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LBOs, DEBT AND R&D INTENSITY

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This paper deals with the impact of debt on R&D intensity for firms undergoing a leveraged buyout (LBO). We develop seven hypotheses based on capital market imperfection theories and agency theory. To test these hypotheses, we compare 72 R&D performing LBOs with 3329 non-LBO control observations and 126 LBOs with little or no R&D expenditures. The regressions yield four statistically significant major findings. First, pre-LBO R&D intensity is roughly one-half of the overall manufacturing mean and two-thirds of the firm's industry mean. Second, LBOs cause R&D intensity to drop by 40 percent. Third, large firms tend to have smaller LBO-related declines in R&D intensity. Fourth, R&D intensive LBOs outperform both their non-LBO industry peers and other LBOs without R&D expenditures.

Ever since Modigliani and Miller (1958) argued that with perfect capital markets the source of financing was irrelevant, scholars have wrestled with the impact of a firm's capital structure on corporate behavior. Although past research has focused on numerous strategic and financial variables, the impact of debt on research and development has received an unusual amount of attention. This is because R&D plays a critical role in determining productivity growth and long-run firm performance. Also, R&D has many of the characteristics that make it susceptible to capital market imperfections.

Most theories predict a negative relationship between debt and R&D intensity. However, the theories draw different conclusions concerning the implications of this relationship. One set of theories, citing moral hazard, asymmetric information and transaction cost problems, suggests that high debt can prevent firms from raising funds for productive R&D projects. Another school, relying on agency problems, emphasizes the incentives for some firms to overinvest in R&D. In this view, debt can help reduce unproductive expenditures.

The leveraged buyout wave of the 1980s provides a natural laboratory for testing these theories and their distinct views. Never in recent history has such a large number of diverse firms so dramatically changed their capital structure. The typical LBO pushed debt to total capital ratios to over 90 percent. The 1980s witnessed over 2000 LBO deals, representing roughly $250 billion in assets. Unlike traditional causes of large rapid debt increases, such as financial distress or large acquisitions, the change in capital structure was the primary goal of these LBO, not a secondary consequence of other events.

Several researchers have investigated the impact of LBOs on firm performance. Virtually all studies praise LBOs for their ability to improve operating performance or cash flow management (Kaplan, 1989; Lichtenberg and Siegel, 1991; Long and Ravenscraft, 1992a; Singh, 1990; Smith, 1991). Offsetting these impressive gains are two potential drawbacks. First, the significant number of LBOs—particularly those in the later 1980s—experienced

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financial distress. Second, the initial profit increases may come at the expense of longer run performance. For example, Kaplan (1989) and Long and Ravenscraft (1992b) uncovered statistically significant declines in postbuyout capital expenditures. However, this decline may also reflect an inefficiently high level of prebuyout capital expenditures.

Little research has focused on the impact of LBOs on R&D. Smith (1991) found sharp declines in R&D expenditures, but only for the five firms in her samples reporting R&D expenditures. Lichtenberg and Siegel (1991), using the National Science Foundation (NSF) RD-1 survey data collected by the U.S. Bureau of the Census, found a statistically insignificant decline in postbuyout R&D. However, the data they employed was contaminated with imputation problems, data errors and a survival bias that may explain the lack of statistical significance. No research has gone beyond the simple average tendencies in R&D intensity surrounding the LBO. Theory identifies conditions that accentuate or mitigate the R&D decline, providing richer tests of the R&D/capital structure relationship. In addition, the link between declines in R&D and longer run performance must be assessed to distinguish between competing theories and to draw policy conclusions.

Related research has investigated the general relationship between debt and R&D. Hall (1990) employed a large sample of COMPUSTAT firms and an R&D series she developed from the COMPUSTAT data. For the period 1977–87, she regressed change in debt on the level of R&D intensity and changes in R&D intensity. For both levels and changes, she found that debt lowered R&D intensity with a 1 year lag. Baysinger and Hoskisson (1989), using a sample of 971 COMPUSTAT firms reporting in 1980–82, demonstrated a strong and statistically significant negative relationship between the level of long-term debt to assets and the level of R&D/sales. These general analyses have costs. The cause of the debt change is unknown. The decline in R&D is not surprising if the increased debt is the result of financial distress. Hambrick (1985) showed that the financial controls employed in turnaround situations cause cuts in discretionary expenditures like R&D.

Debt also tends to increase around large acquisition and diversification programs (Michel and Shaked, 1985). Both of these factors have been linked to declines in R&D expenditures. Hitt *et al.* (1991) compared 191 large acquisitions occurring between 1970 and 1986 with a control group of COMPUSTAT firms. They found that acquisitions lowered both R&D and patent intensity. After controlling for size and industry factors, a negative relationship between the level of diversification and R&D or patent intensity has been found by some researchers (Hoskisson and Hitt, 1988; Baysinger and Hoskisson, 1989), but not others (Jose, Nichols and Stevens, 1986).

The relationship between debt and R&D warrants significant attention. Increases or decreases in technological change can quickly swamp any static short-run gains or loses in efficiency. In fact, the focus of U.S. managers on short run performance has been blamed for the decline in U.S. global competitive advantage (Hayes and Abernathy, 1980; Hill, Hitt and Hoskisson, 1988). Numerous authors have lent support to this claim by establishing a direct link between a drop in U.S. R&D and a decline in technological change or long run performance. For example, Franko (1989) showed that the drop in U.S. R&D spending below foreign competitors was a major cause of the decline in U.S. firms' global market shares. Scherer (1984, Chapter 15) using the disaggregated FTC line of business data and a unique division of R&D into origin and user industries, found a significantly positive relationship between users of R&D and productivity growth. Scherer estimates that the slowdown in R&D in the early 1970s led to a 0.2 to 0.4 percentage points per annum decline in productivity growth during the late 1970s. These findings have led to concerns that hostile takeovers and LBOs might have had a similar effect on R&D and productivity in the 1980s (Dertouzos, Lester and Solow, 1989).[1]

This paper presents a detailed analysis of the impact of debt on R&D for a sample of 72 LBOs reporting R&D expenditures to the NSF

[1] For example, Dertouzos, Lester and Solow state, 'We find irresistible the inference that the wave of hostile takeovers and leveraged buyouts encourages or enforces an excessive and dangerous overvaluation of short-term profitability' (p. 144). They go on to say that an 'important way in which American business can provide for the long term is through investment in R&D' (p. 145). However, another Nobel Prize winner reaches a different conclusion. Miller (1991) comments that 'They (the wider public) worry that these short-run gains (from LBOs) may represent merely the improvident sacrifice of opportunities for high, but long deferred profits— an argument presuming, among other things, that the market cannot properly compute discounted present values' (p. 480).

RD-1 survey and accounting data to the Quarterly Financial Report (QFR). The 72 LBOs occurred between 1981 and 1987. We compare the LBOs to a sample of 3329 non-LBO observations who also report to both data sources. We investigate four basic issues. First, is the prebuyout R&D intensity of LBO firms different from other R&D reporting firms? Second, does the high debt force LBO firms to cut back R&D expenditures? Third, how do other factors, such as size, diversification, restructuring, management commitment and buyout motivation, affect the impact of debt on R&D? Fourth, do R&D savings come at the cost of longer run performance? The answers to these questions sharpen our understanding of the relationship between debt and R&D intensity. They are also critical to a full evaluation of the long run performance of LBOs.

THEORETICAL CONSIDERATIONS

Modigliani and Miller (1958) argued that a firm's capital structure should not affect its investment decisions. A large body of literature has arisen citing numerous reasons why this argument is incorrect, particularly for investment in R&D. According to this literature, internally generated funds are more conducive to R&D investment than external funds. If external funds are needed, the investment in R&D will be greater with equity financing. Debt financing, therefore, is inappropriate for firms where R&D is a critical component of competitiveness.

Two main factors differentiate research in this area. First, articles cite different types of capital market imperfections (both external and internal) that lead to a market failure in R&D financing. Second, the literature expresses two distinct views on the policy implications of the negative relationship between debt and R&D. Much of the literature focuses on factors that would inhibit a firm's ability to finance productive R&D projects (i.e., those projects that yield positive net present value). We refer to these as capital market imperfection theories. However, others argue that some firms have incentives to overinvest in R&D. For these firms, debt can improve firm productivity and social welfare by restricting these unproductive R&D projects. This view falls under the general rubric of agency theory.

There are numerous reasons why debt might prevent a firm from engaging in productive R&D. Myers (1984) focuses on the asymmetric information between the firm's management and external funding agencies. Insiders have superior information about R&D projects that is difficult to reveal to the capital markets. For example, revealing this confidential information can provide an important signal to competitors (Bhattacharya and Ritter, 1983). Even announcing that an R&D project is being undertaken may provide the competition with valuable information. This asymmetric information creates a pecking order where internal funds are preferred to external sources of capital.

Debt financing of R&D projects is also difficult because of potential moral hazard problems (Leland and Pyle, 1977). Debt providers are hesitant to fund risky projects because they bear the downside risk and not the upside gains. Thus, Smith and Warner (1979) conclude that increased debtholder power will create risk-averse managers.

Debt imposes strict rules on corporate governance. When these rules are violated, management and debtholders must renegotiate or enter bankruptcy. Williamson (1988) concludes that debt is more appropriate when the transaction costs of negotiations are low. Transaction costs are a function of asset-specificity. When a firm's assets are easily redeployed (low asset-specificity), debtholders have the option of requiring asset sales or liquidation. Assets that are specialized are not easily sold to another firm. The costs of transferring these assets are high. R&D can be highly specialized and firm specific.[2] To renegotiate, bondholders would need detailed information to decide which projects are worth continuing and at what funding level. Bondholders also are concerned that much of the firm's capital is in the form of human capital, scientists and engineers. It is difficult to write contracts that will ensure that key individuals will stay in the face of funding cut backs. Equity funding, which does not require renegotiations even when dividends must be cut, is more appropriate when asset specificity is high.

For large multidivisional firms, debt affects the workings of the internal capital market. Williamson (1975) argues that internal capital markets can be more efficient than external markets when management employs an M-form

[2] Harrison *et al.* (1991) note that in some cases R&D can be transferred between firms.

structure. He emphasizes the benefits of bureaucratic controls in forming common goals and encouraging the flow of information. However, bureaucratic controls are not the only method for monitoring divisional managers. Hitt and Hoskisson (1990) discuss two other types of controls—strategic and financial. Strategic controls encompass a broad evaluation of divisional managers' plans, including the industry's attractiveness and the competitive reaction. With financial controls, senior management employs primarily objective performance criteria like return on investment when evaluating business unit managers' performance. The distinct divisional organization of the M-form struc ture makes monitoring by financial control possible.

Hitt and Hoskisson (1990) theorize that financial controls may lead to a short-term focus by divisional managers for two reasons. First, return on investment can be increased in the short run by cutting back on long-term investments like R&D. Second, business unit managers cannot diversify employment risk leading to managerial risk aversion. Unless managers are explicitly rewarded for taking such risk, they will avoid high risk, high return R&D projects. Strategic controls, on the other hand, are better able to encompass subjective criteria that reward appropriate risk taking. Therefore, strategic controls are more conducive to R&D investment.

Hitt *et al.* (1991) hypothesize that the use of financial controls is positively correlated with debt, diversification and size. As debt increases, senior management is forced to focus on short-term cash flow goals to meet interest payments. Financial controls are a natural way of transferring these cash requirements to individual divisions. Strategic controls require detailed subjective information. As the number and size of especially unrelated divisions increase, the ability of management to gather and comprehend these subjective variables decreases. Thus, financial controls tend to be used in large diversified organizations.

Hitt *et al.* (1991) also hypothesize that significant events, like acquisitions, absorb substantial managerial energy. This leaves less time for managers to focus on other strategic matters, including innovations. In case studies of LBOs, managers often comment on the time and energy put into meeting debt payments.[3] As with acquisitions, this managerial energy absorption may detract from managers focusing on R&D projects.

A final reason LBOs might reduce productive R&D stems from the tax incentives that are often available to R&D performing firms. Since the debt eliminates tax payments for many LBO firms, tax breaks for R&D are not effective. The loss of tax breaks will turn some R&D projects into negative net present value projects, reducing R&D intensity.

Most of the above theories assume that management will invest only in productive R&D. Therefore, a market failure that prevents R&D funding is detrimental to the firm and society. A long line of research argues that managers may have the incentive and discretion to pursue their own goals at the expense of shareholders. Formalized in terms of agency theory by Jensen and Meckling (1976), this literature dates back to the concepts of the separation of ownership and control (Berle and Means, 1932) and the growth maximization hypothesis of Marris (1963). Jensen (1986) extended these ideas to the concept of 'free cash flow', defined as cash flow over and above what is needed for all positive net present value projects in the firm's opportunity set. If managers are acting in shareholders' interest, they will return all free cash flow to shareholders. A problem exists when managers use the firm's free cash flow to invest in perks or pet projects, including possibly R&D investments.[4]

Debt is a tax efficient way of distributing free cash flow to shareholders. The interest payments

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[3] For example, Ravenscraft and Scherer (1987) included numerous divisional leverage buyouts in their sample of 15 divisional sell-offs. They found that postbuyout, most firms seized previously unexploited cost-cutting opportunities. However, this cost-savings focus sometimes hurt maintenance, R&D and advertising. 'In five engineering-oriented companies, R&D budgets were cut back—in two cases totally, in one case sharply, and in another through the stretch-out of ongoing projects... Most of the interviewees who had made such cuts expressed unease and hope that, once their debt burdens became lighter through repayments, they would be able to invest more in future-building activities' (p. 155).

[4] There are numerous ways that management can abuse free cash flow. They can overinvest in marketing, capital, employment or R&D. The role of cutbacks in capital and employment in LBOs is explored in Long and Ravenscraft (1992b) using plant data from the Census Bureau's Longitudinal Research Data Base operated by the Center for Economic Studies.

commit future cash flows to the bondholder and constrain managers from pursuing unprofitable ventures. Jensen argues that LBOs focus on firms with large free cash flows. Any cutbacks in post-LBO capital expenditures or R&D stem from inefficiently high levels of these expenditures pre-buyout. Several researchers have confirmed that LBOs do focus on firms with above average prebuyout cash flows (Lehn and Poulsen, 1989; Singh, 1990). Studies have also shown a drop in postbuyout capital expenditures (Kaplan, 1989; Long and Ravenscraft, 1992b). However, the impact on R&D from committing a substantial part of cash flow to interest payments has not been fully explored.

In sum, debt is a double edged sword, with both edges cutting R&D. The front edge constrains managers, who may not be acting in shareholders' interests, from investing in negative net present value R&D projects, and it forces cancellation of such projects begun before the debt increase. The rear edge also constrains managers, because capital market imperfections exist for R&D, so that productive R&D projects are foregone or eliminated. Which edge of the sword is sharper can only be determined empirically.

HYPOTHESES

Pre-LBO R&D intensity

Both capital market and agency theories suggest that a high level of debt is not expected for firms with strong technological opportunities. Capital market imperfection theories argue that these firms will have trouble raising the required capital if they are highly leveraged. Agency theory suggests that these firms will lack the free cash flow that warrants restricting managerial discretion with debt. Scherer (1984) and Cohen and Levinthal (1989) show that R&D and technological opportunity are highly correlated at the industry level. Therefore, LBOs should avoid firms in industries with high R&D intensity. These will be firms with high R&D intensity relative to the overall manufacturing average.[5]

H1: Capital market imperfections and agency theory predict that—before the buyout—LBO firms should have R&D to sales ratios significantly lower than the average manufacturing firm.

Change in debt and changes in R&D intensity

The theories relating R&D and debt discussed in the theoretical section are unanimous in arguing that the dramatic increase in LBO debt will lead to a decline in R&D intensity. Thus, a core hypothesis must be that LBOs cause R&D intensity to drop. As noted, this decline does not distinguish between theories nor does it indicate whether a firm's competitiveness has increased or decreased. However, a precondition for further testing is that LBO firms find it difficult to sustain the pre-buyout level of R&D after the LBO. Our central hypothesis is:

H2: For those firms with prebuyout R&D, R&D intensity will decline significantly after the buyout.

Factors affecting the intensity of the R&D/sales decline in LBOs

Average tendencies reveal only part of the story. Richer insight can be gained by testing the conditions affecting the LBO related R&D/sales decline. These conditions include the prebuyout degree of financial vs. strategic control, the motivation for the buyout, and management's continued commitment postbuyout.

Several authors emphasize the role of strategic and financial controls. As firm size or diversification increases, information processing becomes more complex. Bounded rationality further limits management's ability to fully assimilate the information received. Williamson (1975) argued that the M-Form structure will mitigate the potential negatives of a large organization. While recognizing the advantages of the M-form over the U-form structure, other authors see potential problems with internal market allocations (Hayes and Abernathy, 1980; Hill *et al.*, 1988; Hoskisson and Turk, 1990). They argue that even with the M-form structure, controls are needed to

[5] Investing more in R&D intensity than the firm's industry average has not been clearly linked with higher technological opportunity. Therefore, in testing Hypothesis 1, we compare firm R&D intensity to the overall manufacturing industry average rather than the average for the firm's specific industry.

effectively oversee the divisional managers and some of these controls can cause nonoptimal behavior among these managers. In addition to the bureaucratic controls discussed in Williamson's work, Hitt and Hoskisson (1990) analyze strategic and financial controls. Increases in firm size or diversification limit a firm's ability to employ strategic controls. They require rich, subjective, detailed information that is hard to acquire and assimilate when the firm is large or diversified. Thus, as size and diversification increase, firms tend to switch to financial controls. Financial controls emphasize objective measures like return on investment, which in the short run can be increased by cutting longer run investments like R&D. This can cause divisional managers to be more risk-averse and to reduce their commitment to innovation. Hitt *et al.* (1991) find strong support for a negative relationship between diversification and R&D intensity or patent activity, but no consistent relationship between size and these two measures of innovations.

A leveraged buyout is an extreme form of financial control. Cash flow is king after the buyout, resulting in financial controls taking precedence over strategic controls. The buyout induced change in control should be most dramatic for firms that stress strategic controls before the buyout. Since these firms tend to be smaller or more focused firms, they should experience the largest LBO related declines in R&D.

Agency theory implies a different relationship between R&D and size or diversification. The separation between ownership and control generally grows with size and diversification. In fact, extensive unrelated diversification is often a consequence of managers pursuing growth at the expense of shareholder equity. The positive correlation between senior management pay and size reinforces growth goals over profit maximization. Large diversified firms, therefore, are more likely to overinvest in R&D, resulting in more pronounced declines in R&D postbuyout.

These two perspectives lead to the following two-tailed hypotheses:

H3a: Financial vs. strategic control theory predicts a positive relationship between size and the LBO related change in R&D. Agency theory predicts a negative relationship between size and the LBO related change in R&D.

H3b: Financial vs. strategic control theory predicts a positive relationship between diversification and the LBO related change in R&D. Agency theory predicts that this relationship should be negative.

Some LBOs attempt to pare down debt by selling off divisions. The post-LBO debt constraints will be less severe for these firms. This should lead to smaller declines in R&D for the remaining divisions. However, capital market imperfection theories also suggest that high R&D intensive divisions will be targeted for divestiture. Firm R&D intensity would decline, because of the loss of these divisions, not because of cutbacks in R&D. An additional consideration is the potential change from financial to strategic control caused by the restructuring. Hoskisson and Turk (1990) hypothesize that corporate restructuring creates a better balance between strategic and financial controls. They confirm this hypothesis by showing that R&D intensity increases after a restructuring. Since most of the theories predict a positive relationship, our next hypothesis is:

H4: Post-LBO divisional sell-offs will counteract the LBO related decline in R&D.

Several authors have argued that managers have an escalation of commitment to past actions (Schwenk, 1984). Managers have a natural tendency to resist admitting that one of their past decisions was in error. Boot (1992) derives an explicit theoretical model showing that this escalation of commitment leads to managers hanging on to losing divisions. Ravenscraft and Scherer (1991) show that managers do not divest divisions until their performance has declined dramatically over several years. They also demonstrate that the probability of divesting a unit increases significantly with a change in management. One of the motives of LBOs is to force existing managers to correct past excesses. However, the escalation of commitment hypothesis suggests that these corrections will be facilitated by a change in management. Existing managers are more likely to stay committed to ongoing research projects than new managers. In a management buyout (MBO), the prebuyout managers agree to take an equity position in the LBO. Therefore, MBOs should lead to smaller declines in R&D intensity.

H5: There is a positive relationship between MBO and the change in R&D intensity.

Agency theory is often applied to hostile takeovers (Jensen, 1986; Mørck, Shleifer and Vishny, 1988). Hostile takeovers are assumed to target managers who are not acting in the shareholders' interest and are misusing free cash flow. These managers would have the highest propensity to overspend on R&D. This leads to the following hypothesis:

H6: The LBO related decline in R&D intensity is strongest when the LBO is preceded by a hostile takeover threat.

Financial performance impact of the R&D/sales decline

To fully distinguish between the capital market imperfection and agency theories, we must look beyond the changes in R&D and towards the consequence of any R&D decline. According to financial market imperfection theories, the substantial increases in debt surrounding the LBO will prohibit the LBO firm from funding positive net-present value projects. Eventually these cuts will hurt firm performance. The long run performance of firms with sharp declines in R&D intensity should be less than those capable of maintaining R&D. Conversely, agency theory argues that debt will constrain the firm from investing in negative net-present value R&D projects. Therefore, the cutbacks in R&D will not come at the expense of longer run profits. Since agency theory predicts a zero (or negative) relationship between changes in R&D and profits, we use it as the null hypothesis, implying:

H7: Capital market imperfection theories predict a positive relationship between LBO related changes in R&D and LBO related changes in performance.

RESEARCH DESIGN

Sample

The sample consists of the intersection of three datasets needed to test the above hypotheses. The datasets include a comprehensive list of whole company LBOs and two confidential data files, the NSF RD-1 data and the Quarterly Finance (QFR) data. The U.S. Bureau of the Census collects and maintains the latter two files. Figure 1 contains a venn diagram showing the number of non-LBO and LBO observations in each dataset and in their intersections.

The foundation for the comprehensive list of LBOs and their characteristics was the ADP/MLR Publishing M&A Data Base, which contains numerous items on LBOs completed since January 1981. We augmented this list with names of LBOs kindly supplied by Hall (1990), Lehn and Poulsen (1989), Lichtenberg and Siegel (1991), Kaplan (1989), Singh (1990) and Smith (1991). We identified 600 whole company LBOs between 1981 and 1987. For each LBO, we searched the *Wall Street Journal* for a 3-year period before and after the LBO announcement. Information on the announcement and completion dates, the value of the transaction, senior management ownership, management participation in the deal, the number of bidders, prior hostile activity, acquisition and divestiture activity, and several other data items were coded.

R&D data were obtained from a data base at the Census Bureau on detailed company R&D activity. The primary data are collected by the Bureau for NSF. The data base contains primarily whole company data on a large number of R&D related variables for all companies with a minimum R&D expenditure of between

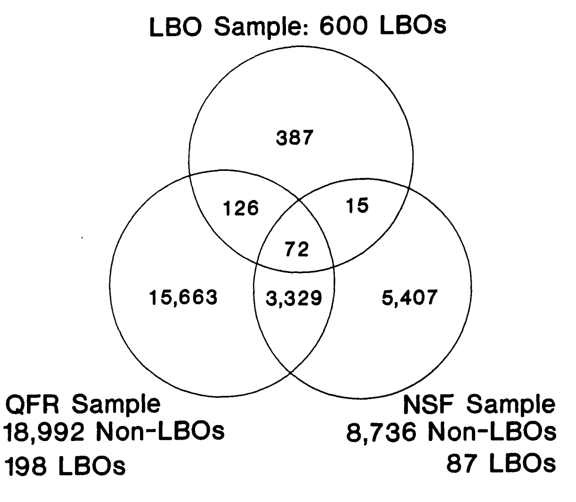

Figure 1. QFR, NSF and LBO samples

\$500,000 and \$1 million.[6] It also surveys smaller R&D performers in selected years. The data contained a number of imputations, data errors, and outliers, particularly for smaller R&D performing firms. In addition, there are many gaps in the data, with usable data on R&D intensity missing for one or more years. With considerable effort, we corrected as many of these problems as possible. We also identified and eliminated all imputed data.

To handle the remaining missing data problems, we use as much R&D data as exist in the 3 years before and the 3 years after the buyout. With t symbolizing the year of the buyout, the firm had to have at least one observation in the $t-3$, $t-2$, or $t-1$ period and at least one observation in the $t+1$, $t+2$ or $t+3$ period. For the pre- and post-periods, simple averages of R&D/sales were calculated for the 1, 2, or 3 observations in the period. The NSF R&D data contained 68 LBOs that reported pre- and post-LBO R&D intensity data.[7] In addition, the data contained 19 LBOs that reported pre-LBO data, but did not file report forms in the post-LBO period.[8]

Our statistical analysis requires a control group of firms not involved in an LBO during the entire sample period. The sampling procedure for this control group is identical to the one employed for LBOs, except now t is any year in which the firm had at least one observation in the $t-3$, $t-2$ or $t-1$ period and at least one observation in the $t+1$, $t+2$ or $t+3$ period. For each of the years 1981–87, we calculated the 1, 2 or 3-year average R&D/sales ratio for the prior 3 years and the succeeding 3 years. We added the firm's data to the control group for each year in which we could make both a preyear and postyear R&D intensity calculation.

For example, if a non-LBO firm has data for each of the years 1981–85 then three pre-post R&D/sales observations would be included in the control group. For t equal to 1982, the change in R&D/sales would be computed as the average of 1983 through 1985 R&D/sales minus 1981 R&D/sales. For t equal to 1983, the change in R&D would equal the average of 1984 and 1985 R&D/sales minus the average of 1981 and 1982 R&D/sales. For t equal to 1984, the change in R&D would be the difference between 1985 and the 1981–83 average R&D/sales. Using the approach, we uncovered 8736 non-LBO control group observations.

Because this procedure ensures that the control group has survival characteristics similar to the LBO sample, it is superior to the more common method of taking the deviation from the industry average. This technique usually includes all firms in the industry average even if the firm is in its first or last year of operation (i.e., it includes births and deaths).

LBOs generally take a public firm private. Thus, post-LBO accounting data are often not publicly reported. To surmount this problem, we obtained accounting data from the QFR file. This file contains an abbreviated income statement and balance sheet on all firms—public or private—with more than \$25 million in assets in mining, manufacturing, wholesaling and retailing. We retrieved the 1977–91 QFR data from archived tapes, linked the data across time and checked it for outliers.[9]

We employ both a short- and long-run measure of performance. The short-run measure calculates the change in cash flow/sales from the year before the buyout to the year after the buyout. The long-run measure computes the change in

[6] The large R&D performer cutoff was increased from \$500, 000 to \$1 million in the mid-1980s. The data for small R&D performing companies were imputed in nonsample years. Sixteen small R&D performers were included in the 72 LBO observations employed in most of this study. If we exclude these small R&D performing LBOs, all statistically significant findings retain their sign and remain statistically significant at the 10 percent level or better.

[7] The sample drops to 44 LBO observations if we restrict the sample to firms with R&D data in both the $t-1$ and $t+1$ years. The sign and significance of the findings in this paper are not materially affected when we restrict the sample to these 44 LBOs.

[8] The fact that 19 firms with pre-LBO R&D data failed to report post-LBO R&D data raises the potential for a survival bias. We tackled the potential survival bias issue by running each regression two ways. For one set, we dropped the 19 firms. In the other set, we assumed their post-LBO R&D value is zero. While there are a number of reasons why a firm might not report NSF data to the Census, we feel the most probable is that the R&D dropped below the NSF cutoff. Therefore, we reported the regressions that contain the 19 firms. The results are quite robust to the other assumption. Without the 19 firms, all of the statistically significant coefficients maintain their sign and remain significant at the 10 percent level or better. The results are robust because the 19 firms had lower than average pre-LBO R&D.

[9] Because there are roughly 15,000 observations per quarter, we screened for outliers by simply eliminating any observation more than three and a half standard deviations from the mean.

cash flow/sales from the year before the buyout to the average of the third to fifth postbuyout years. For whole company LBOs between 1981 and 1987, 198 had data in both the pre and postbuyout year and 122 also had at least one observation in t+3 to t+5 period. The methodology for identifying the QFR data control group mimics the NSF R&D control group methodology. For the 1-year pre/post sample, the control group includes all observations between 1981 and 1987 on each firm, provided that the firm reported data for the year before and the year after the observation. There are 15,663 non-LBO observations in the control group. For the long-run performance sample, the control group observations had to report data in the t−1 year and in at least one of the t+3 to t+5 years.

Because we need both R&D and performance data to test all seven hypotheses, the final sample consisted of the intersection of the NSF and QFR samples. It contains 3,329 non-LBO and 72 LBO observations. This sample is used to test all the hypotheses except Hypothesis 7. For one test of Hypothesis 7, we related changes in R&D to long-run changes in performance, defined as the average of year t+3 to t+5 minus year t−1. This sample contains 2,559 observations with 44 of these being LBOs. For another test of Hypothesis 7, we restricted the sample to LBO firms. For the short-run performance sample there are 198 LBO firms in the QFR data, with 72 of these firms also in the NSF pre/post R&D file. For the long-run performance sample there are 122 LBO firms and 44 report to the NSF file.

Methods

Our primary methodology is a difference in means test between LBO firms and the control group, holding industry and year effects constant. This difference in means test is performed by including an LBO dummy variable in a change in R&D intensity regression. We control for industry and year effects by employing a fixed effects model.[10] Our methodology is similar to simply calculating the average industry and year adjusted R&D intensity for LBO firms. The main difference is the fixed effects model explicitly includes the control group observations, thus incorporating the variance of this group.

We also attempt to explain variations in the LBO induced changes in R&D intensity in order to test Hypotheses 3 through 6. These hypotheses are tested by interacting the LBO dummy with the relevant hypothesized effect (e.g., firm size or diversification). An advantage of the fixed effects model is it implicitly converts these interactions to the deviation from their industry, year average.

Variables

The main dependent variable, R&D/sales, is derived from the NSF R&D data. It is defined as company sponsored R&D plus contract R&D divided by company sales. We focus on R&D intensity in the 3 years before the buyout and the change in R&D intensity from the 3 years before the buyout to the 3 years after the buyout. R&D intensity has been shown to be a reliable archival measure of managers' commitment to innovation and a firm's long run growth (Hitt and Hoskisson, 1990; Young, 1985). R&D is strongly positively related to alternative archival measures of innovation such as the number of inventions and number of patents (Hitt *et al.*, 1991; Scherer, 1984). In fact, Scherer finds that R&D/sales is more closely tied to long-run productivity growth than number of patents.

Tests of Hypothesis 7 employ performance as the dependent variable. Performance is measured by the change in cash flow divided by sales, where cash flow is defined as operating income before depreciation. Cash flow/sales is derived from the QFR data. When relating cash flow/sales to R&D for Hypothesis 7, we do not expense R&D (i.e., we add R&D back into cash flow). When industry dummies are included in the fixed effects model, the R&D and performance variables are measured relative to their industry average for the same time period. When we focus on only firms undergoing LBOs, we explicitly subtract off the industry average for the relevant time period from the cash flow variables.

The central independent variable is an LBO dummy variable that equals one if the firm underwent an LBO and zero otherwise. We interact five variables with this LBO variable.

[10] There are 33 two-digit industries in the QFR data. There are 7 years in the sample (1981–87). Therefore, there are 7*33 dummy variables in the fixed-effects model.

Size is measured as the natural log of company sales. Sales figures are taken from the QFR data. Our proxy for diversification is a dummy variable which equals one if the firm operates in five or more 4-digit SIC industries and zero otherwise. The ADP/MLR Publishing M&A Data base contains a list of up to 11 SIC codes for each LBO. For LBOs that did not appear in this data base, we obtained SIC codes from *Standard and Poors*. We obtained restructuring or divestiture activity information from the M&A Data base and from a search of the *Wall Street Journal* for the three post-LBO years. Divestiture activity was measured by a dummy variable that equals one if the firm sells off 10 percent or more of its assets in the three post-LBO years and zero otherwise. Information on management participation and hostile takeover activity was also found by searching the *Wall Street Journal*. If we found any evidence that the pre-LBO management took an equity stake in the buyout (i.e., the LBO was a management buyout [MBO]), we set the MBO dummy variable equal to one. Similarly, if we found evidence of hostile threats in the 3 years before the buyout, the hostile takeover dummy variable was set equal to one.

Table 1 lists the mean and standard deviation of these variables for the full sample. For the LBO firms, the pre-LBO and post-LBO values are given. The simple averages lend support to Hypotheses 1 and 2. The R&D intensity of LBO firms before the buyout is only 42 percent of the overall manufacturing average. The buyout leads to another 30 percent decline in R&D intensity. Cash flow/sales one year after the buyout are 24 percent higher than cash flow/sales in the year before the buyout. On average, LBOs lead to large gains in performance. In this sample, LBOs tend to target large multidivisional firms. Only a minority of the deals (14 out of 72) were precipitated by a hostile offer and an even smaller number (12 out of 72) instituted a major divestiture program.

RESULTS

The first equation in Table 2 focuses on the prebuyout R&D intensity. It shows that the pre-LBO R&D intensity is significantly below the overall manufacturing average, supporting Hypothesis 1. On average, LBOs do not target high tech firms.

The second equation in Table 2 tests the core hypothesis that LBOs lead to cutbacks in R&D. This hypothesis receives strong support. The debt incurred in an LBO causes a large significant decline in R&D intensity. The R^2 is lower than in many R&D studies, particularly since the industry effects capture traditionally highly significant variables like technological opportunity. However, most studies focus on the level instead of the change in R&D intensity. It is much more difficult to explain changes in R&D than the

Table 1. Means and standard deviations

	LBO Companies $N = 72$				Control group $N = 3329$	
	Post-LBO		Pre-LBO			
Variable name	Mean	S.D.	Mean	S.D.	Mean	S.D.
R&D/sales	0.96	1.46	1.36	1.75	3.26	4.72
Cash flow/sales	11.48	7.21	9.26	5.08	10.10	6.72
Log sales*			12.58	1.38		
# of SIC > 5*			0.63	0.49		
Hostile takeover*			0.19	0.40		
Divestiture > 10%*	0.17	0.38				
MBO*	0.51	0.50				

*These variables were computed for only the LBO subset. They are all dummy variables, except for Log Sales. To compute the number of observations with a value of one, multiply the mean times 72.

Table 2. Pre-LBO R&D and the impact of LBO debt on R&D

Equation #	1	2
Hypothesis #	H1	H2
Independent Variables	Dependent variable	
	Pre-R&D/Sales	Post-minus Pre-R&D/Sales
Constants	YR	IND·YR
LBO Dummy	−1.880***	−0.633**
	(−3.41)	(−2.61)
R^2	0.012	0.095
# of LBOs	72	72
# of Observations	3401	3401

t statistics are in parentheses.
***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, two-tailed tests.

level of R&D. The LBO effect on debt is highly significant, despite this noise.[11]

Table 3 presents the regressions testing Hypotheses 3 through 6. These equations analyze the role of financial vs. strategic control, buyout motivation, and management commitment. The significantly positive coefficient on the size-LBO interaction in Equation 3 supports the strategic vs. financial control side of Hypothesis 3a. It is inconsistent with the agency theory side of this hypothesis. The insignificant coefficients on the interaction terms in Equations 4 through 7 do not support Hypotheses 4, 5 and 6.[12]

Hypothesis 7, the impact of R&D changes on performance, is critical for distinguishing between the capital market imperfections and agency theories. Business and public policy conclusions also hinge on this hypothesis. Therefore, four equations are devoted to testing Hypothesis 7. These equations are presented in Table 4. The dependent variable in these equations is performance measured as either the 1-year or three to five year average post-LBO cash flow/sales minus the 1-year pre-LBO cash flow/ sales. We report both the 1 year and the 3 to 5-year average post-LBO performance because the 1 year sample maximizes the number of observations while the 3 to 5-year average sample best captures long run performance. Fortunately, both approaches yield remarkably similar findings.

The LBO dummy variable in Equations 8 and 9 shows that LBOs do improve performance relative to their industry counterparts. The effect is both large and significant. If LBO related cutbacks in R&D hurt performance, the interaction between LBO and changes in R&D should be positive and significant. In both equations, the interaction coefficient is insignificant. In the 1-year pre/post sample, the coefficient has the wrong sign.

Equations 10 and 11 take a different approach to testing Hypothesis 7. If LBOs incorrectly target firms with large R&D expenditures, then these LBOs should not perform as well as LBOs with little or no R&D. To perform this test we needed to compare the performance of LBOs with and without R&D expenditures. There are 198 LBOs in the QFR sample with 1 year pre/post LBO data and 122 of these have 3 to 5-years post-LBO data. Seventy-two of the 198 and 44 of the 122 are also in the pre/post NSF R&D sample. Equations 10 and 11 use the sample of 198 and 122 LBOs, respectively. These equations regress the post-LBO minus pre-LBO change in cash flow to sales on a dummy variable that equals one if the firm is in the pre/post NSF R&D sample and zero otherwise. Since the control group is omitted from this equation we cannot employ a fixed effects model. Instead, we convert each variable into deviations from their industry average for the appropriate time period. The NSF dummy variable coefficient is positive, significant and substantial in size. LBOs with R&D expenditures clearly outperform those who have little or no R&D.[13]

[11] We also tested for a generic negative relationship between debt and R&D intensity for firms not undergoing LBOs. The coefficients on both the continuous and discontinuous measures of debt change are clearly insignificant in explaining changes in R&D for non-LBO firms.

[12] We also investigated a combination of Hypotheses 3a and 3b. Capital markets and agency theory recognize the independent importance of size and diversification. But, these variables may have important interactive effects. It is possible that agency problems or internal capital market imperfections are more severe for firms that are both large and highly diversified. However, when we combined Equations 3 and 4 in Table 3 and added an interaction term, the R^2 increased by only 0.0002 and the t-statistic on the interaction term was −0.05.

[13] We also estimated Equations 11 and 13 using a 3-year average post-LBO cash flow/sales minus a 3-year average pre-LBO cash flow/sales. The results were very similar.

Table 3. Factors affecting the intensity of the LBO induced R&D change

Dependent variable—Post-LBO R&D/sales minus Pre-LBO R&D/sales					
Equation #	3	4	5	6	7
Hypothesis #	H3a	H3b	H4	H5	H6
Independent variables					
Constants	IND·YR	IND·YR	IND·YR	IND·YR	IND·YR
LBO	−4.510*	−0.622	−0.738**	−0.788*	−0.797**
	(−2.06)	(−1.58)	(−2.78)	(−2.27)	(−2.96)
Log sales[1]	0.308†				
	(1.78)				
# of SIC > 5[1]		−0.018			
		(−0.04)			
Divestiture > 10%[1]			0.623		
			(0.98)		
MBO[1]				0.300	
				(0.62)	
Hostile takeover[1]					0.849
					(1.40)
R^2	0.096	0.095	0.096	0.095	0.096
# of LBOs	72	72	72	72	72
# of Observations	3401	3401	3401	3401	3401

t statistics are in parentheses.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\dagger}p < 0.10$, two-tailed tests.
[1]These variables are interacted with LBOs.

Table 4. The impact of the LBO induced R&D change on financial performance

Equation #	8	9	10	11
Hypothesis #	H7	H7	H7	H7
Dependent variable	Short run change in cash flow/sales[a]	Long run change in cash flow/sales[a]	Industry adjusted short run change in cash flow/sales	Industry adjusted long run change in cash flow/sales
Independent variables				
Constant(s)	IND·YR	IND·YR	−0.063	−0.254
			(−0.10)	(−0.32)
LBO	1.573*	2.059†		
	(1.96)	(1.83)		
Pre-minus Post-R&D/sales	0.615***	0.472***		
	(11.14)	(6.05)		
Pre-minus Post-R&D/sales·LBO	−0.789	0.299		
	(−1.13)	(0.38)		
NSF large R&D performers			2.399*	2.660*
			(2.29)	(2.00)
R^2	0.247	0.236	0.026	0.032
# of LBOs	198	122	198	122
# of NSF large R&D performers	72	44	72	44
# of observations	3401	2559	198	122

t-statistics are in parentheses.
$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\dagger}p < 0.10$, two-tailed tests.
[a]R&D is added back into cash flow, so it is not expensed.

DISCUSSION

We have attempted to give a comprehensive analysis of the impact of LBOs on R&D. We began with a basic proposition that is often cited in the literature, but has never been proven statistically with a comprehensive sample. LBOs target significantly below normal R&D intensive firms. Pre-LBO R&D/sales is less than half the overall manufacturing average. LBOs occur primarily in low tech industries. Still, the R&D expenditures of LBO firms are not trivial. Over 40 percent of the manufacturing LBOs are classified by NSF as large R&D performers. Also, the variance in R&D intensity among LBO firms is large, implying that some LBOs are occurring in high-tech industries.

Consistent with theoretical expectations, R&D/sales decline significantly as a result of the buyout. The size of the decline is dramatic, with R&D intensity dropping by almost 40 percent.[14] Capital structure does affect R&D investment.

The search for factors that determine the extent of the R&D decline met with only partial success. We did find that large firms had smaller declines in R&D intensity. This finding is consistent with Hoskisson and Hitt (1988) who argue that large firms already emphasized financial over strategic control before the buyout. The switch to extreme financial control was less dramatic for these firms. A similar argument should apply to diversified firms. However, our dummy variable, which took on a value of one if the firm had five or more 4-digit SIC codes, was insignificant. This finding may simply reflect the crude nature of our diversification proxy. Hoskisson *et al.* (1993) show that while SIC counts have some validity, they are much less powerful than categorical or entropy measures. Furthermore, our diversification proxy does not distinguish between related and unrelated diversification. Baysinger and Hoskisson (1989) demonstrate that strategic controls are easier to employ in firms with related diversification. Thus, the negative impact of related diversification on R&D intensity is much less than for unrelated diversification.

The insignificance of the post-LBO divestiture dummy variable in explaining LBO related R&D changes is a mixed blessing. While it fails to confirm our hypothesis, it does eliminate the possibility that the decline in R&D is the result of LBO firms selling off R&D intensive divisions.

We failed to find evidence that R&D intensity is impacted by continued managerial commitment (MBOs). Possibly, the constraints imposed by high debt can force managers to break their commitment to their past decisions, making a change in management unnecessary.

We also failed to find evidence that a prebuyout hostile takeover attempt indicates severe agency problems. The pre-LBO hostile takeover attempt variable, has no significant impact on the LBO related change in R&D intensity. The direct evidence on the hypothesis that hostile takeovers target inefficiently managed firms is mixed. Mørck, Shleifer and Vishny (1988) show that hostile takeover targets have below average tobin's q. On the other hand, Herman and Lowenstein (1988) found that hostile takeovers in the 1980s sought firms with profits that were significantly above their industry average. Our finding of an insignificant hostile takeover coefficient tends to support the Herman and Lowenstein view.

LBOs clearly target firms with below average R&D. They also further cut this subnormal expenditure. The concern is, do these cuts harm firm competitiveness? The findings indicate that the cuts do not hurt both short-run and long-run performance. When the sample consists of R&D performers, the results show that the declines in R&D do not significantly affect an LBO's ability to generate performance improvements. For our measure of long-run performance (Equation 9), the coefficient on the interaction between R&D changes and the LBO dummy does have the right sign. However, the coefficient size suggests a small average impact. For a typical R&D/sales

[14] Lichtenberg and Siegel (1991), who also used the NSF RD-1 survey data, failed to find significant R&D declines from LBOs. We undertook a sizable effort to clean the NSF data they used. We eliminated 20 percent of the LBOs because their data had been imputed and an even larger percentage of control group firms. We performed a survival bias sensitivity test on 25 percent of the LBOs that failed to report post-LBO. We identified a number of data errors in the file. Our linking the QFR and NSF data files led to a more representative control group for the LBOs who perform R&D of medium to large manufacturing firms. Despite the loss of a number of LBOs to imputations, the number of LBOs performing R&D is larger in our sample than Lichtenberg and Siegel's because we began with a more complete list of LBOs. Each of these data changes reduced the substantial noise present in Lichtenberg and Siegel's sample.

cutback of 0.63, performance would decline by 0.19 or only about 10 percent of the 2.06 increase in cash flow/sales. On the other hand, this coefficient's variance is large. For a firm with a typical R&D cut-back and a one standard deviation above average coefficient, performance would improve by 33 percent less than a firm that did not cutback R&D.

When we compare LBOs that perform R&D with those that have little or no R&D expenditures, the results are even more conclusive. The R&D performing LBOs have significantly greater performance improvements in the first five post-LBO years than the non-R&D performers. In fact, the intercept reveals that the non-R&D performers failed to significantly improve performance. Since this latter result is surprising, it raises the possibility that pre-LBO R&D intensity is correlated with some other critical LBO performance variable. Long and Ravenscraft (1992a) expand on Table 4 Equation 10 by including eight additional variables. The coefficient on the NSF dummy variable drops by 36 percent when these other variables are included. However, it remains significant at the 10 percent level despite some multicollinearity.

These findings on the relationship between changes in R&D and performance are consistent with the work of Chan, Martin and Kensiger (1990). They found that the stock market reacts positively to announcement of R&D increases in high R&D intensive industries. Conversely, the market reacted negatively to announcements of R&D increases in low R&D-intensive industries.

How are firms able to sustain performance in the face of debt induced R&D decreases? One clear explanation is that, on average, they target firms for which R&D is not critical. Another possible explanation may lie in the source of funding. Banks can overcome some of the asymmetric information, moral hazard and transaction cost problems associated with debt (Diamond, 1984). R&D performing LBOs increased their bank financing as a percent of total long-term debt by 19.6 percent after the LBOs. By relying heavily on bank financing, the LBO firms may have been able to maintain funding of the most productive R&D projects.

In the theoretical section, we identified two broad schools of thought relating debt and R&D—capital market imperfections and agency theory. Most of the seven hypotheses were linked to these theories. Each of the two schools received some strong support. Both theories correctly predicted that LBOs would target low-tech firms and that LBO debt would lead to declines in R&D intensity. Two hypotheses, however, were inconsistent with agency theory. Large firms, which should have more pre-LBO waste according to agency theory, do not cut R&D intensity as much as smaller firms. This finding is more consistent with capital market imperfection theories. Hostile takeover threats also fail to affect the LBO related changes in R&D as predicted by agency theory. On the other hand, the findings on Hypothesis 7 supported agency theory over capital market imperfections. The cutbacks in R&D do not hurt the ability of LBOs to generate short- and long-run increases in cash flows. This failure of capital market imperfection theories is mitigated somewhat, because these theories suggest that bank financing can reduce capital market imperfections. Thus, although the two schools often lead to different hypotheses, the overall results are supportive of both perspectives.

CONCLUSIONS

This paper analyzed the effect of LBOs on a critical component of long-run performance—R&D. Our analysis revealed four major findings on the LBO/R&D relationship. First, LBOs typically target low-tech firms. The average pre-LBO R&D intensity is less than one-half of the overall manufacturing average. Second, the substantial increases in LBO related debt causes R&D intensity to decline. Post-R&D LBO expenditures are 40 percent below their pre-LBO level. Third, large firms tend to have smaller LBO-related declines in R&D intensity. Firms that are more than 1.5 standard deviations above normal tend to increase rather than decrease R&D. Fourth, the declines in R&D intensity do not appear to hurt the ability of LBOs to generate performance gains. On average, LBOs improve operating performance by 15 percent or more. LBOs with prebuyout R&D expenditures have significantly larger gains than LBOs with zero pre-LBO R&D. Cutbacks in R&D have no statistically significant effect on performance.

These findings have important implications for capital market theories and for public policy. Capital market imperfection theories and agency theory are supported by three out of the four major findings. Agency theory's weakness is that it can only predict the direction and not the extent of the LBO related decline in R&D. However, this may simply reflect weaknesses in our agency theory proxies—size, diversity and hostility. They may not be as highly correlated with agency problems as prior work suggests. Capital market imperfection theories correctly predict the direction and cause of the R&D decline in LBOs. However, it incorrectly assesses the effect of this decline. R&D cutbacks do not significantly hurt an LBOs ability to generate performance improvements. Since capital market imperfection theories recognize conditions that mitigate the negative impact of capital market imperfections, this inconsistency is possible. Our conjecture is that LBO firms avoid the negative consequence of these imperfections by selecting low-tech firms that can withstand an R&D cut and by seeking bank financing which reduces asymmetric information problems. Even setting aside these explanations for the failure of each theory, three out of four is a pretty good batting average in statistical work. We conclude, therefore, that both theories apply to LBOs.

The policy implications are even clearer. With respect to R&D, the typical LBO does not pose a business or public policy problem. While critics are correct in predicting that LBOs lead to cutbacks in R&D, the cutbacks do not appear to hurt performance. Much of the R&D that gets cut must be marginal, low productivity R&D. Care must be taken in generalizing this conclusion. Other aspects of LBO performance must be fully explored before a general policy conclusion can be made about LBOs. Potential LBO drawbacks include overpayment, reduced capital expenditures, tax subsidies, more marginal deals in the latter 1980s, and the substantial risks of financial distress. The findings also do not imply that, in general, debt does not harm R&D. To the contrary, the findings show that debt can force R&D to be cut. The key is that the typical LBO must have targeted a low growth, low technological opportunity firm with noncritical R&D expenditures. Applying these findings to U.S. firms that do not meet these selection criteria could be hazardous to the firms' health and U.S. competitiveness.

These conclusions come with a number of caveats. First, while we had a larger and longer time series sample than any prior study of LBOs, it is possible that for some types of R&D, the payoff (or the loss from cutbacks) takes longer than 5 years. Second, NSF reporting procedure creates gaps in the time-series data. We circumvented this problem by averaging as many of the three pre-LBO years or post-LBO years as possible. A more complete time-series would yield more accurate estimates. Third, data constraints led us to a SIC count measure of diversification which is inferior to other measures used in the literature. The insignificance of this variable's coefficient is probably due to mismeasurement rather than inaccurate theoretical predictions. Fourth, research on the level of R&D intensity often employs more control variables than the industry and year effects used in this study. We employed the atheoretical fixed effects approach in part because the theory on changes in R&D is much less well developed than the theory explaining R&D levels. Still, our less extensive controls could result in an omitted variable bias. Fifth, employing other measures of managerial commitment to innovation would enhance confidence in the findings. These could include archival measures such as the number of patents or innovations. Or, they could involve extensive, detailed case studies of LBOs with large pre-LBO R&D expenditures.

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