	19.4%	n/a
1996	267	13	5.2%	36,714	4.0%	29.4%	88.4%
1997	286	16	5.2%	20,492	1.7%	35.7%	54.0%
1998	288	21	8.3%	67,741	4.5%	27.3%	79.1%
1999	302	25	9.6%	157,708	7.7%	38.7%	118.0%
2000	228	22	10.8%	100,750	5.0%	37.2%	124.0%
Total/Average		165	6.5%	514,068	4.4%	29.1%	96.9%

Note: We define a transforming merger as one where the price exceeded $500 million or represented at least 20 percent of the buying and/or selling firm's market value. If a merger involves two firms in the sample, we record it in this table as a single unique merger, but in the regression analysis as a merger for both firms. The market value of a firm is defined as the market value of its equity plus the book value of its long-term debt. "n/a", or not available, indicates the data are missing.

[33] The number of firms involved in transforming merger can differ from the number of unique mergers if two firms from the sample were involved in a merger and/or if a single firm was involved in multiple mergers in a particular year.

Table 2

Sample Means and Standard Deviations

	Large-Firm Sample (n=1,591 firm years)		Small-Firm Sample (n=1,492 firm years)	
	Mean	Standard Deviation	Mean	Standard Deviation
Tobin's q, top-coded at 20	3.17	2.60	2.88	2.82
Indicator for Tobin's q > 20	0.006	0.075	0.014	0.118
Number of marketed drugs	3.53	7.35	0.082	0.442
Indicator for no marketed drugs	0.560	0.497	0.951	0.216
Percent of drugs launched 9-14 years ago	13.3	24.4	1.08	9.95
log(enterprise value), $millions	7.35	1.92	4.48	1.21
Foreign firm indicator	0.362	0.481	0.209	0.407
Ratio of cash to sales	3.11	8.46	2.68	7.65
Percent change in sales, t-3 to t-1	25.7	49.4	25.1	60.6
Indicator: sales data missing	0.151	0.359	0.212	0.409
Percent change in operating expenses, t-3 to t-1	25.3	36.6	24.4	44.0
Indicator: operating expenses missing	0.155	0.362	0.199	0.399

Notes: Large firms had an enterprise value (market value of equity plus book value of debt) exceeding $1 billion at least once during the sample period. Small firms had sales of at least $20 million at least once during the sample period but never had an enterprise value exceeding $1 billion.

Table 3

Differences in the Characteristics of Merging and Non-merging Firms

Panel A: Large-firm sample (n=1,049 firm years)

	Mean for firms that merged in t	Mean for firms that did not merge	t-statistic for difference in means
Tobin's q, top-coded at 20	2.62	2.92	1.24
Indicator for Tobin's q > 20	0.00	0.0062	3.01**
Number of marketed drugs	9.72	2.29	4.94**
Indicator: no marketed drugs	0.278	0.586	7.49**
Percent of drugs launched 9-14 years ago	23.4	10.3	3.63**
log(enterprise value), $ millions	8.60	6.82	5.49**
Foreign firm indicator	0.391	0.359	0.71
Ratio of cash to sales	1.36	3.34	3.56**
Change in sales, t-3 to t-1	23.7	24.2	0.08
Indicator: sales data missing	0.053	0.161	4.97**
Change in operating expenses, t-3 to t-1	23.5	24.6	0.23
Indicator: operating expenses missing	0.068	0.163	4.00**

Panel B: Small-firm sample (n=1,000)

	Mean for firms that merged	Mean for firms that did not merge	t-statistic for difference in means
Tobin's q, top-coded at 20	2.34	3.04	1.67*
Indicator for Tobin's q > 20	0.00	0.015	4.62**
Number of marketed drugs	0.091	0.070	0.23
Indicator: no marketed drugs	0.900	0.954	1.49
Percent of drugs launched 9-14 years ago	0.00	1.25	3.61**
log(enterprise value), $ millions	4.11	4.34	1.02
Foreign firm indicator	0.174	0.211	0.78
Ratio of cash to sales	2.13	3.24	1.05
Change in sales, t-3 to t-1	41.9	26.1	1.28
Indicator: sales data missing	0.101	0.218	3.05**
Change in operating expenses, t-3 to t-1	45.1	27.0	1.82*
Indicator: operating expenses missing	0.073	0.205	4.00**

Notes: ** = difference in sample means is significantly different from zero at the 5-percent level. The sample for this table is smaller than for Table 3 and Table 4 because we include only firm-year observations that are included in the second stage regressions.

Table 4

Marginal Effects of the Probability of Participating in M&A Activity: Large-Firm Sample

	Acquirer	Target	Pooling Merger	No M&A Activity
Tobin's q	-0.276	-0.0027**	0.030	0.248
	(0.186)	(0.0012)	(0.044)	(0.18)
Number of marketed drugs	-0.0349	-0.00029	-0.012	0.047
	(0.047)	(0.00038)	(0.020)	(0.053)
Percent of drugs launched	0.104**	-0.00033	0.0012	-0.105**
9-14 years ago	(0.051)	(0.00028)	(0.014)	(0.052)
% drugs 9-14, squared	-0.0013**	2.8×10^{-6}	-0.000035	0.0014**
	(0.00057)	(4.6×10^{-6})	(0.00015)	(0.00057)
% Change in sales, t-3 to t-1	-0.0042	-0.000022	-0.0032	0.0074
	(0.013)	(0.000085)	(0.0041)	(0.014)
Enterprise value (ln)	1.00**	0.0035**	0.321**	-1.33*
	(0.315)	(0.0015)	(0.144)	(0.347)
% Change in operating expenses	0.0094	0.000066	0.011**	-0.020
t-3 to t-1	(0.017)	(0.00011)	(0.0047)	(0.018)
Foreign firm indicator	0.294	-0.0084**	-0.324	0.038
	(0.815)	(0.0042)	(0.296)	(0.847)
Ratio of cash to sales	0.0035	-0.00036	-0.069	0.066
	(0.051)	(0.00030)	(0.053)	(0.071)
Mean of dependent variable (percentage points)	4.65	1.76	1.95	91.6
Observations (firm-years)	74	28	31	1,458

Notes: The marginal effects are based on a multinomial logit regression where the dependent variable takes on the value one if a firm was involved in a particular type of merger activity in year t, and zero otherwise. The marginal effects are presented as percentage point changes in the probability of an outcome. The regression also includes indicator variables for firms with missing data on operating expenses and sales, for firms with a Tobin's q above 20, and for firms with no marketed drugs in year t-1.

Table 5
Marginal Effects of the Probability of Participating in M&A Activity: Small-Firm Sample

	Acquirer	Target	Pooling Merger	No M&A Activity
Tobin's q	-0.079	-0.068**	7.4×10^{-8}	0.147*
	(0.070)	(0.029)		(0.076)
Number of marketed drugs	0.135	-5.02**	-1.7×10^{-6}	4.89**
	(0.206)	(1.41)	(6.1×10^{-6})	(1.42)
Percent of drugs launched	-1.22**	-0.120**	1.2×10^{-6}	1.34**
9-14 years ago	(0.273)	(0.037)	(1.6×10^{-6})	(0.273)
% drugs 9-14, squared	0.010**	0.00027**	-9.2×10^{-9}	-0.011**
	(0.0023)	(0.000083)		(0.0023)
% Change in sales, t-3 to t-1	-0.00021	-0.00027	6.9×10^{-8}	0.00049
	(0.0025)	(0.0016)		(0.0029)
Enterprise value (ln)	-0.077	0.190**	5.7×10^{-6}**	-0.113
	(0.108)	(0.053)	(2.4×10^{-6})	(0.123)
% Change in operating expenses,	0.0046	-0.00037	-1.5×10^{-7}	-0.0042
t-3 to t-1	(0.0028)	(0.0018)		(0.0034)
Foreign firm indicator	0.143	-0.070	-0.385**	0.312
	(0.336)	(0.129)	(0.166)	(0.403)
Ratio of cash to sales	-0.0069	-0.029**	-1.3×10^{-6}	0.036*
	(0.014)	(0.015)	(1.8×10^{-6})	(0.020)
Mean of dependent variable (percentage points)	1.54	2.08	1.01	95.4
Observations (firm-years)	23	31	15	1,423

Notes: The marginal effects are based on a multinomial logit regression where the dependent variable takes on the value one if a firm was involved in a particular type of merger activity in year t, and zero otherwise. The marginal effects are presented as percentage point changes in the probability of an outcome. The regression also includes indicator variables for firms with missing data on operating expenses and sales, for firms with a Tobin's q above 20, and for firms with no marketed drugs in year t-1. The standard errors for four of the coefficients in the pooling arm of the multinomial logit are so small that they are reported to be zero by the Stata program. The point estimates for these four coefficients are also very small.

Table 6: Effect of a Merger on Firm Performance, Large-Firm Sample
Change (Percentage Points) Between Year t and t+1

	Operating Profit		Enterprise Value		Sales		Employees		R&D	
1st year after a merger										
Merged in **t-1**	-10.72	-5.36	1.60	10.34	-5.590*	-0.15	-3.25	1.57	-8.514*	-7.39
	(8.20)	(12.74)	(7.75)	(13.58)	(3.07)	(4.03)	(2.75)	(4.59)	(5.01)	(7.25)
Merged in **t-1** * propensity score		-12.64		-37.35		-11.78		5.87		32.18
		(56.04)		(39.39)		(20.02)		(16.64)		(20.47)
Propensity score, t-1		-19.31		-9.78		-20.99		-40.64***		-40.60***
		(28.60)		(17.23)		(14.95)		(10.77)		(11.17)
Mean of dependent variable	4.11	4.11	17.30	17.30	13.80	13.80	9.50	9.50	13.40	13.40
Observations	993	993	996	996	992	992	911	911	967	967
R^2	0.01	0.01	0.13	0.13	0.03	0.03	0.05	0.06	0.04	0.05
2nd year after a merger										
Merged in **t-2**	3.99	21.16	-2.89	-5.66	-6.25	-5.49	-6.107**	-5.66	-0.48	2.32
	(11.71)	(16.82)	(6.64)	(10.12)	(4.11)	(7.21)	(2.50)	(4.64)	(4.15)	(7.27)
Merged in **t-2** * propensity score		-90.77		12.61		14.33		19.28		0.64
		(58.28)		(37.29)		(24.01)		(16.24)		(23.77)
Propensity score, t-2		-5.77		3.66		-25.2*		-30.2***		-21.9*
		(20.89)		(16.02)		(14.50)		(9.49)		(12.97)
3rd year after a merger										
Merged in **t-3**	-28.01	-60.705**	-1.08	-8.87	-4.00	6.36	-8.09	-0.13	-0.65	-0.52
	(17.14)	(30.20)	(9.32)	(15.82)	(5.47)	(5.71)	(5.50)	(7.87)	(5.03)	(6.74)
Merged in **t-3** * propensity score		219.43**		57.83		-40.78		-32.71		16.02
		(102.69)		(54.06)		(30.43)		(33.88)		(43.18)
Propensity score, t-3		-40.97		-17.19		-26.198*		-18.50*		-22.97
		(38.79)		(18.84)		(14.27)		(10.29)		(14.14)

Notes: The results of 30 separate ordinary least squares regressions are reported in this table. The dependent variable is the change between t and t+1 in a firm performance measure, measured in percentage points relative to the midpoint between the two years. The regressions also include a constant, an indicator for foreign firms, and year indicators. Operating profit is sales minus manufacturing, selling, general, and administrative expenses (operating profit is pre-tax and excludes R&D expenses). The means of the dependent variables and the R^2 values are similar for the regressions analyzing the impact of mergers in the second and third year following the merger. There are about 120 and 240 fewer observations for the latter two sets of regressions.

Table 7: Effect of a Merger on Firm Performance, Small-Firm Sample
Change (Percentage Points) Between Year t and t+1

	Operating Profit		Enterprise Value		Sales		Employees		R&D	
1st year after a merger										
Merged in **t-1**	-40.49*	-53.87*	2.83	8.35	-4.03	-13.83	-6.08	-15.51	-13.52	-38.32**
	(23.86)	(31.17)	(10.17)	(12.14)	(6.34)	(8.82)	(7.59)	(9.98)	(14.72)	(17.72)
Merged in **t-1** * propensity score		94.97		1.83		116.81**		161.11***		301.30***
		(164.37)		(71.71)		(52.53)		(43.52)		(87.86)
Propensity score, t-1		30.72		-70.68		-44.45		-99.22***		-146.04***
		(79.35)		(54.58)		(43.43)		(25.68)		(36.80)
Mean of dependent variable	-19.3	-19.3	5.72	5.72	12.6	12.6	7.49	7.49	8.37	8.37
Observations	930	930	934	934	922	922	887	887	841	841
R^2	0.03	0.03	0.07	0.07	0.02	0.02	0.02	0.06	0.01	0.03
2nd year after a merger										
Merged in **t-2**	-9.27	-8.15	-23.96	-18.69	-4.60	-13.25	4.11	-0.60	-3.26	-7.15
	(22.76)	(27.29)	(15.25)	(21.96)	(10.30)	(15.20)	(5.49)	(8.00)	(7.47)	(11.14)
Merged in **t-2** * propensity score		70.72		-31.21		130.29		87.25**		99.01
		(189.31)		(130.87)		(81.81)		(40.74)		(72.98)
Propensity score, t-2		-125.03		-35.11		-62.57		-58.79**		-93.47*
		(88.87)		(55.50)		(40.16)		(28.89)		(51.03)
3rd year after a merger										
Merged in **t-3**	4.61	-6.04	-13.65	-2.09	1.57	7.27	-5.64	-13.14	-3.19	-9.27
	(26.50)	(42.50)	(14.19)	(14.96)	(4.65)	(7.68)	(7.29)	(9.72)	(15.57)	(30.22)
Merged in **t-3** * propensity score		201.82		-217.70*		-61.40		153.55		112.94
		(475.00)		(110.32)		(97.04)		(128.55)		(295.18)
Propensity score, t-3		-66.41		69.68		-46.52		-61.38		-53.62
		(97.51)		(59.65)		(62.07)		(46.67)		(44.67)

Notes: The results of 30 separate ordinary least squares regressions are reported in this table. The dependent variable is the change between t and t+1 in a firm performance measure, measured in percentage points relative to the midpoint between the two years. The regressions also include a constant, an indicator for foreign firms, and year indicators. Operating profit is sales minus manufacturing, selling, general, and administrative expenses (operating profit is pre-tax and excludes R&D expenses). The means of the dependent variables and the R^2 values are similar for the regressions analyzing the impact of mergers in the second and third year following the merger. There are about 120 and 240 fewer observations for the latter two sets of regressions.