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THE IMPACT OF CORPORATE RESTRUCTURING ON INDUSTRIAL RESEARCH AND DEVELOPMENT

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ABSTRACT

This paper investigates whether the recent wave of corporate restructuring in the United States has had a negative impact on research and development investment by industrial firms. Using a newly constructed sample of about 2500 manufacturing firms from 1974 to 1987, I examine three major classes of restructuring events: leveraged buyouts and other "going private" transactions, mergers and acquisitions in general, and substantial increases in leverage.

The major conclusions are first, that leveraged buyouts do not occur in R&D-intensive sectors or firms and cannot therefore be having much of an impact on R&D spending; rather, the evidence seems consistent with an agency cost and cash flow-driven model of buyouts. Second, major increases in leverage are followed by substantial declines in the R&D intensity of the firms in question, and the effect takes at least three years to work through. Finally, although the evidence on acquisitions by publicly traded firms is mixed, the basic conclusion is that any declines in the R&D intensity of acquiring firms relative to their past history appear to be associated with the leverage structure of the transaction rather than the acquisition itself.

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I. Introduction

It is a widely held view that the wave of mergers, leveraged buyouts, and restructurings in the corporate sector during the 1980s has had and will have a detrimental effect on industrial spending on research and the development of new products and processes in the United States. Critics of this recent activity point to the stagnation in real R&D expenditures by the private sector during the eighties and suggest that these restructurings are a major cause of the decline.[1] Others view this process as a healthy revitalization of U.S. industry in the face of foreign competition and a changing regulatory and financial environment.[2]

Why are so many people concerned about this increase in restructuring

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[1] See, for example, the National Science Foundation report, "Corporate Mergers Implicated in Slowed Industrial R&D Spending," March 1989, which identified 24 companies among the top 200 R&D performers which had undergone mergers or other restructurings in 1984-1986. The report found that the R&D expenditures of these firms declined by 5.3 percent from 1986 to 1987, while those for the rest of the sample rose by 5.4 percent during the same period.

[2] See, for example, Michael C. Jensen, "Agency Cost of Free Cash Flow, Corporate Finance, and Takeovers," American Economic Review 76 (1986), pp. 323-339, and "Eclipse of the Public Corporation," Harvard Business Review (Sept.-Oct. 1989), pp. 61-74 for arguments of this sort.

activity? After all, the traditional view of economists (at least since the work of Miller and Modigliani)[3] has been that the investment policy of the firm should be independent of its choice of financial structure; one implication of this theoretical result is that the R&D policy of a firm should be unaffected by its choice of leverage. Yet it is clear that many economists and businessmen believe that the increases in debt-equity ratios which are typical of the corporate restructurings and acquisitions of the present day put pressure on the firm to use its cash flow to service the long term debt at the expense of investments, particularly those of a long term nature such as R&D. The argument is that substituting debt for equity substitutes a fixed interest obligation for the optional dividends which were formerly paid to shareholders, thus leaving the discretionary spending of earnings vulnerable to downturns in the industry or economy.

This argument, while superficially persuasive, has several obvious problems: first, if good (high payback) investment projects are available, the firm should be able to finance them by going again to the equity or debt markets when retained earnings are not available. The source of financing for these projects should have nothing whatever to do with whether they are undertaken. Second, if the merger, acquisition, or LBO truly causes good projects to be canceled, the firm should be worth less under the new ownership form, and the shareholders should not have accepted an offer which reflects this lower value, or conversely, the buyers should not have been willing to offer more than the current trading price.

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[3] Franco Modigliani and Merton H. Miller, "The Cost of Capital, Corporation Finance and the Theory of Investment," <u>American Economic Review</u> 48, pp. 261-297, and Merton H. Miller and Franco Modigliani, "Dividend Policy, Growth, and the Valuation of Shares," <u>Journal of Business</u> 34, pp. 411-433..

Most of those who stress the beneficial effect of takeover and restructuring activity would agree with the second of the above arguments, but not the first; that is, they do not rely on Miller-Modigliani in its pure form, but argue that the market values the firm's prospects correctly, but that managers have a tendency to make the wrong (from the point of view of the shareholder) investment choices and thus a firm can be "undervalued" by a market which perceives this fact but is not 100 percent certain that a raider will come along to correct the situation. In other words, they would argue that in many cases, diverting the cash flow being spent on investment projects to interest payments on debt is a good discipline for the firm's managers, since they have a tendency to invest in projects whose return is lower than alternatives which would be available to the firm's shareholders if they instead received the earnings as dividends.[4] An implication of this "efficient markets" view of corporate restructuring is that substantial increases in debt should occur in firms and industries where the available investment projects are low return (such as shrinking, older industries and those without a strong technological base).

Thus there are two different arguments which imply that increases in corporate restructuring, particularly those associated with increases in leverage, will be associated with declines in R&D spending (and investment in general), but these two arguments lead to opposing conclusions as to the social cost or benefit of such changes. The first (optimistic?) view is that financial markets are "efficient", but the managers of firms do not always act in the shareholders' interest (agency costs). Because long-term

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[4]Michael C. Jensen (1986).

debt provides managerial discipline, and the market knows this, we tend to see leveraging occur in industries and situations where good payback projects are not available (i.e., where R&D is low or ought to be). Thus we <u>expect</u> R&D to fall after a (leveraged) acquisition in this story, but this fact has no negative connotation.

The second argument assumes that financial markets are myopic, and do not value long term investments like R&D properly, so that firms which undertake them may be undervalued and provide attractive takeover opportunities. After the takeover event (or the successful defense of a hostile takeover), potentially "good" R&D projects are cut in order to sustain the interest payments on the increased long term debt. The implication of this argument is that market myopia is to blame and that the public good may be served by interfering with the takeover process.

The main distinction between these two lines of reasoning is in the results: both suggest that increases in debt will be followed by cuts in R&D projects, but in the first case this is at the least <u>privately</u> optimal, whereas in the second, R&D projects which have high potential rates of return may be cut. Owing to the fact that we do not observe these projects and their outcomes, it is difficult to see how to choose between these two pictures of the world except by indirect evidence: we can investigate the general question of whether there does appear to be market myopia with respect to R&D investment, or we can explore the characteristics of the actual transactions -- in which industries do they occur, what kinds of projects appear to be cut, is there evidence that R&D is actually being threatened.

There already exist several pieces of evidence to suggest that financial markets are not completely myopic with respect to R&D spending:

these studies are of two different types, a pair of event studies in the finance literature,[5] and a series of total market value studies including R&D capital.[6] The event studies investigate the immediate stock price effect of an announcement of an increase in R&D spending; the argument is that if the market is myopic, the announcement of such a long-term investment project should have a negative price effect because the market expects that short-term earnings will be adversely affected. Jarrell et al. studied 62 firms that announced an increase in R&D spending and found that the average 20-day appreciation in the stock of such firms was 1.8 percent. The Woolridge study controlled more carefully for R&D investment announcements which were accompanied by other earnings news, and still found a 30-day excess return of 1.5 percent associated with R&D increases for 45 such announcements. This evidence argues against extreme market myopia, but a drawback of this type of approach is that it says nothing about whether the size if the market reaction is of the right order of magnitude: does the increase in value of the firm have any connection to the expected present discounted value of the (surprise in) the returns to be generated from this investment increase? If not, the market may still be discriminating against such investments.

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[5]Gregg A. Jarrell, Ken Lehn, and Wayne Marr, "Institutional Ownership, Tender Offers, and Long-Term Investments", (Securities and Exchange Commission, April 1985), and J. Randall Woolridge, "Competitive Decline and Corporate Restructuring: Is a Myopic Stock Market to Blame?" Journal of Applied Corporate Finance 1 (Spring 1988), pp.26-36.

[6]Zvi Griliches, "Market Value, R&D, and Patents," Economic Letters 7 (1981), pp. 183-187; Iain Cockburn and Zvi Griliches, "Industry Effects and Appropriability Measures in the Stock Market's Valuation of R&D and Patents" (NBER Working Paper No. 2465, December 1987); Bronwyn H. Hall, "The Value of Intangible Corporate Assets: An Empirical Study of the Components of Tobin's Q" (NBER and University of California at Berkeley, November 1988).

A similar argument, but one applied to managerial myopia rather than market myopia is presented by Stein:[7] "The more reluctant managers are to invest, the higher will be the present value of those few projects that they do find sufficiently attractive to undertake and, hence, the more positive should be the market reaction to the announcement of a new investment." The same type of reasoning suggests that value-maximizing managers facing a myopic stock market may choose to undertake only very high-return R&D projects, but these would still produce positive announcement effects.

The other type of evidence is a long-term analysis in levels: the basic idea is to regress the total market value of the firm (debt plus equity) on the book value of the assets, both tangible and intangible, arguing that long run equilibrium implies that all the assets should be priced at their book value on average, at least in the cross section. Departures from a coefficient of unity are interpreted as an overpricing or underpricing of the particular asset by the market. The regressions are usually performed with the intangible assets (the stock of R&D capital or patents, advertising, etc.) measured relative to the physical assets, so that the coefficient measures the relative price of such capital (a coefficient of unity is not imposed on the tangible assets). The results here strongly indicate that R&D capital is not seriously underpriced (Cockburn and Griliches obtain a coefficient of around 1.4, while I get about 0.9 using a larger sample of firms for more years; both studies find a coefficient for tangible assets which is insignificantly different from

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[7] Jeremy C. Stein, "Takeover Threats and Managerial Myopia," Journal of Political Economy 96 (February 1988): pp. 61-80.

unity). However, belief that this coefficient represents the market's pricing of R&D investment rests crucially on the choice of depreciation rate used to construct the R&D capital.[8] If the depreciation rate were actually higher than the 15 percent used in both studies (a likely possibility, since for these purposes, the depreciation rate we want measures the decline in the appropriable R&D capital), the true value of the coefficient would be even higher. An interesting finding in both these studies is that the valuation of the current R&D flow is even higher than that predicted by the coefficient of the stock, which does suggest that rapid depreciation is taking place.

Taken together, these pieces of evidence seem to rule out total market myopia towards long-term investment as a reasonable hypothesis; no one who reads the glossy annual reports of high technology companies, which trumpet their R&D spending, would seriously entertain the idea that the market does not value it at all. However, there are limitations to this approach: the event studies do not really tell whether we got the correct order of magnitude, only that the sign was right. The market value studies are flawed in that there is typically a one-to-one relationship between the "depreciation" of R&D and the coefficient of the stock, so that we cannot tell precisely whether financial markets value the R&D stock correctly, but only that they value it.

Thus, in this paper I take a different approach to investigating

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[8]This is not a new point: see, for example, Zvi Griliches (1981). See also Ariel Pakes and Mark Schankerman, "The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Rate of Return to Research Resources," in Zvi Griliches, ed., R&D, Patents, and Productivity (University of Chicago Press, 1984) for a discussion of the evidence on depreciation or decay rates for the appropriable revenues from R&D expenditures.

whether financial markets discriminate against long-term investments (and thus ignore the returns to such investment while encouraging financial restructurings). I focus on the R&D characteristics and outcomes of the actual restructurings which occur, and attempt informally to see which of the two descriptions of the world seem consistent with the facts.

The goal of the paper is to assess the empirical evidence on the implications of corporate restructuring on industrial research spending, focusing specifically on the manufacturing sector of the economy, where most industrial R&D is performed. To this end, I have constructed a new panel dataset for U.S. manufacturing firms from the Compustat files,[9] containing publicly available data on the R&D spending and other characteristics of about 2500 firms from 1959 through 1987 (annual data).[10] I use this file to investigate the actual consequences for R&D spending of the different types of changes in corporate structure which have taken place in the last ten years: mergers and acquisitions, both public and private, leveraged buyouts, and increases in debt levels which are not accompanied by ownership changes. After collecting the evidence, I turn to an examination of what the results can and cannot tell us about the questions posed at the beginning of the introduction.

I. The Trends in R&D and Corporate Restructuring

To set the stage for what follows, I begin by examining the recent aggregate trends in industrial research and corporate restructurings in

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[9] Standard and Poor Corporation, Compustat Annual Industrial, Over-the-Counter and Research Files (New York: Standard and Poor Corporation, 1978-1987 editions).

[10] Bronwyn H. Hall, "The Manufacturing Sector Master File: 1959-1987" (NBER and the University of California at Berkeley, 1989).

order to define more carefully the facts which I would like to explain. In spite of attempts by researchers here and abroad to find better measures of innovative activity, expenditures on Research and Development remain the most widely available and best measured of the so-called "scientific indicators."[11] Since they are also almost the only dàta on innovation available at the firm level at this time,[12] I rely on them exclusively in what follows.

Figure 1 shows three different measures of the level of real industrial R&D expenditures between 1972 and 1987. The solid curve is the total amount of R&D expenditure which industrial firms funded themselves (that is, was not paid for by the government or other source), as reported to NSF.[13,14] The concern raised by the data behind this figure is that while R&D grew at an average rate of close to 7 percent per annum in real

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[11]See the various national and international publications on scientific indicators, e.g., National Science Foundation, Science Indicators (Washington, D.C.: U.S. Government Printing Office, 1987); OECD, Main Science and Technology Indicators (Paris: OECD, various years); Statistics Canada, Canadian Science Indicators (Ottawa: Ministry of Supplies and Services, various years).

[12]In the past, I and coauthors at the National Bureau of Economic Research have also used patent statistics for this purpose [see Zvi Griliches, Ariel Pakes, and Bronwyn H. Hall, "The Value of Patents as Indicators of Inventive Activity," in Partha Dasgupta and Paul Stoneman, eds., Economic Policy and Technological Performance (Cambridge: Cambridge University Press, 1987) for a summary of this work]. Owing both to the fact that we have found patents and R&D to be highly correlated in the cross section in the past, with patents a far noisier measure than R&D, and because budget and time constraints preclude the data construction effort needed to add individual firm patent counts to my new panel dataset, I have chosen not use patents here. I may attempt to incorporate them in future work on this topic.

[13]National Science Foundation, Science Indicators (Washington, D.C.: U.S. Government Printing Office, 1987).

[14]All series on this figure have been deflated by and updated version of the "Griliches-Jaffe" R&D deflator, which is a weighted average of a labor cost index and the implicit price deflator in the non-financial corporate sector (Bronwyn H. Hall, Clint Cummins, Elizabeth Laderman, and Joy Mundy, "The R&D Master File Documentation," NBER Technical Working Paper No. 72, 1988).

terms between 1979 and 1984, the rate of growth has dropped to two percent per annum in the last three or four years; examination of aggregate investment patterns during the same period shows a smaller decline, from a growth rate of four percent per annum to approximately zero.[15] Is this decline related to the increase in corporate restructuring, as some would suggest? Certainly the timing is right: Table 1 shows that the total size (in terms of numbers of employees) of corporate restructurings was roughly constant between 1978 and 1984, and then doubled suddenly in 1985, increasing again in 1986 to three times its earlier level. Before I discuss this table in detail, however, I will digress slightly to describe briefly how it and my dataset were constructed.

Most of the empirical results in this paper are based on the first results from a large dataset construction effort to build a new panel of Compustat firms in manufacturing which contains data from 1959 through 1987 for firms on Compustat during at least one year between 1976 and 1987.[16] This sample consists of about 2500 manufacturing firms which were in existence sometime between 1976 and 1987, augmented by a few non-manufacturing firms which were formerly manufacturing firms or which acquired manufacturing firms during the period. In the course of the construction of this panel dataset, I identified about 1200 firms which had exited by the last year (1987). For all these firms, the reason for exit (type of acquisition, bankruptcy, liquidation, name change, or other reason), the actual year of the event, the stock market value at the time

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[15] Economic Report of the President (Washington, D.C.: U.S. Government Printing Office, 1989), Table B-63, Manufacturing Investment in Plant and Equipment.

[16] Bronwyn H. Hall, "The Manufacturing Sector Master File: 1959-1987."

of exit (acquisition or liquidation price), and the name of the acquirer were looked up in variety of printed sources.[17] After cleaning and checking all the exits, I obtained the final result that about 480 of these had been acquired during the period by other publicly traded firms, about 100 by foreign firms, and about 250 went private through LBO or other transaction. Approximately 130 went bankrupt or were liquidated. The remainder were not true exits, but were name changes or delistings from the stock exchanges.[18]

This list of exits is a key input into the study of corporate restructurings, since all such events which involve an entire firm will appear on this list except for the case where a firm restructures by buying back its stock and issuing a large amount of debt, i.e., by increasing its leverage ratio substantially. Using this dataset, however, I attempted to identify these cases as well, by computing the change in long term debt for each firm from year-to-year and dividing it by the market capitalization of the firm at the beginning of the year (that is, by the sum of debt and equity). Firms with changes in debt which were larger than 75 percent of this number in any one year were deemed to have restructured during that year.

The table shows that acquisitions of all types (where size is

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[17] Key sources are the Wall Street Journal Index (Princeton, N.J.: Dow Jones Books), Capital Changes Reporter (Chicago: Commerce Clearing House), and the Directory of Obsolete Securities (no publisher given).

[18] The delistings are a small fraction of the total (about 30 firms, mostly very small) which generally were delisted because of financial distress (valueless stock) or because shareholder interest fell below the cutoffs imposed by the exchanges; to a great extent, firms of this type exit for another reason such as liquidation or acquisition, but the few which I cannot identify as having done so end up in this class. The name changes and other reorganizations are larger in number (about 200 firms during the period), and for these firms I attempt to splice the data for the reorganized or renamed firm, when I can find it on the file, to that from the old firm. Most of the time I was successful in this effort.

measured by the number of employees) have been increasing in the manufacturing sector during the 1980s, with the increase in acquisitions by privately held or foreign firms occurring somewhat later than the rise in leveraging or acquisitions as a whole. In 1977, only-one half of 1 percent of employment in this sector was affected by these transactions, whereas in 1986 (the last year for which complete data are available) 6.4 percent of employment was.

Does my panel dataset show the same type of aggregate R&D behavior as the NSF numbers? To answer this question, I look again at Figure 1: The top curve is the total R&D expenditure by firms in my sample.[19] The closeness of this series to the NSF data up until about 1984 is a bit misleading, since neither one is a subset of the other: the primary differences are that the NSF numbers include R&D done by non-publicly traded firms, and the Compustat numbers (my sample) contain foreign-performed R&D as well as domestic. I show both series so that one can get some idea of how my sample reflects the economy as a whole. The increasing divergence in the two series is undoubtedly due to the increasing presence of foreign firms on U.S. stock market exchanges and the increasing performance of U.S. R&D abroad (which is included in the Compustat numbers, but not in NSFs).

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[19] Initial analysis of the data for firms in my sample revealed a shortfall of the number of firms with good data in 1987. This turned out to be due to the fact that Compustat had not yet updated the data series for approximately 140 of the 1650 firms in my sample in 1987; those which were missing data were predominantly smaller firms from the OTC file. In order not to bias the interpretation of the trends too much, I have adjusted the 1987 figures to reflect the fraction of the firms which were missing 1987 data, using the employment figures for these firms from the previous year. This yields about a seven percent increase in any totals for 1987, including those in Figures 1 and 2.

To verify this and examine the discrepancies further, in the same figure I show the R&D expenditure for Compustat firms with the expenditures by foreign-owned firms which are included in the database removed (the bottom curve).[20] This series tracks the NSF series very closely until the last two or three years, where it does not show the same type of decline (but remember that the 1987 numbers are partially estimated due to the incompleteness of the sample for this year). The remaining discrepancy is undoubtedly due to the few privately held firms in the United States which report R&D to NSF, but are not required to file 10-Ks with the Securities and Exchange Commission.

Figure 2 shows the same result in a different way: the growth rates of real R&D expenditure from NSF and for the domestic portion of the Compustat sample are very close until 1986, when my data shows less of a decline than NSF; the major remaining discrepancy in the data is due to R&D performed abroad by U.S. firms, which may indeed have been increasing, accounting for the difference between the two sets of numbers. The conclusion to be drawn from these two figures is that my data will be adequate for drawing conclusions about the effects of corporate restructuring on aggregate R&D, although changes in the very recent past may be somewhat imprecisely measured, since the Compustat data shows much less of a decline than the NSF data.

II. Private Acquisitions and Leveraged Buyouts

I begin by examining a type of restructuring that has been

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[20] In 1972, this spending comprised only 3 percent of the total, but by 1987 it had risen to 18 percent, so that including it in the total will seriously bias conclusions about aggregate R&D spending by U.S. firms.

specifically attacked as a major cause of declines in R&D spending, but which turns out to be a very minor part of the story in manufacturing: the "going private" transaction, and in particular, the leveraged buyout. Leveraged buyout is the general term used for a transaction which changes both the ownership and financial structure of a public corporation. In a typical buyout, the firm changes from a public company to one that is privately held by a small group of investors including management, and the equity of the firm is replaced to a large extent by corporate debt held by banks, insurance companies, and other purchasers of high-yield debt. The benefits of this kind of restructuring are held to be twofold: first, for some firms, debt may be a relatively cheaper form of financing than equity, and second, concentrating the ownership of the firm in the hands of a few managers and friendly banks may reduce or eliminate the agency costs which arise when the ownership of the firm is widely dispersed across public shareholders.

Kohlberg, Kravis, and Roberts, an investment firm which assists in a great many of these transactions, summarize their criteria for selecting companies as follows:[21] 1) a history of profitability and steady cash flow, 2) products with well-known brand names and strong market position, 3) low-cost producers, 4) potential for real growth without cyclical swings in profitability, 5) products which are not subject to rapid technological change. Looking over these criteria, the goal seems clear: minimize volatility in earnings and ensure a stable source of rents so that the debt involved can be serviced. These criteria, particularly the last, will not

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[21] Kohlberg, Kravis, Roberts, and Co., "Presentation on Leveraged Buyouts" (KKR, January 1989).

generally select in favor of firms where R&D is important, which increases the probability that the LBO offer will dominate an offer financed in a different manner (under the assumption the markets are efficient, at least at acquisition time).

It is perhaps natural that practitioners of the LBO should focus on the problem of servicing the debt incurred by the transaction and that therefore they should appear to be focused exclusively on the cash flow properties of the asset in question. However, Williamson[22] has provided an alternative, although complementary, view of the motivation of the leveraged buyout. His argument is that the LBO will take place in a firm where the leverage ratio has gotten out of alignment, due to the maturity of the line of business and the size of the tangible assets. Although these characteristics are correlated with smooth cash flow, there are important differences: for example, a major asset of many firms experiencing LBOs is not redeployable, but can be relied upon to generate a steady source of rents. This asset may be loosely labelled "brand name recognition." It is created by a combination of investments, tangible and intangible (advertising), and is likely to be greater in more mature firms.

The assets created by investments in R&D are precisely those which are not very redeployable (and are often difficult to transfer without substantial investments by the receiving firm): the knowledge of how to operate a new process or make a new product. A foreclosing bank is likely to discount an R&D laboratory and the human capital vested in its employees far more highly than it will discount the value of an office building or

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[22] Oliver E. Williamson. "Corporate Finance and Corporate Governance," Journal of Finance 43 (1988), pp. 467-491.

factory full of general purpose equipment. Thus both cash flow and asset specificity considerations argue strongly that LBOs will not take place in firms and industries where R&D is important. In the following I investigate whether that is indeed the case.

In my sample of approximately 700 acquisitions of publicly traded manufacturing firms between 1977 and 1988, I was able to identify about 80 acquisitions as leveraged buyouts using several sources: a list kindly supplied to me by Steven Kaplan, the Wall Street Journal articles reporting the event, and the Merger and Acquisition Sourcebook, which reports the type of financing used to make an acquisition. The remainder of the acquisitions where the acquirer was not another publicly traded firm (about 180 of them) were generally smaller and could not be clearly identified as management or leveraged buyouts, although it is possible that some of them are.

Table 2 shows the total number of acquisitions which occurred in each year between 1977 and 1987 and the number of those which were leveraged buyouts and other "going private" transactions.[23] To give an idea of the increasing size and importance of the LBO, the next five columns show the total employment involved, the average number of employees in each type of deal, and the percent of manufacturing sector employment which was affected. It is clear from the table that the number and size of each LBO have increased during the mid-eighties, while the private acquisitions have remained roughly constant in size (while increasing in number).

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[23] I have excluded from this table transactions in my sample which took place in 1988 and 1989, since this part of the sample is incomplete and would give a misleading picture of the aggregate.

However, note that only in 1987 has the number of employees affected risen above 1 percent of the total. Although a great deal of ink has been spilled about these types of transactions, they are still small relative to the sector as a whole.

Table 3 examines the industrial composition of the LBOs, paying particular attention to the amount of research and development investment involved (the data for the private acquisitions are very similar and are omitted to save space). The first column characterizes the R&D performance of the industry by displaying the average R&D intensity of all the firms within that industry in 1976 (the year the sample was drawn). The next two columns show the number of LBOs which occurred in that industry and the total number of employees involved. It is easy to see from these adjacent columns that industries with high R&D intensity are industries where little LBO activity takes place: There are only seven LBOs (with 70,000 employees) in the six industries[24] where R&D is greater than 2 percent of sales on average, while there are 58 (with over 600,000 employees) in the ten industries where R&D is less than 1 percent of sales.[25]

The final three columns assess the potential impact of these leveraged buyouts on the different industries. The column labelled "Total industrial R&D" gives the spending by all the Compustat firms in the industry in 1982, while the column labelled "R&D in LBOs" gives the R&D spending for each firm involved in an LBO for the year closest to the transaction for which

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[24] Two of these LBOs account for most of the employment acquired in these industries: Revlon, which is not really in a high-tech industry, and Lear-Siegler, an aerospace-automotive-electronics conglomerate.

[25] For the private transactions, the results are even stronger: there are 24 transactions in the six high-R&D industries involving 25,000 employees, but 144 in the ten low-R&D industries involving 467,000 employees.

the data were available (usually one or two years before). These figures have been deflated so that they are all in 1982 dollars for comparability.[26] The percentage figures are intended to give an idea of the importance of the transactions for R&D in any given industry; since the numerator is measured over several years and the denominator is a flow variable (the R&D spending in 1982), these figures are a very rough measure of the importance of the transactions to the R&D of the industry.

These columns show that only in the Textile, Rubber and Plastics, and Stone, Clay, and Glass industries is a significant share of R&D investment even involved in these transactions. In terms of absolute magnitudes, five industries account for over 75 percent of the R&D acquired through LBOs: Textiles, Pharmaceuticals ($100 million of which is the previously mentioned Revlon transaction), Rubber and Plastics, Electronics (the Lear-Siegler buyout), and the Automotive industry. Aside from the Revlon and Lear-Siegler deals, the main story seems to be one in which the leveraged buyout facilitates the shrinkage of an older, low-tech industry.[27] Such industries already have had low R&D spending for a long time, so that increases in LBO activity have very little effect. Another way to see this is to note that the 762,000 employees involved are about 4 percent of the total employment in 1982, while the $471 million of R&D is only 1 percent of the total in 1982. Both the industries involved and the relative unimportance of R&D confirm that LBO activity is largely confined to

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[26] See Bronwyn H.Hall, Clint Cummins, Elizabeth Laderman, and Joy Mundy (1988) for a description of the construction of this deflator.

[27] This fact has already been noted by Steven Kaplan ("Management Buyouts: Evidence on Post-Buyout Operating Changes", University of Chicago Graduate School of Business, 1989) and Frank R. Lichtenberg and Donald Siegel ("The Effects of Leveraged Buyouts on Productivity and Related Aspects of Firm Behavior," Columbia Graduate School of Business and the NBER, 1989).

sectors which are not technologically oriented.

Although I would like to study the subsequent history of those firms which went private via leveraged buyouts, this is difficult because in many cases they no longer must file 10-Ks with the SEC (this is in fact one of the stated reasons for going private). In spite of this fact, Kaplan[28] has found that for at least some of these LBOs it is possible to find publicly-reported post-buyout data. For his sample of about 40 LBOs, he finds that only seven are even performing R&D, before or after the buyout.[29] Using an entirely different sampling methodology (the establishment-based Census of Manufacturing coupled with data from the previously mentioned NSF RD-1 Survey), Lichtenberg and Siegel[30] have analyzed the 43 firms which underwent LBOs between 1981 and 1986 and also were surveyed by NSF.[31] They found that the R&D intensity of those firms which were <u>performing R&D</u> increased by roughly the same amount as non-LBO firms during the same period, although the average intensity of even the R&D-doing firms which underwent LBOs was half that of the sample of R&D performers as a whole. This last fact is consistent with my results.

The major conclusion from this part of the investigation is that restructurings which take manufacturing firms private do not pose a major threat to R&D investment in the United States. This is not because R&D is necessarily maintained at the same levels after such transactions (which

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[28] Steven Kaplan (1989).

[29] Steven Kaplan, private communication, 1989.

[30] Frank R. Lichtenberg and Donald Siegel (June 1989).

[31] Their sample of entire-firm LBOs between 1981 and 1986 consists of 80 LBOs which account for about 70 percent of the aggregate LBO value during that period. Although there is undoubtedly substantial overlap with my sample of 62 during the same period, the samples will not be identical.

often do involve increased levels of debt), but because R&D-intensive firms and high-technology industries are not good candidates for these acquisitions. In addition, the limited evidence we have does suggest that even in those cases where an R&D-performing firm does undergo a leveraged buyout, the newly private firm maintains the same pattern of investment. These facts, together with the Lichtenberg and Siegel results on productivity increases following LBOs,[32] lend credence to the "efficient markets" view of at least this type of restructuring activity. In the next section I move on to look at a far more important set of acquisitions, those by other publicly traded firms, which affect three times as many employees as those discussed in this section of the paper.

III. Acquisition Activity in the Manufacturing Sector

In previous work[33] I investigated the relationship between the increase in acquisition activity in the U.S. corporate sector in the early eighties and R&D investment using a large panel of U.S. manufacturing firms. I found that the manufacturing sector acquisitions from 1976 to 1986 fell into two main groups: half were acquired by firms in my sample (the publicly traded manufacturing sector), and half by private or foreign firms. The latter group were disproportionately in low-tech industries (most of which are low-growth also), and accounted for only fourteen percent of the total R&D that was acquired and less than one percent of the

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[32] Lichtenberg and Siegel (June 1989). They find significant increases in productivity growth at the plant level in the five years following an LBO, and substantial reductions in Central Office overhead expense, which argues for the efficiency-enhancing aspects of these transactions.

[33] Bronwyn H. Hall, "The Effect of Takeover Activity on Corporate Research and Development," in Alan J. Auerbach, ed., Corporate Takeovers: Causes and Consequences (Chicago: Chicago University Press, 1988), pp. 69-96.

total R&D in the manufacturing sector. We have already seen that this characterization of at least the private acquisitions holds when I extend the period examined through 1987.[34]

I then went on to investigate what happened afterwards in the sample of acquisitions which remained in the publicly traded sector. Using a sample of about 300 acquisitions, I calculated the change in R&D intensity for the combined firm pre- and post-merger (over two and three year intervals). There was no significant evidence of declines in spending, although the relatively short intervals after merger and small samples at the industry level made the tests somewhat less than conclusive. The same question was also studied by Fusfeld[35] using a much smaller (9 observations) sample of significant financial restructurings, and he reached the same conclusion. In both studies, there is evidence that longer periods after merger should be examined. In addition, the recently completed study of 24 major mergers and restructurings by the National Science Foundation previously cited[36] provides evidence of a substantial decline in R&D spending after acquisition or other restructuring. All of this suggests that the question is worth further investigation.

Why are the NSF results different from mine and Fusfeld's? There are

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[34]The acquisitions by foreign firms are a different matter; the total size of these transactions in the two years 1986 and 1987 was the same as in the previous ten years, and their R&D and industry profiles are more like that of the public acquisitions now, although somewhat less R&D-intensive. They appear to be driven by the increasing globalization of the economy rather than by the desire to increase leverage.

[35]Herbert I. Fusfeld, "Corporate Restructuring: What Impact on U.S. Industrial Research?" Research Management 30 (July-August 1987), pp. 10-77.

[36]National Science Foundation (1989).

several possibilities: as mentioned above, they use a different data source (the RD-1 survey conducted for them by the Census Bureau, which is confidential), the period they examine is somewhat more recent, they focus specifically on restructurings which are not necessarily acquisitions, and they use a different measure of R&D performance, the level of R&D expenditures rather than R&D intensity. It is unlikely that the differences between the two data sources for R&D spending, the 10-K report and the RD-1 survey, will be systematically biased, although they are undoubtedly different.[37] However, as Lichtenberg and Siegel[38] point out, the NSF sample consisted of one major LBO and seven other restructurings in addition to 16 acquisitions, so the samples are not directly comparable. The most important difference is that NSF used the level of R&D investment rather than the intensity, which I would argue is misleading, since it fails to adjust for the overall change in the average size of manufacturing firms during the same period. The discrepancy is magnified both because the majority of these restructurings seem to be directed at shrinking the firms and because the overall size of the manufacturing sector was shrinking at the same time.

My previous study used data on acquisitions which took place before 1987 and my panel actually ended in 1985, so I was not able to track

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[37]These differences have been discussed earlier; at the individual firm level, the primary differences are that the NSF numbers do not include R&D spending by U.S. firms abroad, nor do they include contracted out research or some routine engineering expenditures (National Science Foundation, A Comparative Analysis of Information on National Industrial R&D Expenditures (Washington, D.C.: U.S. Government Printing Office), Special Report 85-311). None of these differences (which affect a subset of the firms, mostly the larger ones) are likely to be large enough to change conclusions about R&D growth in firms undergoing acquisition.

[38]Frank R. Lichtenberg and Donald Siegel, June 1989.

post-acquisition R&D for mergers which took place in 1985 and 1986 very well. Therefore I now repeat my earlier test for post-acquisition declines in R&D intensity using the 480 acquisitions in my new sample. The distribution of two year changes in combined-firm R&D intensity for firms which participated in mergers and for those who did not is shown in Figure 3. For firms which were not acquired, the average two-year change over the whole 1976 to 1987 period is used.

The figure shows both the changes for all firms, including those which report no R&D during the period, and then the changes only for those firms which do have R&D data both before and after the acquisition.[39] The top part of the figure tells a slightly different story from my 1987 paper: there does appear to be a significant difference between the distributions for mergers and non-mergers. This is confirmed by a non-parametric Wilcoxon test for differences in the distribution, which yields a $\chi^2(1) = 9.5$. The difference between the two distributions is small, but it is significant. However, it does not occur when we confine the sample to those firms which reported R&D both before and after the acquisition; for the bottom panel of the figure, the Wilcoxon test yields a $\chi^2(1) = 0.5$. This implies that most of the decline is coming from R&D-doing firms which are absorbed into firms which do not report R&D.[40]

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[39]Firms are mandated both by the Financial Accounting Standards Board and by the SEC to report R&D expenditures in their Annual Reports if they are "material". Most of the firms in the technology sector do so, particularly since they view it as a positive signal for investors. When R&D is not reported, it usually means that the R&D to sales ratio is very low. However, there can be exceptions to this rule for some firms in some years; for the small number of cases where this happens for one year out of many with positive R&D, I have interpolated the missing number.

[40]There are about 80 such firms in the sample, and about 50 firms which did not report R&D before being acquired, but whose acquirers did afterwards. The number of acquirers which switch from reporting R&D to non-reporting or

To examine this result more precisely and to investigate whether it has changed over time, I perform a simple comparison of means, while controlling for differences across industry and time in the average firm R&D intensity. That is, I ask the question: How does the R&D intensity of those firms in my sample which acquired other firms differ in the years immediately following the transaction from that of other firms in the same industry during the same period? I regress the R&D intensity for each firm-year observation on a set of industry and year dummies and on dummies for whether this particular firm is zero, one, two, or three years away from having acquired another firm in my sample. This regression is performed with the hypothesized "acquisition" effect assumed constant over all the years, and also allowing it to vary from year to year. If the acquisition mix is changing over time, this latter method is required to avoid biasing the estimates of the effect. It also will tell us whether the difference in my results with data through 1985 and 1987 is due to a shift in behavior.

The results of these regressions are shown in Figure 4 and summarized in Table 4. The top half of this table shows results for all the firms in all the years, treating any observations which have no R&D data as zero-R&D observations (which most, but not all of them will be). The average effect is negative and it increases as we go one or two years out from the

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vice-versa around the time of acquisition is about 30, with a larger number electing to stop reporting (20) than start (10). Thus more firms choose to treat R&D spending as non-material after acquisition than switch to reporting it, which leads to a small decline in average R&D intensity when we include these firms. However, the probability of making a reporting switch, conditional on the state in which the firm finds itself before acquisition, is the same for either non-reporting or reporting, so it is difficult to know what to conclude from this.

acquisition, reaching almost one half of one percent in the second year after the acquisition. However, even in this year the coefficient is not significant at conventional levels (a t-statistic of 1.6) and the individual year effects are widely varying and all insignificant. The predominant effect appears to be negative, but there is huge variability in R&D performance even within an industry, and this dominates the estimates of the differences of the means. To put it concisely, the summary F-statistic for an acquisition effect on R&D intensity is $F(38,20137) = 0.45$ when I measure individual year effects or $F(4,20171) = 1.70$ when I constrain the effect to be the same for all vintages.

If I include the firm's own lagged R&D intensity instead of using industry dummies to predict the average expected level, the effects are even smaller and less significant. However, the first lag of R&D intensity occurs during the year in which the acquisition took place, which may be an atypical year for the firm's data. Therefore, in Table 4 I also show the results for R&D intensity lagged twice (using the year before acquisition to control for the acquiring firm's average R&D to sales ratio). The results are closer to those I obtain when I only control for the R&D intensity of the firm's two digit industry; whether I control only for industry, or for the specific firm, I obtain a similar result: the R&D intensity appears to decline after acquisition, but by an insignificant amount.

In spite of the statistically insignificant results, Figure 4 tells a different story: this figure shows how the difference in mean R&D intensity between acquiring and non-acquiring firms evolves over time relative to the firms' two-digit industry. The four lines are the effects 0 to 3 years from the date of the acquisition. A pattern clearly emerges from this graph: the acquisitions in the later years are followed by far greater declines in R&D intensity and the declines appear to be permanent, in the sense that they do not become any smaller even three years after the acquisition. Although still insignificant, the declines are quite large in economic terms, a change of intensity of more than one percent in some years.[41]

Because of the near constancy of the effect over several years after the acquisition, I chose to constrain the acquisition effect to be permanent, that is, to permanently lower the expected R&D intensity of the acquiring firm. These results are shown in Figure 5, where I compare the R&D intensity relative to that of a firm's industry and to its own lagged intensity. The pattern here is quite striking: over time, the R&D to sales ratios of acquiring firms are falling substantially, but when we control for the past R&D to sales ratio of the firm itself, there is no such decline (for one lag) or only a small effect (for two lags). This suggests that the mix of firms performing acquisitions during the period from 1977 to 1987 is shifting toward those which have low R&D intensity relative to their own industry.

What should we conclude from this? Even if we concede that the methodology is flawed because we cannot assume a one way causal relationship

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[41] This graph reveals that the lack of conventional statistical significance may be due to the inadequacy of the probability model I am using to construct the test. However, the major defect in my model is that I treat each firm-year as a random draw net of time and industry effects, rather than allowing for correlation across years for each firm; one expects that allowing for such correlation would actually lower the significance level rather than raising it. One can get an idea of what the result would be in that case by looking at the test-statistics for the regression where I include the firm's own lagged R&D intensity (the second, third, fifth, and sixth lines of Table 2), which is almost like including a fixed firm effect in the model.

between the making of an acquisition and the R&D intensity of the firm in succeeding years (since both are aspects of a particular corporate strategy of a particular firm), the fact remains that evidence of a large systematic decline in R&D <u>intensity</u> post-acquisition is difficult to find in a statistical sense, but seems to be visible in the data. A glance at the estimated differences in R&D intensity by year and time since acquisition in Figure 4 does suggest the following: 1) there may be a negative effect during the nineteen-eighties (a succession of negative coefficients), even though the earlier period is mixed, and 2) what effect there is appears to be cumulative, since it is still growing slightly in the second year after the merger. Figure 5 helps to reconcile this result with my earlier Wilcoxon test for differences in the growth of R&D intensity between acquiring and non-acquiring firms, since it shows that it makes a big difference how finely one controls for pre-acquisition R&D intensity, that is whether one uses firm or industry levels. It would clearly be desirable to augment the results for mergers in 1986 and 1987 through 1988 and 1989 in order to clarify the rather murky results in those years.

These hints of decline in R&D intensity post-acquisition during the eighties lead me to ask the following question: Unlike the small NSF and Fusfeld studies, neither this investigation nor my previous one[42] explored the differences between acquisitions undertaken with various kinds of financing. The arguments given earlier imply that the source of the problem (if there is one) is the associated change in the leverage ratio of the acquiring firm. To investigate this question, I computed the total

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[42] Bronwyn H. Hall (1988).

change in debt for the acquiring firm (including the debt taken on from the acquiree) between the beginning and end of the year in which the acquisition took place. I then divided this change in debt by the total equity value of the seller at the time of acquisition, i.e., the price paid by the buyer. This quantity is a kind of leverage ratio for the acquisition itself if the acquisition was the main investment undertaken by the firm during the year. It will be approximately zero if no new debt was incurred to finance the transaction, and approximately one if the transaction was completely financed by debt.

The dispersion of these leverage ratios was very wide,[43] suggesting that some acquisitions account for a relatively small portion of the changes in debt levels experienced by the acquiring firms from one year to the next. One implication of this fact is that this calculated leverage ratio is a relatively blunt instrument with which to identify leveraged acquisitions. Investigation of the buyer and seller in a sample of these transactions during the relevant year in the Wall Street Journal Index found that only 12 percent could clearly be identified as acquisitions financed by debt; in an equal number of cases, the acquiring firm was in financial trouble for other reasons and had increased its leverage by taking out new financing. Many of them were too small to be mentioned, or there was no evidence that the acquirer made any special financial arrangements for the acquisition. If the acquisitions are relatively unimportant to the overall acquiring firms, we have to ask ourselves

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[43]The mean was 0.65 with a standard deviation of about 3, while the median was -0.2, owing to a large number of observations with a slight decline in debt in the transaction year. Over one third of the observations had debt changes which were greater than the value of the acquisition in absolute value (46 negative and 92 positive).

whether the focus on acquisition-induced leverage is misdirected. It may be that the real question we are interested in is the overall effect of leverage, whether acquisition-induced or not; this is explored in the next section.[44]

I then compared these leveraged acquisitions to the leveraged buyouts discussed earlier. Does the type of firm acquired determine the financial structure of the acquisition, regardless of whether the acquirer is private or public, or do the LBOs have particular characteristics which can be attributed to the fact that they are also management buyouts -- that is, the new owners are former managers who may have particular information about the firm and how it should be managed. The acquisitions by public firms on the other hand, are more likely to be driven by synergistic considerations than by the benefits of debt restructuring; the choice of debt as a means of finance may be a secondary consideration determined by the type of firm being acquired. A table similar to Table 3 (not shown) confirmed that the two types of leveraged transactions are quite different: the 84 leveraged acquisitions are considerably smaller than the LBOs in Table 3, they involve higher R&D relative to their size (about twice as much per employee), and they are scattered across all industries, with a slight majority in cyclical capital equipment industries. From this evidence, it appears that the forces driving LBOs are not the same as those which cause these types of acquisitions. The most likely reason for the lack of similarity is that leverage in this case is only occasionally

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[44]The acquisitions themselves were distributed across a wide size range. Although half of them were less than 14 percent of the combined firm, about one quarter were larger than 30 percent. The average size was 20 percent, so they were not negligible with respect to the acquirer.

related to the acquisition itself. In the next section I try a different approach to estimating the effect of acquisition-induced leverage.

IV. Leverage and R&D

Earlier I suggested two commonly stated hypotheses which would imply a negative relationship between corporate restructuring and R&D investment, only one of which seemed to call for a policy response. There is an intermediate position, in which financial markets are "efficient" in the sense of pricing firms correctly conditional on the information available to them, but where problems of asymmetric information between the managers of a firm and its shareholders or potential shareholders lead to less than optimal outcomes for the investment policy of the firm. A decline in R&D associated with an increase in leverage may result in this world also, and it may indeed be the case that our current financial structure (including the tax system) discriminates against these types of intangible investments.

Why might leverage be particularly negative for R&D investment? Many authors have suggested reasons why the cost of external capital (debt or equity) may be higher for R&D projects than for physical investments. Leland and Pyle, and Kihlstrom and Matthews have argued that there is a moral hazard problem in transferring information about a risky project from an entrepreneur (firm) to investors (shareholders or debt holders), which leads to a preference for retained earnings as a source of finance for this type of investment.[45] Bhattacharya and Ritter have shown that if there is a

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[45]Hayne E. Leland and David H. Pyle, "Informational Asymmetries, Financial Structure, and Financial Intermediation," Journal of Finance 32 (1977): pp. 371-387; Richard Kihlstrom and Steve Matthews, "Managerial Incentives in

cost to revealing information about innovative projects to the market (and hence, to potential competitors), firms will also find the cost of external capital higher than that of internal finance.[46] In the case of debt finance, there is an additional problem, since banks (and other bondholders) often prefer some sort of tangible security which can be sold in the event of default. In cases where retained earnings are not available, such as new startups, substantial equity shares (in the form of venture capital), not long-term bonds, are the rule.

These arguments, together with the empirical evidence on liquidity and investment, both old and new,[47] restore the link between investment and the source of finance which was broken by Modigliani and Miller. They also imply that the cost of external finance, especially debt, will be higher when investment projects are more uncertain, produce fewer redeployable assets, have knowledge externalities, and are subject to more severe asymmetric information problems between owners and managers. All of these factors imply that internal finance will be more preferred for innovation and R&D investment than for ordinary investment; an implication of this fact is that an exogenous increase in the fraction of earnings devoted to interest expense, such as that caused by an increase in long term debt, will penalize these types of investments.

The difficulty of investigating this hypothesis in the data available

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Publicly Traded Firms" (University of Pennsylvania, 1984).

[46]Sudipto Bhattacharya and Jay R. Ritter, "Innovation and Communication: Signaling with Partial Disclosure," Review of Economic Studies L (1985): pp. 331-346.

[47]For example, John R. Meyer and Edwin Kuh, The Investment Decision: An Empirical Study (Harvard University Press, 1957); Steven M. Fazzari, R. Glenn Hubbard, and Bruce C. Petersen, "Financing Constraints and Corporate Investment," Brookings Papers on Economic Activity 1(1988): pp. 141-206.

to us is that investors are not unaware of this link between investment and financial policy and a finding that leverage decreases R&D investment may only mean that that particular firm at that particular time is facing a set of investment opportunities which do not have high payback potential and reducing R&D while increasing debt may indeed be the optimal policy, at least privately. In spite of this problem, I still believe it is worthwhile to investigate firms where substantial increases in leverage occur; full consideration of this simultaneity problem awaits further work.[48]

My approach to gathering the facts on leveraged restructurings is similar to the one I followed for acquisitions in Section IV: I define a leveraged restructuring as a firm-year where the increase in long term debt is greater than 75 percent of the total market value of the firm (debt plus equity) in the beginning of the year. There are 177 such restructurings; their (size-weighted) distribution by year was shown in the last column of Table 1. Unlike the other types of restructurings, these refinancings show two period of increased activity, the early 1980s and after 1985.

In Table 5 I display the industry and R&D characteristics of the firms involved in such restructurings. Unlike the LBOs shown earlier, these transactions take place in all types of industries, although there does seem to be a preference for those which are relatively capital intensive (chemicals, petroleum, stone, clay, and glass, machinery, motor vehicles, and aircraft), confirming the importance of redeployable assets in debt

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[48] It is not simply a problem of simultaneity of the leverage and investment decision; the problem is also that individual firm rationality in this setting may not be socially optimal, since we are dealing with a type of investment which has been shown repeatedly to have substantial externalities.

financing. The firms in question are less R&D-intensive than the others in their industry (compare the fraction of industry employment with the fraction of industry R&D) with two exceptions: the chemical industry, where DuPont took on large amounts of debt to finance the Conoco acquisition in 1981,[49] and the automotive industry, where almost all of the total is the restructuring of Chrysler Corporation in 1980-1982. Thus even here, we see that the unsuitability of high leverage for R&D-intensive firms may be having an effect.

I then go on to perform the same kind of investigation into post-transaction R&D intensity as I did in the case of manufacturing sector acquisitions. Specifically, I compute the average R&D intensity of leveraging firms 0 to 3 years after the transaction, relative to the firms in their industry. These differences in mean, which are again very imprecisely determined, are shown in Figure 6. It is not surprising that they are negative, since we already saw that these firms were relatively less R&D intensive, but the absolute magnitude, particularly after 1983, is rather startling: a difference of 2.5 percent in R&D intensity is a fifty percent difference in R&D if the average level is 5 percent of sales (which is typical of R&D-doing firms).

The figure also shows that the difference in R&D intensity is essentially permanent: the curves for 1, 2, and 3 years out lie almost on top of each other, and are larger than that for the year of leveraging. I therefore treat the effect as permanent in the same way I did the acquisition effect, in order to reduce the sampling variability, and

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[49] This debt was later paid down fairly quickly and R&D in the combined company increased both in level and as a percent of sales from 1981 to 1985 (Fusfeld, 1987).

compute it relative to the firm's own lagged R&D intensity in order to see if there really was a decline. This is shown in Figure 7, which reveals that the largest differences shown in Figure 6 are due to the differences between leveraging and non-leveraging firms in pre-transaction R&D intensity. When I control for the firm's own behavior, however, I still show a decline in R&D spending which is roughly constant throughout the period, and is on the order of magnitude of one half of one percent of sales.[50] The individual year effects are still jointly insignificant, but the overall decline has a t-statistic of 3.0 (remember that neither of these tests is completely valid, owing to the lack of independence across observations).

Throughout this analysis I have treated leveraging analogously to acquisitions, as though it were a discrete event, in order to compare the results directly. However, the change in the leverage for these firms is actually distributed as a continuous variable, for which I have arbitrarily chosen a cutoff of .75 to define a restructuring.[51] Ideally I would like to use the full information in the leverage variable, but it is difficult to know how to incorporate it in the absence of a fully specified model for the investment-financing choice. My solution is shown in Table 6: I regress the R&D intensity of all the firms on the first three lags of the leverage changes; the coefficients in this regression are the percent

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[50] Both Figure 6 and Figure 7 use only data for R&D-performing firms, about 11,000 firm-year observations; the results are very similar if I use all 19,000 observations, treating firms which do not report R&D for one or more years as having zero R&D during those years.

[51] To check the results, I also used .5 as a cutoff. As expected, the negative coefficients were slightly smaller and more precisely measured due to the larger sample. This suggest that using a continuous variable as I do in the following may be a better idea.

change in R&D intensity per an absolute change in leverage ratio. I have again included year, industry, and the lagged R&D intensity for the firm as controls.

The results are quite interesting: whether we look at all firms or only R&D-doers, R&D intensity falls following an increase in leverage. The full effect is about 0.75 and it takes at least three years to work (using the numbers in the second and fourth columns). At the cutoff change in leverage which I was using earlier, this is an absolute change of 0.56 percent in the R&D-to-sales ratio, which is consistent with Figure 7. For a typical R&D-doing firm with an R&D-to-sales ratio of 3.7, this would imply a decline in R&D spending of about 15 percent, which is not negligible. Of course, most firms in most years do not experience this kind of leverage increase, so that the aggregate declines will not be huge.

In this regression, I also investigated the role of acquisitions by including a dummy for firms which had acquired one of the firms in my sample during the past three years, and also interacting that dummy with the change in leverage, to see if there was a separate additive effect from acquisitions (the results on leverage were not significantly affected by including these variables, so I only show the combined regression). The basic conclusion from the regression is that the acquisition effect we saw in Figure 5 is largely accounted for by controlling for changes in leverage. The F-statistic for including these variables is very insignificant, partly because the coefficients are so poorly measured. Leverage does not appear to have any greater effect when it is associated with making an acquisition, a fact which is not too surprising once we know it.

The conclusion from this part of the investigation is that declines in

R&D intensity do seem to follow after restructurings which increase leverage, and that the small declines after acquisitions which I found earlier may be associated with increased leverage rather than the acquisition per se. Although this fact is interesting, and is consistent with anecdotal evidence, the data have not yet told us whether the foregone projects are ones that should have been funded.

V. Conclusions and Discussion

I begin my discussion of what we can conclude about the effects of corporate restructuring on R&D by summarizing my empirical results. First, I find that leveraged buyouts and other private acquisitions of publicly traded manufacturing firms are taking place overwhelmingly in sectors where R&D investment and innovation have not been important, at least to the industry as a whole. The industries and firms in question are those with the steady cash flow necessary to service the debt (they are largely smaller firms in the consumer nondurable industries: Food, Textiles, the auto parts sector of the Motor Vehicle industry, the tire sector of the Rubber and Plastics industry, and Miscellaneous Manufacturing) or those which have been downsizing for some time under pressure from foreign competition and reduced innovative opportunities (Textiles again, Fabricated Metals, and Stone, Clay, and Glass).

The total amount of R&D involved in ten years worth of transactions is 767 million dollars, a small fraction of the 40 billion-dollar industrial R&D budget in 1982. Even if this R&D were to be cut drastically, it would have little impact on total spending. In fact, although this R&D disappeared from my aggregate statistics since the firms went private (and ceased to report to the SEC), I cited evidence from Kaplan and Lichtenberg and Siegel that these firms did not reduce their spending as a result of the transaction in any case.

The second finding was less clear: there was mixed evidence as to whether acquiring firms in the publicly traded manufacturing sector reduced their R&D intensity as a result of the acquisition. Firms involved in acquisitions seemed to experience permanent declines in their R&D intensity relative to other firms in their industry, but this effect was stronger in the later part of the period than in the earlier, and was partly due to the fact that the mix of firms making acquisitions shifted toward firms with lower R&D intensities during the eighties. Although the statistical evidence was weak, the size of the effect was large in economic terms, amounting to a one-half of 1 percent decline in R&D intensity for those firms engaged in R&D (that is, from an overall mean of 3.4 percent to 2.9 percent) for the 1982 to 1987 period. This decline did seem to be associated with the more leveraged of the acquisitions, lending credence to arguments that cash flow impacts R&D spending.

Finally, the most dramatic results of restructuring were found in those transactions where a firm moves to a substantially higher debt position than it had been in before; here the size of the decline in R&D intensity was about 0.8 percent (from 3.4 to 2.6) for the 1982 to 1987 period. It appeared that the declines after acquisition could also be attributed to increases in leverage, although the results on this question are very imprecise, in spite of the large samples involved. This statistical imprecision serves to remind us that the overwhelming characteristic of a sample of firms is the variability of their experiences and the number of factors actually involved in predicting outcomes; of necessity, I have focused only on a limited part of the story.

Does this result, that increased leverage is associated with declines in R&D spending at the firm level, explain the decline in industrial R&D spending in the late eighties? The answer to this question is "probably not," for several reasons. First, for these firms there were two periods of substantial leverage increase during the period in question, 1977 to 1980, when the average change in leverage over all firms was about 0.04, and 1986-1987, when the change was about 0.037. During the earlier period, R&D spending overall was growing substantially. Even in the later period, the decline in overall R&D spending implied by this kind of leverage increase is about one-half of 1 percent, which will not account for the observed decline in growth rates.

However, these results are suggestive. Regardless of whether you believe that leverage is efficiency-enhancing or that it leads to a decline in productive investment, the link between leverage and reduced R&D spending has been established. I would interpret the fact that the more extreme forms of leverage increase (LBOs and other such transactions) are occurring in industries not normally considered innovative and the fact that they seem to have other efficiency benefits as evidence that the agency cost hypothesis is the correct one, and that these transactions are beneficial on the whole. On the other hand, I would argue that R&D spending in general may be an unintended victim of the drive to shift the source of financing toward debt, because its particular characteristics make it unsuited to that type of corporate environment. The evidence presented here supports this hypothesis, but far more work needs to be done before we can clearly identify the problem and say what the solution is.

Table 1

CORPORATE RESTRUCTURING IN THE PUBLICLY TRADED MANUFACTURING SECTOR

Year	Total Employment (1000s)	Employment (1000s) in Public Acquisitions	Foreign	Private	LBOs	Leveraging*
77	20863.	66.0	1.3	10.4	0.6	30.7
78	21107.	191.8	46.9	17.9	0.0	22.5
79	21935.	311.3	11.9	15.5	1.3	58.7
80	21284.	152.8	24.8	1.6	13.6	150.4
81	20880.	310.0	15.6	42.4	19.4	142.6
82	19806.	186.2	38.3	49.6	35.2	256.0
83	20138.	298.0	0.0	14.9	33.1	33.9
84	20034.	188.0	2.2	104.7	93.5	73.6
85	19279.	382.7	111.4	52.1	132.9	146.9
86	18526.	656.3	190.5	84.1	172.6	116.1
87	17898.	179.9	201.4	63.9	247.6	113.5
Total		3017.6	728.1	456.9	748.8	1144.9
Average size (1000s employees)		6.4	7.7	2.6	9.7	6.5

* Leveraging firms are those whose increase in long-term debt in any one year was greater than 75% of the sum of their debt and equity at the beginning of the year.

Table 2

LEVERAGED BUYOUTS IN THE MANUFACTURING SECTOR: 1977-1987

	Number of			Average Employment in		% of Total Employment in	
Year	Acquisitions	LBOs	Other Private	LBOs	Private	LBOs	Private
1977	29	1	6	0.6	1.7	0.003	0.05
1978	59	0	11	--	1.6	--	0.08
1979	48	1	8	1.3	1.9	0.006	0.07
1980	41	2	2	6.8	0.8	0.07	0.01
1981	71	3	16	6.5	2.6	0.10	0.20
1982	63	8	17	4.4	2.9	0.17	0.25
1983	68	9	13	3.7	1.1	0.16	0.07
1984	89	19	26	4.9	4.0	0.47	0.52
1985	96	12	28	11.1	1.9	0.69	0.27
1986	117	11	27	15.7	3.1	0.93	0.45
1987	99	11	19	22.5	3.4	1.46	0.38
Total	780	77	173	9.7	2.6		

The columns labelled "Private" are acquisitions where the acquirer was not publicly traded, but the acquisition could not be identified as a leveraged buyout in any of my sources.
The employment figures in columns 5 and 6 are in 1000s of year-round employees.

Table 3

LEVERAGED BUYOUTS BY INDUSTRY: 1977-1987

Industry*	Industry R&D to sales ratio**	No. of LBOs	Employment (1000s)	Total industrial R&D in '82	R&D in LBOs (1982 $)	% R&D in LBOs
Food & kindred prods.	.160%	11	142.4	917.0	30.7	3.3%
Textiles & apparel	.169	16	203.2	73.0	60.2	82.[illegible]
Chemicals, excl. drugs	1.80	1	6.3	4033.6	2.4	0.06
Pharmaceuticals & med. instr.	4.87	4	31.5	3556.4	113.5	3.2
Petroleum refin. & extrc.	.337	0	--	3548.2	--	0.0
Rubber & misc. plastics	.915	6	53.4	733.4	63.5	8.7
Stone, clay, & glass	.372	3	62.2	263.0	21.7	8.3
Primary metals	.269	2	10.0	370.4	4.2	1.1
Fabricated metal products	.563	8	32.0	331.6	12.8	3.9
Engines, farm & const. equip.	1.37	4	21.5	1125.2	31.4	2.8
Computers, off. & acct. equip.	5.32	0	--	7858.5	--	0.0
Other mach., not electric	1.58	7	15.1	617.3	10.7	1.7
Electric equip. & supplies	4.40	1	1.4	2891.5	1.1	0.04
Electronic equipment	3.44	1	29.7	5902.3	35.5	0.6
Motor vehicles & trans. equip.	.766	4	95.5	2969.5	69.6	2.3
Aircraft & aerospace	2.02	0	--	3249.6	--	0.0
Prof. & sci. equipment	4.10	1	3.5	746.5	9.5	1.3
Lumber, wood, & paper	.342	3	7.1	701.8	0.6	0.09
Miscellaneous manufacturers	.340	5	16.8	448.1	3.2	0.7
Total	1.82	78	761.5	40,341.9	470.6	1.2

* The industry definitions are given in Appendix A.

** The R&D to sales ratio for the industry in 1982 is shown.

Table 4

POST-ACQUISITION R&D INTENSITY

Dependent Variable: R&D/Sales (percent)

20,204 observations (includes non-R&D doers)

Other variables in the equation	Dummy if acquisition occurred: This year	1 year prior	2 years prior	3 years prior	F* Statistic
Year dummies, industry dummies	-.233(.191)	-.313(.205)	-.358(.228)	-.249(.254)	1.70
Year dummies, $(R/S)_{-1}$	-.079(.113)	-.142(.122)	-.147(.135)	-.017(.150)	0.72
Year dummies, $(R/S)_{-2}$	-.191(.144)	-.215(.155)	-.273(.172)	-.147(.191)	1.61
11,774 observations (R&D-doers only)					
Year dummies, Industry dummies	-.597(.293)	-.773(.314)	-.875(.354)	-.780(.388)	4.73
Year dummies, $(R/S)_{-1}$	-.182(.180)	-.276(.193)	-.331(.218)	-.140(.239)	1.35
Year dummies, $(R/S)_{-2}$	-.373(.225)	-.436(.241)	-.583(.272)	-.415(.298)	2.96

* This is the F-statistic for a test that the four acquisition effects are zero.

Table 5

FINANCIAL RESTRUCTURINGS WITH SUBSTANTIAL DEBT-EQUITY CHANGES**
1977-1987

Industry*	Number	Employment (1000s)	% industry employment	R&D (1982 $)	% industry R&D
Food & kindred prods.	14	32.0	1.6	1.7	0.2
Textiles & apparel	11	63.0	10.8	3.3	4.5
Chemicals, excl. drugs	5	138.5	10.5	546.3	13.5
Pharmaceuticals & med. instr.	5	46.2	5.7	109.6	3.1
Petroleum refin. & extrc.	5	224.9	13.1	400.9	11.3
Rubber & misc. plastics	7	8.1	2.0	0.3	0.04
Stone, clay, & glass	5	30.6	11.6	30.5	11.6
Primary metals	11	30.3	4.0	1.8	0.5
Fabricated metal products	9	15.3	3.2	5.4	1.6
Engines, farm & const. equip.	7	13.0	3.0	20.5	1.8
Computers, off. & acct. equip.	7	65.0	5.4	278.1	3.5
Other mach., not electric	18	90.9	18.4	113.7	18.4
Electric equip. & supplies	8	29.3	1.9	13.5	0.5
Electronic equipment	6	2.8	0.2	3.5	0.06
Motor vehicles & trans. equip.	9	168.5	10.4	460.9	15.5
Aircraft & aerospace	5	88.2	7.6	102.7	3.2
Prof. & sci. equipment	2	2.2	0.4	0.0	0.0
Lumber, wood, & paper	14	21.5	2.8	10.1	1.4
Miscellaneous manufacturers	29	69.3	2.8	1.6	0.4
Total	177	1144.9	5.8	2099.8	5.2

* The industry definitions are given in Appendix A.
** A restructuring is defined to be a firm whose long-term debt increases in one year by more than 75% of the total market value of the firm.

Table 6

R&D INTENSITY AND CHANGES IN LEVERAGE

1977-1987

Variables	Incl. non-R&D Doers (16,498 obs.)		R&D-Doing Firms Only (9982 obs.)	
	Leverage Effect for All Firms			
ΔLev^{*}_{-1}	-.38(.15)	-.19(.10)	-.51(.27)	-.33(.18)
ΔLev_{-2}	-.29(.15)	-.24(.10)	-.23(.27)	-.27(.18)
ΔLev_{-3}	-.31(.14)	-.15(.10)	-.33(.26)	-.19(.18)
	Acquiring Firms Post-Acquisition (Relative)			
Intercept	-.08(.14)	-.03(.09)	-.39(.21)	-.18(.14)
ΔLev_{-1}	-.06(.49)	-.18(.33)	-.36(.86)	-.13(.60)
ΔLev_{-2}	-.13(.47)	0.02(.32)	-.74(.84)	-.26(.58)
ΔLev_{-3}	-.16(.48)	0.11(.32)	-.43(.90)	0.21(.62)
Other vars in regression	Year dummies, Ind. dummies	Year dummies, R/S_{-2}	Year dummies, Ind. dummies	Year dummies, R/S_{-2}
Standard error	3.29	2.22	3.95	2.74
F-statistic** (DF)	0.06 (4,16462)	0.09 (4,16479)	0.26 (4,9946)	0.10 (4,9963)

The dependent variable is the R&D-to-sales ratio of the firm in each year.

* ΔLev is the change in long term debt during the year divided by the total market value of the firm (debt plus equity).

**This is the F-statistic for a test that the hypothesized acquisition effects are zero in a regression which also includes the leverage variables.

FIGURE 1

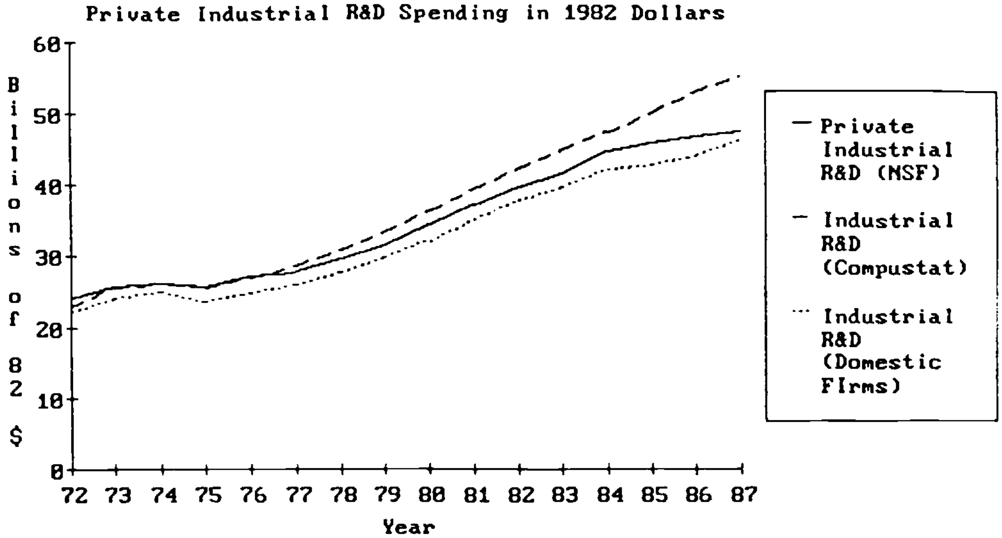


FIGURE 2

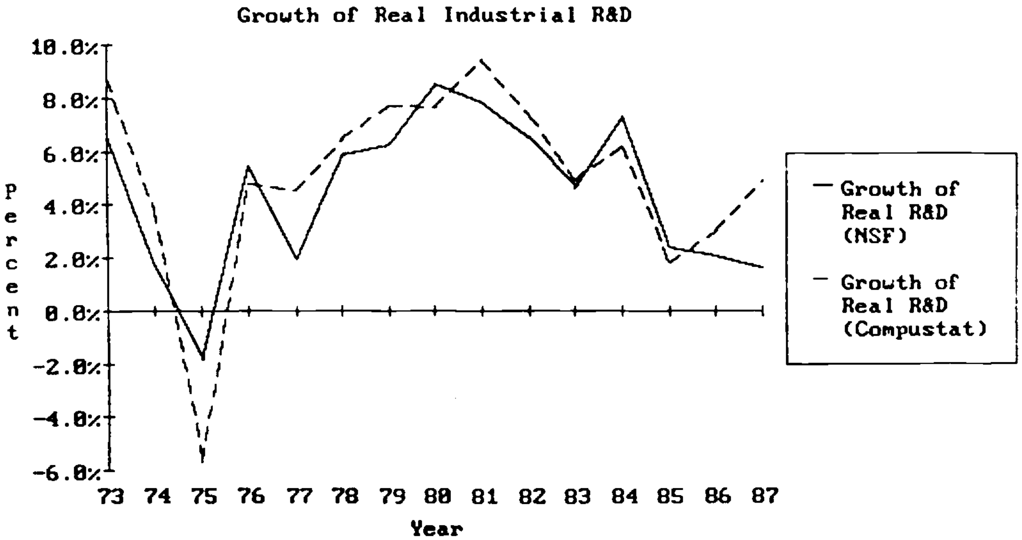
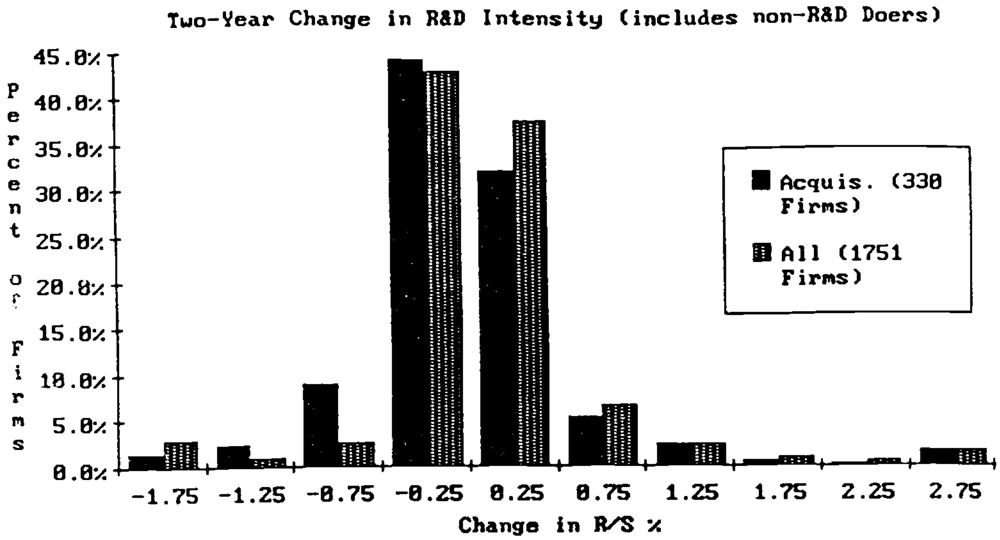
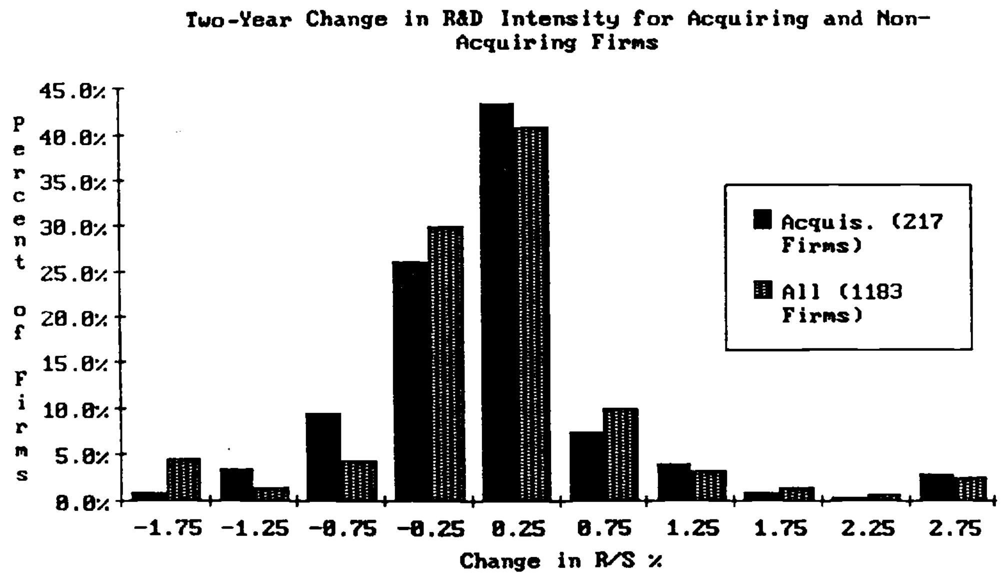


FIGURE 3



Two-Year Change in R&D Intensity (includes non-R&D Doers)
Percent of Firms
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Acquis. (330 Firms)
All (1751 Firms)
-1.75 -1.25 -0.75 -0.25 0.25 0.75 1.25 1.75 2.25 2.75
Change in R/S %



Two-Year Change in R&D Intensity for Acquiring and Non-Acquiring Firms
Percent of Firms
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Acquis. (217 Firms)
All (1183 Firms)
-1.75 -1.25 -0.75 -0.25 0.25 0.75 1.25 1.75 2.25 2.75
Change in R/S %

FIGURE 4

R&D Intensity of Acquiring Firms Relative to Industry

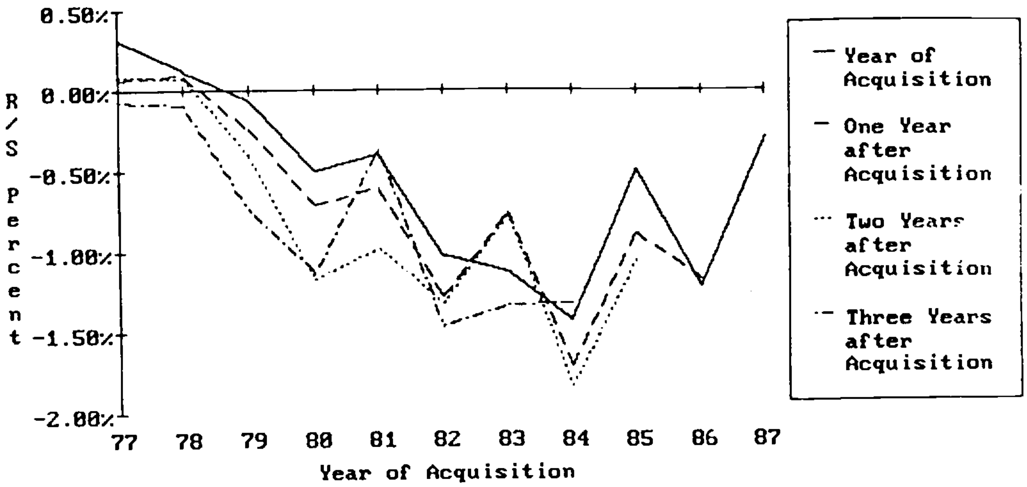


FIGURE 5

R&D Intensity of Acquiring Firms Post-Acquisition

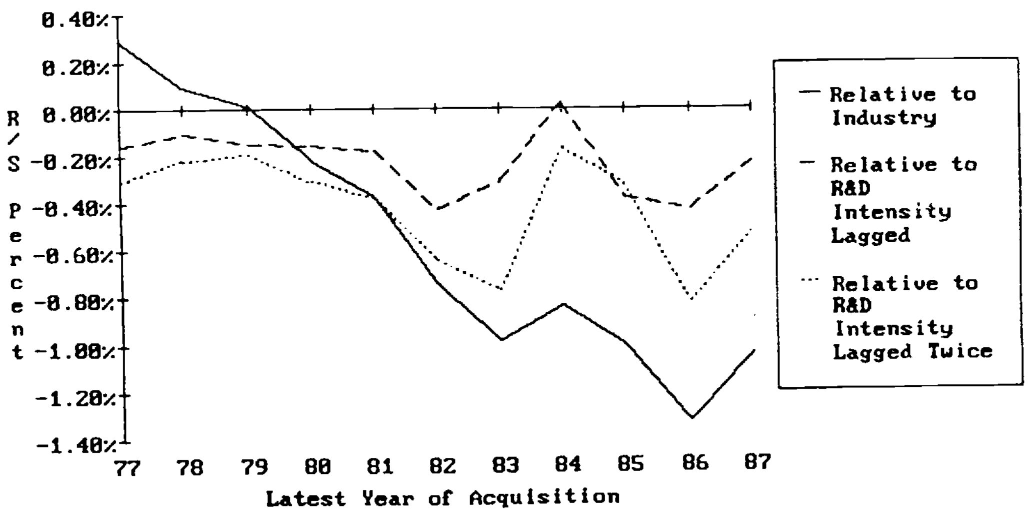


FIGURE 6

R&D Intensity of Leveraging Firms Relative to Industry

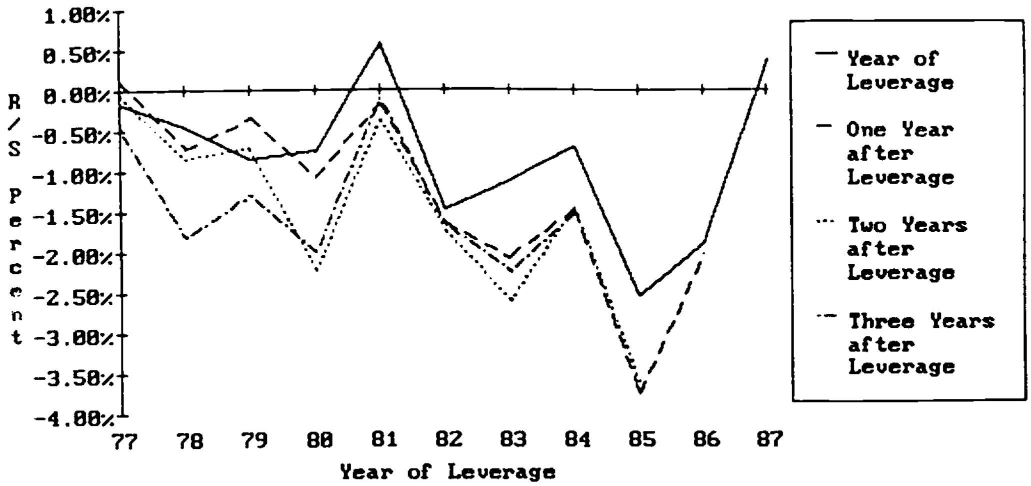
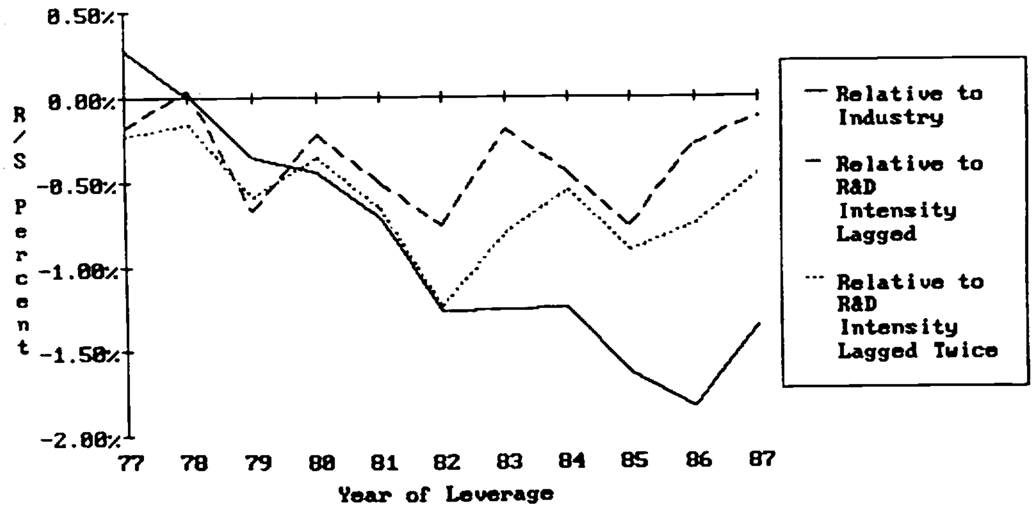


FIGURE 7

R&D Intensity of Leveraging Firms Post-Leveraging



Appendix A

COMPOSITION OF INDUSTRY CLASSES

Industry	Included SIC groups
Food and Kindred Products	20
Textiles and Apparel	22, 23
Chemicals, excluding Drugs	28, excluding 2830, 2844
Pharmaceuticals & Medical Equipment	2830, 2844, 3841, 2843
Petroleum Refining and Extraction	29
Rubber and Miscellaneous Plastics	30
Stone, Clay, and Glass	32
Primary Metals	33
Fabricated Metal Products	34, excluding 3480
Engines, Farm & Construction Equipment	3510-3536
Office, Computer, & Accounting Equipment	3570, 3573
Other Machinery, not Electric	35, excluding 3510-3536, 357
Electric Equipment and Supplies	36, excluding 3650-3679
Electronic Equipment	3650-3679
Motor Vehicles & Transportation Equipment	37, excluding 3720-3729, 3760
Aircraft and Aerospace	3720-3729, 3760
Professional and Scientific Equipment	38, excluding 3841, 3843
Lumber, Wood, and Paper	24, 25, 26
Miscellaneous Consumer Goods	21, 31, 3900-3989, 3480
Miscellaneous Manufacturers, N.E.C.	27, 3990