NBER WORKING PAPER SERIES

THE EFFECT OF TAKEOVER ACTIVITY ON CORPORATE RESEARCH AND DEVELOPMENT

Bronwyn H. Hall

Working Paper No. 2191

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
March 1987

This paper was prepared for a National Bureau of Economic Research Conference on the Economic Effects of Corporate Mergers and Acquisitions held in Key Largo, Florida, on February 19-21, 1987. The research reported here is part of the NBER's research program in Productivity. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

NBER Working Paper #2191
March 1987

The Effect of Takeover Activity on Corporate Research and Development

ABSTRACT

It is widely thought that increases in corporate mergers and acquisitions of the sort which the United States has experienced in the recent past lead to a reduction in such longterm investment activities as R&D because of a shortened horizon on the part of managers. This paper uses a newly created dataset containing all acquisitions of publicly traded firms in the manufacturing sector in the last ten years to answer some basic questions which pertain to this issue. I find that the firms involved in acquisitions and mergers where both partners are in the manufacturing sector have roughly the same pattern of R&D spending as the sector as a whole and that the acquisition itself does not cause a reduction in R&D activity on the part of these firms. Moreover, the R&D capital thus acquired is valued more highly by the acquiring firm than by the stock market. On the other hand, I also find that the substantial increase in the number and size of acquisitions made by privately held firms in the eighties is concentrated primarily on firms with low R&D intensity which also are in non-R&D intensive industries. Because the pattern of low investment in R&D is longstanding, and because the firms taken over have less rather than more R&D capital than the industry as a whole, it seems unlikely that the recent increase in takeover activity has had a significantly negative effect on R&D spending in these industries.

Bronwyn H. Hall
NBER
204 Junipero Serra Boulevard
Stanford, CA 94305

March 1987

The Effect of Takeover Activity on Corporate Research and Development

Bronwyn H. Hall[1]

1. Introduction

Economists generally agree that research and development activity is an important factor in the long-term growth of the economy. The purpose of this paper is to explore the effects, possibly deleterious, of the recent increase in takeover activity in the U. S. corporate sector on the level and pattern of research activity. R&D is interesting in this context because it is a decision variable for the firm which is viewed as "long-term" in nature -- if a wave of mergers distracts managers from all but shortrun activity, we might expect that R&D performance would cease to be optimal.

This paper uses evidence on the observed characteristics of the mergers which actually take place in order to shed some light on this topic. It explores the factors which determine the probability of an

---

[1] I am grateful to Zvi Griliches and Timothy Bresnahan for ongoing discussions, to Alan Auerbach, Charlie Brown, Lawrence Lau, Tom Macurdy, Ariel Pakes, and John Shoven for comments at various times during this research, and to Chris Hall for help with the data collection. Comments by seminar participants at Stanford University, University of Santa Clara, Boston University, Harvard University, MIT, University of Chicago, and University of California at Berkeley were also helpful in preparing this revision. Some of this work was done while I was a Sloan Dissertation Fellow and a John M. Olin graduate research fellow, and I thank these foundations for their support. The data preparation effort was partially supported by a National Science Foundation Grant (PRA 81-08635) and by the National Bureau of Economic Research.

acquisition as well as the valuation of these factors at the time of takeover in order to quantify the role of R&D in acquiring and acquired firms. For this purpose, I build a simple model for acquisition choice which is tractable for estimation and captures the idea that there is heterogeneity across firms and therefore unique synergies to a merger: different targets are worth different amounts to acquiring firms and the highest valuer is most likely to make the acquisition.

The question of whether increased merger activity is a good thing for the economy in general remains unresolved and is not likely to be resolved by focusing purely on the experience of the firms involved. There is the view of Jensen (1986) and others that merger activity represents an unambiguously positive shifting of assets into their best use and provides the best mechanism for ensuring that managers act in the shareholders' interest. A more neutral view would hold that the level of merger activity is just a byproduct of this asset shuffling and has no particular externality; it fluctuates from time to time in just the same way as the number of shares traded on the stock market fluctuates from day to day. The negative view, associated with Scherer (1984), sees acquired entities (lines of business in his empirical work) as almost always suffering declining profitability after merging, and infers from this result the conclusion that increased acquisition activity is likely to be a wasteful thing for the economy as a whole.

Roll (1986) essentially provides an efficient financial markets explanation of the phenomenon observed by Scherer, although that was not his specific aim: He argues that we only see transactions where the management of acquiring firms misperceives the value of the target firm as too low, and hence that even under efficient markets, we get more negative surprises than positive. This picture of acquisition activity implies that an increase in mergers is associated with an increase in corporate "hubris" (his term) which is not good for the economy as a whole. However, for this view to hold in the presence of efficient markets, the offer made by an acquiring firm should be associated with a fall in its share price, since shareholders should be capable of inferring that the decision to buy is likely to be a bad one. The existing evidence on bidding firm returns does not seem really consistent with this.

Is merger activity likely to have a negative effect on R&D performance? One reason it might is substitution: if firms with large amounts of cash would rather spend it than return it to shareholders in the form of dividends, we would expect R&D and acquisition to be substitutes for these firms. An increase in the attractiveness of acquisition opportunities would depress spending on internal investment, including R&D. They may be substitutes on the real side also: there are two ways to acquire knowledge capital, either by investment within the firm (an R&D program) or by purchasing another firm after its R&D program has yielded successful results. The latter strategy has the advantage that more information is available about the output of the R&D, which tends to be higly uncertain. Under the two assumptions of no scale economies or diseconomies in R&D over the relevant range <u>and</u> perfect capital markets, the two strategies should be perfect substitutes for the firm.

Alternatively, the view that some acquisitions are used as "cash cows" to service the debt incurred in order to finance them also implies a negative effect on R&D activity: an easy way to increase short-term cash flows at the expense of long-term profits is to cut spending on such things as R&D. However, evidence that this indeed takes place in the instances we observe is not evidence that it is the wrong thing to do: the longrun profit rate may not have been high enough to justify the pre-merger R&D level of the acquired firm, and cutting it may be precisely what a now presumably better management should do.

There is some evidence on a few of these questions: Using roughly the same data as mine, Addanki found no support for the hypothesis that firms with larger R&D programs were attractive acquisition prospects. If anything, innovators were less likely to be acquired. An SEC study (1985) found that firms which were taken over invest less in R&D than other firms in their industry, although they did not control for size, which could account for some of the result. The same study produced a related piece of evidence on the market valuation of long term investments such as R&D: the 20 day excess return for an announcement of an increased level of R&D was 1.8 percent, suggesting that the market placed a positive value on such announcements.

On the other hand, for a sample of 1337 Industrial File firms in 1976, of which 301 were acquired by 1983, I found that once I had controlled for Tobin's q at the beginning of the period, the R&D to assets ratio was positively related to the probability of being acquired. The coefficient was consistent with a shadow price for the R&D capital stock of around 0.6 times that for the physical capital stock of the firm. In other words, firms for which the measured ratio of market value to book value was high because they also had intangible assets such as a large R&D program, were more likely to exit from the sample by merger, **ceteris paribus**. In this version of the probability model, I did control for size, so the R&D effects would not be confounded by the negative correlation between the size of the firm and its R&D intensity. However the coefficient was rather imprecisely measured, and results tended to be sensitive to the exact choice of sample (whether or not the sample included firms traded Over-the-Counter, for example).

In this paper, I investigate these somewhat inconsistent results on the attractiveness of R&D-doing firms as takeover candidates further, as well as exploring some of the other issues related to R&D performance and takeover activity. To this end I assemble a dataset on all the publicly traded U.S. manufacturing firms which were acquired between the years 1976 and 1986, and examine the pattern of acquisition and merger: were the acquired firms more or less R&D intensive than others in their industry? What were the characteristics of the acquiring firms and what kinds of synergy favored the merger? I also examine what happened to the R&D of the new larger firm, to see if there is any evidence that the acquisitions take place partly to reduce R&D expenditures because of scale economies or other reasons. Finally, is there any evidence that winners (successful innovators) were being picked by the mergers and acquisitions process, suggesting that this is how successful innovators capture the appropriate rate of return?

2. Modelling the Acquisition Decision

My approach to modelling takeover activity views such activity as a response to changes in states of the world (such as technology shocks) which make some assets less productive in their current use than in some alternative use. Because of information lags, transactions costs, or whatever, these assets do not move continuously into their optimal use, so the shocks induce a disequilibrium which is resolved by the purchase of discrete bundles of assets by other firms. In other words, merger activity is the result of the rearrangement of productive assets in response to changes in the available technology, or, in the case of the domestic manufacturing sector, to changes in the nature and level of competition from the rest of the world.[2]

I begin by denoting the value of the assets of a particular firm as $V(X) = V(X_1,X_2,...)$, where X is a vector of characteristics of the firm, such as capital stock, R&D stock, industry, tax characteristics, and so forth. The value function V can be thought of as the present discounted value of the revenue streams which could be generated from these assets either alone or in combination with other assets. For the moment, I do not necessarily identify $V(X_i)$ with the current stock market value of the firm, although in a world with fully informed rational shareholders and efficient markets, $V(X_i)$ would of necessity be the price at which this bundle of assets traded. The reason I do not make this assumption here is the well-known fact that acquisitions take place a a significant positive premium over pre-announcement stock market value (Jensen and Ruback (1983) and the references therein), which implies that some agents place a higher value on X_i than the market. Thus it would be a mistake to impose at the outset a constraint that the market for corporate assets is in a fully-informed equilibrium,

---

[2] An additional reason for changes in merger activity might be changes in the transactions or other costs associated with buying another firm. For example, Jensen (1986) has suggested that the innovation of junk bonds facilitates takeovers by small entities of large firms which would not previously have taken place. In my investigation here, I am abstracting somewhat from the changes in takeover technology which have occured in the recent past, since they primarily affect things in the time series dimension, and my focus is on cross sectional differences and similarities among takeovers.

since it is the disequilibria which drive the acquisition process. The implications of this assumption for the estimation strategy will be clarified after I present the model.

I assume that each period (a year in my data), the optimal configuration of corporate assets changes due to shocks to the economic environment. Acquiring firms are subscripted j, and possible targets, which consist of my entire sample of firms, are subscripted i. Each firm in my sample can acquire any other firm; if it does so, then the increment to the value of the acquiring firm j due to the new configuration of assets is denoted $V_j(X_i)$. Assuming for the moment that only one acquisition is possible per period, firm j will buy firm i (that is, j and i will find it beneficial to combine) if

$$(1) \qquad \begin{array}{ll} V_j(X_i) - P_i > V_j(X_k) - P_k & \qquad \forall\ k \in \text{Sample} \\ V_j(X_i) - P_i \geq 0 & \end{array}$$

where P_i is the price he will have to pay for i's assets. The last condition ensures that there is a positive gain from the acquisition; many potential acquirers will find that it holds for none of the targets and hence will acquire no firms during the period.

Equation (1) is similar to the equations which define product choice by a consumer in a Random Utility Choice model (McFadden (1973), Manski and McFadden (1981) and references therein). To see this, think of the asset aggregation function (V's) in this model as analogous to consumer utility expressed as a function of the underlying (Lancastrian) characteristics of the good. Thus the market for acquisitions resembles the market for differentiated products, with one important difference:

in the consumer demand literature, price enters the indirect utility function directly, since the consumers are assumed to be price-takers. In this market, one cannot assume that the price firm j will pay for the assets is independent of his attempt to purchase them. The empirical evidence is that by making a bid, firm j reveals something about the value of the assets which was not previously known and hence finds it necessary to bid above the current trading price. In a companion piece Hall (1987b) I derive the equilibrium price in a market with a large finite number of unique differentiated buyers and sellers and show that it will lie somewhere between the value of the good to the highest valuer and the next highest valuer. In the econometric work here, I assume that the price at which the potential acquirers will evaluate the purchase is not P_i, the current trading price of firm i's stock, but an unobservable $V(X_i)$, which is a function of the assets X_i.

The advantage of viewing the acquisition decision in this way is that there exists a large body of literature on the econometric estimation of models of the demand for differentiated products in terms of their characteristics, on which we can build in order to describe the types of mergers which take place and how the characteristics of targets are valued by different acquirers. Although I frequently use the language of consumer demand to describe the acquisition decision throughout this paper, it should be kept in mind that because price is not exogenous, what is actually being estimated can be interpreted instead as an equation determining the gains from particular mergers, where the buyers and sellers are treated symmetrically, rather than an equation describing the demand of an acquiring firm for a target.

An estimating equation is derived from the conditions in equation (1) by partitioning the gain to firm j from the acquisition into observable and unobservable components:

$$(2) \qquad V_j(X_i) - P_i = f(X_i,X_j) + \varepsilon_{ij}$$

and letting ε_{ij} have an extreme value distribution. If the ε_{ij}'s are independently distributed across alternative, then one obtains the usual multinominal logit probability that an acquisition will take place:

$$(3) \qquad P(j \text{ buys } i|C) = \frac{\exp(f(X_j,X_i))}{\sum_{k\in C}\exp(f(X_j,X_k))}$$

where C is the entire pool of firms. The likelihood function is formed by multiplying these probabilities and conditioning on the observed characteristics of the acquirers and potential targets.[3]

At this point the alert reader will notice that the choice set C is very large: potentially it includes any firm within or without the United States. Even if I confine the choice set to my dataset, it consists of more than 2000 firms, which raises questions as to the feasibility of econometric estimation and the validitiy of the IIA

---

[3] As was suggested by one of the discussants of this paper, Ariel Pakes, it is possible to reverse this model by viewing the decision from the perspective of the potential target. In this case the coefficients of the gain function are estimated from a comparison of the actual acquirer to those firms which might have acquired the target. If the specification is correct, and the ε_{ij}'s are truly independent, both methods should give the same estimates of the structural parameters. A full exploration of the econometric specification of such a model, although interesting, is beyond the scope of the current paper. Work now underway on this topic suggests that differential propensities to be acquired or to make an acquisition (that is, lack of independence of the alternatives) may have a role here.

assumption. Fortunately, McFadden (1978) has considered the large choice set problem and suggested two approaches for dealing with it. The first solution is to construct a nested logit model, which describes the choice from 2000 alternatives as a hierarchical sequence of choices each of which considers vastly fewer alternatives. For example, I might hypothesize that firms choose the industry in which they wish to make an acquisition first, and then choose among firms in that industry. This solution requires more a priori information, but has the advantage that it gets around the IIA problem somewhat. I have not chosen to use this model in my initial exploration of the data, since I wished to avoid imposing too much structure on the choice problem at the outset.

The second solution to the problem of very large choice sets suggested by McFadden is simpler to implement, although possibly not the most powerful or realistic in terms of its assumptions: One randomly samples from the unchosen alternatives and includes only a subset for each observation. McFadden shows that as long as the sampling algorithm has what he calls the "uniform conditioning property" and the choice probabilities satisfy the IIA assumption, estimates obtained using the subset of alternatives and a conventional multinomial logit program are consistent. The uniform conditioning property is defined as

$$\text{(4)} \qquad \text{If } i,j \in D \subset C, \text{ then } \pi(D|i,z) = \pi(D|j,z)$$

where D is the subset of alternatives used, π is the probability distribution used to draw D from C, and z are the exogenous variables of the model. The algorithm which I used to generate my subsets D has this property, since my D consists of the chosen (numerator) alternative augmented by a random sample selected from the other alternatives. The size of D which I used was seven, but this is obviously an area where more experience and experimentation would be desirable.

For the econometric estimation of the model in equations (2) and 0), I need to specify a functional form for $f(X_i,X_j)$. The difficulty with this function as written is that the gains from different acquisitions are likely to have extremely heteroskedastic and possibly nononormal disturbances ε_{ij} due to the large size range of the firms in the dataset.[4] I would like to choose a specification that mitigates this problem as much as possibly, since the multinomial logit estimates will be biased in this case. My solution to the problem is to specify the acquisition choice problem in terms of rates of return to acquisitions rather than total gains; this implies a condition of the form

$$(5) \qquad V_j(X_i)/P_i > V_j(X_k)/P_k$$

rather than equation (6). By using a multiplicative disturbance for the value functions and then taking logarithms, I arrive at the following estimating equation for the econometric model:

---

[4] In data of this kind, with a skew size distribution, the functional form which typically has disturbances which are normally distributed is the log-log. For example, consider the form

$$\log V = \beta_0 + \beta_1 \log X + \varepsilon, \qquad \varepsilon \sim (0,\sigma^2)$$

If we choose instead to estimate using V, we obtain

$$V = e^{\beta_0} X^{\beta_1} e^{\varepsilon} \approx A_0 X^{\beta_1} (1+\varepsilon e^{\varepsilon})$$

by a first order Taylor series expansion; this disturbance is clearly very heteroskedastic (and skew).

$$(7) \qquad P(j \text{ buys } i|C) = \frac{\exp(v_j(X_i)-v(X_i))}{\sum_{k\in C}\exp(v_j(X_k)-v(X_k))}$$

where the lower case v denotes the measurable component of the logarithm of the valuation function. The subscripted v denotes the valuation from the perspective of the acquiring firm, whereas v without a subscript is the function which describes the equilibrium price at which the firm's assets will trade.

For the econometric estimation, I model the logarithm of V as a function of firm characteristics including the logarithm of the capital stock, R&D intensity, and the two-digit industry. The exact functional form I use is motivated partly by a simple intertemporal optimizing model of a firm with a given stock of assets A, and partly by a desire for tractability and interpretability of the estimating equation. A Cobb-Douglas price-taking firm with one type of capital for which there are adjustment costs, and with all other inputs freely variable has a value function

$$(8) \qquad V(A) = a_0 \, A^{\sigma}$$

as a result of maximizing present discounted cash flow, where σ is a scale parameter which is equal to unity in the constant returns case (Lucas and Prescott (1971), Mussa (1974), Abel (1983,1985)). In the absence of a good model for the value function of more than one kind of capital (see Wildasin (1984)), I incorporate a second capital, knowledge capital K, by the simple expedient of aggregating it with A, but with a freely varying coefficient:

$$(9) \qquad V(A,K) = a_0\ (A+\gamma K)^{\sigma} = a_0\ A^{\sigma}\ (1+\gamma(K/A))^{\sigma}$$

Taking logarithms,

$$(10) \qquad v(A,K) \approx \sigma \log A + \sigma \log(1+\gamma(K/A)) \approx \sigma \log A + \sigma\gamma\ (K/A)$$

Thus the coefficient of size in my estimating equation can be interpreted as a scale coefficient and that of R&D intensity as representing a premium (or discount) which the R&D capital receives in the market over that of ordinary capital. Of course, in order to interpret the R&D coefficient in this way, one must be careful to measure K and A in comparable stock units.

Using the basic underlying model for the valuation of the assets of the firms, I capture the synergy of combining the two firms in two different ways. The first models the gain from the acquisition, $v_j(X_i) - v(X_i)$ as a linear function of the assets of the two firms and the distance between them in asset space:

$$(11) \qquad v_j(X_i) - v(X_i) = X_j\beta_1 + X_i\beta_2 + |X_j - X_i|\beta_3$$

where the X variables are the vector of variables describing the assets of the firm in question (for example, $\log A_i$ and $(K/A)_i$). Because of the form of the multinominal logit probability, the coefficients of the acquiring firm's characteristics, β_1, will not be estimable since they cancel from the numerator and denominator, so that only X_i and $(X_j - X_j)^2$ will enter the logit equation in this case. In any case these coefficients will contain both terms from $v(X_i)$ and the linear terms from $v_j(X_i)$.

The second method for modelling the synergistic relationship between the two firms starts from the notion that each acquiring firm has a value $v_j(X_i)$ for the target firm i which is a different function of firm i's characteristics, so that

$$(12) \qquad v_j(X_i) = \gamma_j X_i + \eta_{ij}$$

I then model the "shadow prices" γ_j as linear functions of the characteristics of firm j. This will imply that cross products of the variables for firm j and firm i enter the equation for the probability of a choice. The advantage of this formulation is that it allows us to place a valuation interpretation on the estimated coefficients; in other words, the γ_j estimates are hedonic prices of the characteristics X_i.

3. **Data and Sample Statistics**

The data from which I draw my sample consist of 2519 manufacturing firms on the Industrial and Over-the-Counter Compustat tapes which existed sometime during the 1976 to 1985 period. The basic features of the 1976 based subset of this sample were described in Bound et al (1984) and Cummins et al (1986) and the construction of the whole sample is described in Hall (1987a). It consists of a rolling panel of firms, with annual data available as far back as 1959 for some firms; all firms are followed as long as they remain publicly traded and therefore in the Compustat files, with the last year of coverage being 1985. The number of firms actually in the sample in any one year declines from a high of about 2000 in 1976 to around 1500 in 1985.

I used four sources of information in order to identify the reasons for exit of the approximately 900 firms which were not in the file as of 1985 as well as the name of the acquiring firm for all acquisitions: the FTC Merger Reports of 1977 through 1980, a list of around 400 acquisitions involving Compustat firms supplied to me by Auerbach and Reishus (for more detail see Auerbach and Reishus (1986)), the Directory of Obsolete Securities (1986), and the Standard and Poor Corporate records, which provide news reports indexed by firm name every year for the entire period in question. This yielded a complete breakdown of the reasons for exit: of the 875 firms which exited the sample by 1985, 601 were acquired, 94 went bankrupt or were liquidated, 115 underwent a name change (and should have the data for the new entity restored to the file), 45 were reorganized (the capital structure was changed significantly enough so that it was reported in the Directory of Obsolete Securities), and 20 exits remain unexplained.

After splicing together the records for firms whose names had changed (e.g., U. S. Steel became USX Corp), and also those for firms whose CUSIPs changed because of reorganization, I updated this distribution of exits and searched out the remaining unexplained exits. The final tabulation is shown in Table 1 by year of exit. The most striking fact in this table is the well-known one that the rate of acquisition has risen from the late seventies into the eighties (note that my numbers for 1986 are undoubtedly incomplete). In addition, a large part of the increase in the acquisition rate between the 1976-1981 period and the 1982-1986 period is due to the increase in acquisition activity by privately held and foreign firms. Weighted by employment, these acquisitions have tripled, while the acquisitions by publicly traded firms have increased by one third. In this case, privately held means acquisition by a firm which does not file 10-Ks with the SEC on a regular basis and is therefore not in our sample; some of these are leveraged buyout by management or other investors ("taking the firm private").

Because the non-publicly traded acquirers perform roughly half the acquisitions, and these acquisitions are likely to be a nonrandom sample (for example, they are on average about fifty to sixty percent as large), throughout the paper I will try to compare results for my subsample of acquisitions with those for the whole sample. Unfortunately, it is not in general possible to obtain data on the pre and post-acquisition experience of these acquirers, which is a limitation of this study.

Some simple statistics on all the acquisitions are presented in Table 2a, where I show the industrial breakdown for the firms in the manufacturing sector in 1976 and 1981 and for the subset which were acquired between the two periods 1977 to 1981 and 1982 to 1986. To give an idea of the relative importance of acquisition activity by industry, I also report the total employment in these firms. Judging by the fraction of an industry's employees which were affected by acquisition, the industries with the greatest activity are Food, Textiles, and Electrical Machinery. In fact, over a third of the employees in the manufacturing sector subject to takeover were in these three industries. The other industries with a substantial number of employees involved in acquisitions are Rubber and plastics, Fabricated metals, and Machinery. There does not seem to be much of a pattern, except when we look at the second period. There, the industries with the largest acquisition share seem to be the older, perhaps somewhat technologically backward industries which are in the process of upgrading to meet foreign competition. Is the acquisition activity in these industries primarily oriented toward consolidation and shrinkage of the industry, or is there also an attempt to buy smaller firms in the industry which have been successful innovators? I will defer this question until we examine the R&D to sales ratios of the stayers and exiters.

Out of the approximately 600 firms that were acquired, I was able to identify 342 that were acquired by firms on the Industrial or OTC Compustat files; of these, there are about 320 for which I have good data on both acquiree and acquirer. This excludes any which were acquired by foreign firms, as well as those acquired by privately held firms. It does include nonmanufacturing firms which acquired firms in the manufacturing sector. The characteristics of the subset for which I have data on the acquirer are given in Table 2b. Although they account for only half the acquisitions made during this period, they have two-thirds of the employees involved in acquisitions (two million out of three million). I also show the industrial distribution of the firms which are doing the acquiring; there are fewer firms in this column since some make more than one acquisition during the period.

Table 2b makes it clear that there is no overwhelming pattern to the merger and acquisition activity: the distribution by industry of acquirers and acquirees is quite different, but not in a particularily meaningful way. The largest share of firms were taken over in the Aircraft, Machinery, and Electrical machinery industries, while the Aircraft, Electrical Machinery, and Petroleum industries had the largest share of firms performing acquisitions. This last fact is a consequence of the fact that these industries are also the ones with the largest number of employees per firm on average.

In Tables 3a and 3b, I investigate the differences in R&D intensity between exiting firms and those which remain in the industry, and then between acquiring firms and those firms which they acquire. For those firms which are acquired by firms in the publicly traded manufacturing sector, the difference in R&D intensity between acquired firms and stayer firms is insignificantly different from zero for the whole manufacturing sector and for each industry taken separately. Only in Primary and Fabricated metals is there a suggestion that the exiting firms are doing slightly more R&D than those which stay. There is no evidence that the dominant pattern is either a weeding out of firms which are technologically backward, or a culling of successful R&D projects.

However, the firms acquired by private companies or by foreign firms do have significantly lower R&D intensity than those acquired by the manufacturing sector: one percent on average rather than two percent. This pattern persists throughout the whole period; it is not a consequence of the rise in private buyouts in the latter part. It occurs partly because these acquisitions tend to take place in the less R&D intensive, more slowly growing industries such as textiles: with only one exception, the petroleum industry, the industries with less than average R&D intensity are those where private and foreign acquisitions are a larger than average share of all acquisitions. These industries, which contain half the firms in the sample, account for seventy percent of the acquisitions by private or foreign companies. This suggests that the recent increase in acquisition activity due to leveraged buyouts or other such private purchases is more or less orthogonal to the R&D activity in manufacturing. Even if all such purchases resulted in the complete cessation of R&D activity by the firm, this would amount to only around 500 million 1982 dollars a year compared to expenditures on R&D by the manufacturing sector of approximately 40 billion 1982 dollars per year.

When I examine the firms actually doing the acquiring, there does seem to be a suggestion that R&D intensity is lower in the surviving firms; the firms being taken over have on average a higher R&D to sales ratio than the ones which take them over. However, this is primarily due to the 38 non-manufacturing takeovers of manufacturing firms which occurred, and we expect that in this case, the firms are being combined with an entity that may do considerably less R&D in its non-manufacturing lines of business. At the industrial level, it is difficult to draw any strong conclusions owing to the relatively small samples.

The columns labelled $\Delta R/S$ in Tables 3a and 3b are an attempt to answer the question of what happens to the R&D program of the combined firm after an acquisition has taken place. $\Delta R/S$ for Stayers is the average two-year change in R&D intensity over the period for the firms in the industry. $\Delta R/S$ for Exiters is the two year change in R&D intensity around the time of acquisition for the firms involved in the acquisition classified by the acquired firms industry. In Table 3b the same quantity appears, classified by the acquiring firms industry. The pre-acquisition R&D intensity is computed in the following way:

$$(13) \quad (R/S)_{pre} = (R_j + R_i)/(S_j + S_i)$$

where i,j index the two firms involved. The conclusions are not changed by restricting attention to those acquisitions where both R_j and R_i are non-zero, so the numbers presented are for all firms.

The individual industry numbers are difficult to interpret, owing to the imprecision with which they are estimated, although there do seem to be some significant increases in R&D around acquisition time, particularly in textiles, machinery, computers, and electronics. Viewed in the context of differing patterns of industry growth, this finding may have different meanings for different industries: in the textiles and machinery industries for example, two thirds of the acquirers are outside the publicly traded manufacturing sector, so the acquistions which we see here are a special group and are perhaps a reflection of the improved prospects for the remaining firms after the industry has shrunk (see Schary (1986) for a more detailed study of the long-run reaction of firms in the textile industry to its declining profitability). In computers and electronics, however, almost all the acquisitions are in the manufacturing sector, specifically in closely related industries, and the growth in R&D is perhaps another indicator that the firms engaged in acquisition activity need to invest more rather than less in order to exploit the value of their acquisitions.

Overall, however, there is little evidence of a significant difference in the mean growth rates of R&D intensity between firms involved in acquisitions and non-acquiring firms. Comparing the means is only part of the story, however: it is possible that R&D intensities change in different ways for different types of acquisitions in such a way as to leave the mean growth rate unchanged. To check this, in Figure 1, I plot the distribution of these changes for all firms in the manufacturing sector and for the acquisitions only. These plots show some evidence that the variance of the changes in R&D intensities are somewhat higher for the acquisitions, and even that more of them experience a decline than the overall sample. However, non-parametric tests[5] for the difference of the overall means of $\Delta R/S$ in Tables

---

[5] I used the Wilcoxon Rank Sum test (best for the logistic distribution), the Median Score test (best for double exponential), the Van der Waeden

3a and 3b accept equality in almost all cases (whether or not publicly traded non-manufacturing acquisitions are excluded, whether or not zero R&D-doers are excluded). The only case where a significant positive difference exists is when all publicly traded firms and zero R&D-doers are included, and here only for two of the four non-parametric tests. The same conclusion holds when I look at three year changes around the time of acquisition (not reported). The conclusion is that there is no overwhelming evidence of a change in R&D behavior around the time of acquisition by acquiring firms.

In the next section I try to quantify the determinants of acquisition further by estimating probability models involving more than one explanatory variable, since it is known that size is systematically related both to R&D intensity and to the probability of being acquired, making these tables somewhat difficult to interpret in detail.

4. Estimating the Probability of Entering the Acquisition Market

Before I present results for the full-blown multinomial logit model of acquisition matches, I present estimates of the "marginals" of such a model. These estimates are not marginals of the distribution of the multinomial logit model in the statistical sense, since they cannot be obtained by aggregating over the choice set,[6] but they summarize

---

test (best for normal), and the Savage test (best for exponential).

[6] In the special case where there are no synergies in acquisition (the gain is additively separable in the characteristics of i and j), these are the true marginal probabilities of acquisition and being acquired, but it seems unlikely that this particular model holds in these data. Simple significance tests on the interaction terms confirm this.

the data from the perspective of the acquiring and acquired firms separately. They also provide an indication of the change in the sample when I restrict the data to the approximately 300 acquisitions for which I can actually observe both partners.

I assume that the reduced form for the probability of being acquired in any one year can be written as a logit function of various firm characteristics:

$$(14) \qquad P(i \text{ acq in year } t|X_{it},t) = \exp(\beta X_{it}+\alpha_t)/(1+\exp(\beta X_{it}+\alpha_t))$$

where X_{it} are the characteristics of the firm. The estimates of β and α_t can then be obtained with a conventional maximum likelihood logit estimation. The same type of model can also be used to estimate the probability of firm j making an acquisition in year t, conditional on its characteristics X_{jt}.

The model of acquisition sketched in Section 2 uses the assets of the firms to predict their valuation, and hence the gain from merger. To keep things simple, I focus on two assets: capital stock (including all plant and equipment, inventories, and other investments), and the stock of knowledge capital. These two assets do tend to be the most significant in a simple stock market value equation. For the buyers and sellers in 311 transactions which took place between 1977 and 1986, I have constructed estimates of the book value of the physical assets in current dollars and the R&D capital held by these firms one year before the acquisition, using methodology described in Cummins, et al (1985). Adjustments for the effects of inflation on the book value of the physical assets have been applied, and R&D capital has been depreciated at a rate of fifteen percent per year (see Griliches and Mairesse (1981, 1983)). Before use, these variables are then deflated to be in 1982 dollars, using a fixed investment deflator and an R&D deflator (Cummins et al (1985)) respectively, since I will be pooling across years.

I estimated equation (14) using as regressors size (the log of capital stock), the R&D stock to capital stock ratio, and a trend variable. I also included a dummy for the more technologically oriented industries (those with R/S greater than one percent in Table 3a) to check whether the R&D effects were in reality industry effects. These estimates are shown in Table 4; the first column pertains to the complete sample of acquisitions for which data existed, while the other columns are for two subsets: firms acquired by private or foreign firms and firms acquired by firms in my sample (mostly manufacturing with a few non-manufacturing firms).

The estimates for the two groups are quite different, and confirm the findings in the simple statistics of Table 3a. For the private acquisitions, there is a much steeper positive trend, and all the other variables have predictive power. Size, R&D intensity, and whether the firm is in a science-based industry have a significant negative effect on the probability of it being acquired by a privately-held or foreign firm. On the other hand, these variables have no effect on the probability of it being acquired by a publicly traded manufacturing firm. Thus, it is likely that the private acquisition activity is targeted towards those industries and firms where growth opportunities have already been perceived by current management as unprofitable. This could be construed as evidence that management has cut R&D spending for these firms in an effort to avert takeovers, but if so, they have not been successful. It seems more likely that this activity facilitates a needed shrinkage in the assets devoted to these particular activities.

Without knowledge of subsequent events in these firms, it is difficult to be more precise about the reason for this finding. What is true is that manufacturing acquisitions seem to be indistinguishable from non-acquired manufacturing firms.

The equation for the probability of making an acquisition is shown in the bottom half of Table 4. I consider three different samples: acquisitions made during the whole sample period, and then those for the two subsets: 1976 to 1981, and 1982 to 1986. The results are unsurprising: size is postively related to making an acquisition, and the probability of making an acquisition rises towards the end of the period, while R&D intensity is not important. When I focus on the two subperiods, a difference does emerge: in the eighties, the firms making these large acquisitions have a somewhat lower R&D intensity than the other manufacturing firms, suggesting some substitution between R&D performance and acquisition activity. I also included the TECH variable in these equations, but it was completely insignificant in all periods, so this result is not due to a shift of acquisition activity towards non-technologically oriented industries.

5. Results for the Matching Model of Mergers

I now turn to estimates of the multinomial logit model of the match between acquiring and acquired firms. In this version of the paper, I confine my sample to firms which actually made acquisitions; that is, my estimates are conditional on a firm having chosen to enter the takeover market and describe the choice made once the firm is in the market. A reasonable way to augment this model so that it also describes the decision to enter the market would be to build a nested logit model, where the decision to make an acquisition is logically prior to the choice of target. The estimates which I obtain here are consistent for the lower branch of such a nested logit model (McFadden (1978,1981)) although the interpretation of the coefficients would change. The upper branch would be somehwat similar to the Logit model estimated in Table 4, since it would describe the choice between making any acquisition or making none, but it would include an additional term corresponding to the "inclusive value" of the set of takeover candidates available. In other words, the characteristics of the available targets would enter in the form of a kind of index function along with the characteristics of the acquirer.

With this caveat in mind, I now describe the application of the Random Utility Choice model to this problem. It is well-known that when the unobserved part of the utility function has an extreme value distribution, the probability of a particular choice being made from a set of alternatives has the multinomial logit form (again, see McFadden (1973), and Manski and McFadden (1981)). It is only slightly less well-known that any model for choice probabilities can be written in the multinomial logit form, with the proviso that if the independence of irrelevant alternatives assumption does not hold, characteristics of the other choices may enter into the "utility" function associated with a particular choice. This needs to be kept in mind, since it allows us to view the multinomial logit model estimated here as a descriptive summary of the data we observed, even if the underlying interpretation of the V functions as determining acquisition probability is suspect.

The results of estimation conditional on an acquisition being made are shown in Table 5. These are estimates of the choice model given in equation (7), with the choice set consisting of the chosen alternative plus six others randomly selected from the firms in the sample that year. In the first two columns, Model I captures the character of the match ($v_j(X_i)$) very crudely with the absolute value of the difference in size and the difference in R&D intensity of the two firms. In addition, the size of the target and its R&D intensity enter the logit equation (via $v(X_i)$. The second column includes a dummy for whether or not the firms are in the same industry; it improves the explanatory power ($\chi^2(1) = 183.$), but does not affect the other coefficients very much. The estimates imply that mergers which involve a large difference in size are less likely to take place, and that mergers between firms with differing R&D intensities are less likely to happen. Thus there is fairly strong evidence that mergers within the manufacturing sector tend to be between firms which are alike in their characteristics.

The next set of estimates in Table 5 are for the model (Model II) suggested in equation (12) and they provide a richer description of the matching taking place in the merger market: Taking the estimates in the last column as representative, they imply an equation for the incremental value of an acquisition to a firm of the following form:

$$(15) \qquad v_j(X_i) = \gamma_{0j} + \gamma_{1j}\log A_i + \gamma_{2j}(K/A)_i$$

γ_{0j} is not identified in the conditional logit model since it cancels from the numerator and denominator of equation(7), but the other coefficients are the following:

$$(16) \qquad \gamma_{1j} = \gamma_{10} + 0.17 \log A_j - 0.18 \ (K/A)_j$$

$$\gamma_{2j} = \gamma_{20} + 0.32 \log A_j + 4.1 \ (K/A)_j$$

In other words, the bidding firms value the size of the target at an increasing rate with respect to their own size and a decreasing rate with respect to their R&D intensity, and, more interesting, the shadow price for the R&D intensity of the target is an increasing function of the size and R&D intensity of the bidding firm. This may arise partly because of the preference for firms to acquire firms close to their own industry, but the simple correction of controlling for the match being in the same industry had very little effect on the magnitude of the estimates, although it did reduce the R&D match coefficient somewhat, as expected. Further investigation of this finding particularily within and across industries seems warranted.

What do these estimates tell us about the valuation of the R&D stock of the firm at the time of acquisition? Unfortunately, it is not possible to say very much about this without making strong assumptions about the way in which $v(X_i)$, the price paid for the acquisition, is determined, since the estimates of the coefficients of the characteristics of the target will contain terms from both the $v_j(X_i)$ (e.g., γ_{10}) and the $v(X_i)$ equation.[7] This limits my ability to interpret equations (17) beyond pointing out that the shadow value placed on R&D capital is steeply rising with the acquiring firms R&D intensity.

On the other hand, it is possible to know something about the price actually paid for the assets of the firms which were acquired, and to compare this with the preacquisition value of these assets. For the

---

[7] I am grateful to Charles Brown, one of the discussants, for pointing out that the identifying assumption used the first version of this paper, $\gamma_{10}=0$, is not very reasonable.

acquisitions which actually took place, I have collected such data for 271 of the 311 acquisitions in the sample. I use the value of debt plus equity in the year before the acquisition as the preacquisition market value of the firm (see Cummins et al (1985) for details). I then collected data on the price actually paid to each holder of a share of common stock in the acquired firm at the time of acquisition and used the rate of return thus earned by holders of the common stock between the year before acquisition and acquisition to update the value of debt plus equity (assuming that the total value of the firm was increasing along with the value of the common stock). This procedure is necessary owing to the difficulty of valuing the claims of all stock and bondholders at the time of exit.

Using these numbers, I estimated a valuation equation for these 271 firms in the year before acquisition and at acquisition time. The results were

$$(18) \qquad \log V(A,K) = \alpha_t + \underset{(0.02)}{0.96} \log A + \underset{(0.12)}{0.49} (K/A)$$

$$(19) \qquad \log V(A,K) = \alpha_t + \underset{(0.03)}{0.95} \log A + \underset{(0.14)}{0.65} (K/A)$$

where α_t denotes a dummy for the year in question. These equations suggest that a firm's R&D stock is valued at a slight premium over its value in the stock market when the firm is a candidate for takeover. This is strikingly consistent with Addanki's (1985) findings using some of the same data but a different model, and deserves to be investigated further by integrating these equations into the full multinomial logit model of acquisition choice.

The analysis in this section has yielded two findings which bear on the role of R&D in acquisition activity: First, the takeover premium is positively related to the amount of R&D capital possessed by the firm. Second, there does seem to be a kind of matching at work in the merger market: firms prefer to acquire firms which look more like themselves, especially with respect to R&D intensity. This result is not one that is easily determined from the aggregate (marginal) patterns of merger estimated in Table 4, and this suggests that the full matching model which I tried for the first time here may yield more information about the merger market than we have hitherto been able to obtain. It would be desirable to verify this result with some additional information about the other firm characteristics which prompt takeover activity.

6. Conclusions

I began this paper with some questions about costs and benefits of increased merger activity in the United States and suggested that exploring the role of Research and Development activity might shed some light on whether at least the firms involved were benefitting from the increase. I also cited some earlier and rather inconsistent evidence on the attractiveness of R&D in the takeover market. With respect to this last, the richer model of acquisition which attempts to match buyers and sellers seems to provide an explanation for some of the earlier results: although on average acquired firms invest the same or slightly less in R&D as the industry norm, the R&D which they do is valued more highly at the margin by the firms which take them over. This result at least hints that successful innovators are being taken over. In addition, there is evidence that larger gains are generated by acquisitions where both firms involved have high R&D intensity.

I also found evidence that much of the acquisition activity by private and foreign firms in the domestic market is directed towards firms and industries which are relatively less R&D intensive and have a weaker technological base, so that this kind of acquisition activity cannot be a major factor in causing a shift of focus away from innovation activity, unless we take the view that managers in these industries saw themselves as threatened with takeover far in advance and cut R&D spending in anticipation. Given the nature of the industries involved, this seems somewhat unlikely. Explaining this result would seem to require further investigation into the motives for private acquisitions.

Finally, I found very little evidence in the existing data (through 1985) that acquisitions cause a reduction in R&D spending; in the aggregate, firms involved in mergers showed no difference in their pre and post-merger R&D performance over those not so involved. At the individual industry level, the results were too imprecisely measured to draw firm conclusions.

However, I have left many open questions which deserve further attention: First, at the level of econometric specification, what are the optimal regressors in such a model, the optimal sampling for the choice set, and how do the results change when a nested logit model is used to estimate the probability of acquisition and the probability of the choice made. Second, can we learn more about the precise valuation of this part of the returns to R&D by incorporated exit prices directly into the model of acquisition probability Finally, is there more information about the relative importance of other reasons for merger to be gained from a more complete model of the acquisitions market using this framework?

Table 1

Reasons for Exit from the Publicly Traded Manufacturing Sector

Number of Firms and Employment*

Year	Total Exits		Acquisition by Public Domestic Firm		Acquisition by Private Firm		Acquisition by Foreign Firm		Liquidated or Bankrupt	
1976	28	92	24	89	1	0	2	2	2	0
1977	55	256	35	165	5	6	11	81	2	2
1978	42	243	20	204	13	22	8	16	1	0
1979	33	131	23	80	5	14	2	7	1	14
1980	59	353	31	270	5	15	8	21	9	17
1981	81	323	35	220	22	58	6	18	11	16
1982	67	190	23	72	23	47	7	36	11	30
1983	71	249	27	102	21	66	3	1	10	16
1984	115	596	44	290	38	161	10	74	11	10
1985	111	823	43	552	36	138	7	78	19	11
1986	58	466	23	153	15	86	8	52	5	14
Total	704	3721**	332	2195	199	615	72	385	101	132

Notes:

*The first entry in each pair of columns in the number of firms, and the second entry is the total employment (in 1000s) in these firms the year prior to exit.

**Columns and rows do not sum due to a few exits as yet unidentified as to reason and/or year of exit.

Table 2a

Characteristics of 550 Manufacturing Acquisitions

1977-1986

	Number	Empl.	Acquired 77-81		Number	Empl.	Acquired 82-86	
Industry	in 76	in 76	Percent	% Empl.	in 81	in 81	Percent	% Empl.
Food	158	1,753	19.0	18.6	120	1,771	25.0	17.0
Textiles	153	996	7.2	6.1	117	831	26.5	24.3
Chemicals	103	1,378	19.4	4.6	87	1,382	10.3	9.0
Drugs	92	739	10.9	4.4	99	793	14.1	15.3
Petroleum	66	1,456	9.1	5.2	58	1,681	8.6	8.1
Rubber,Plstcs	76	708	9.2	1.0	61	545	23.0	22.3
Stone,Clay,Gl	58	373	17.2	8.2	47	342	23.4	13.4
Prim. Metals	87	771	11.5	8.0	76	796	15.8	18.0
Fab. Metals	136	565	13.2	5.2	115	576	21.7	18.9
Engines	59	592	10.2	9.6	53	570	5.7	1.5
Computers	113	1,107	12.4	3.0	130	1,566	3.8	0.6
Machinery	157	657	21.0	17.3	122	557	14.8	11.2
Elec. Mach.	82	1,492	14.6	7.1	84	1,447	22.6	8.5
Electronics	192	2,000	8.3	2.6	198	2,376	7.6	5.6
Autos	77	1,357	14.3	4.6	62	1,041	19.4	10.3
Aircraft	40	823	12.5	1.7	37	984	21.6	9.4
Instruments	87	232	8.0	5.3	88	265	8.0	2.6
Lumber&Wood	154	916	9.7	6.1	127	824	16.5	7.2
Misc Mfg	166	957	11.4	5.0	150	1,091	18.0	10.0
Total Mfg	2056	18,874	12.8	6.6	1831	19,436	15.6	10.4

All employment figures are in thousands; they include part-time and seasonal workers, and exclude any contract employees or consultants.

The first four columns refer to acquisitions made between 1977 and 1981 as a share of the industry as it existed in 1976. The next four columns are for acquisitions made between 1982 and 1986 as a share of the industry in 1981.

The number of firms acquired and the employment in those firms are shown as a percent of the base period number of firms and employment.

Table 2b

Characteristics of the Buyers and Sellers in 314 Manufacturing Acquisitions

1977-1986

	Total #	Employ.	-------- Acquired 77-86 ------				Acquiring 77-86	
Industry	in 1976	in 1976	Number	Percent	Employ.	% Emp.	Number	Percent
Food	158	1,753	26	16.5%	541.5	30.9%	23	14.6%
Textiles	153	996	11	7.2%	50.0	5.0%	14	9.2%
Chemicals	103	1,378	19	18.4%	182.1	13.2%	12	11.7%
Drugs	92	739	17	18.5%	110.7	1.5%	12	13.0%
Petroleum	66	1,456	8	12.1%	164.6	11.3%	14	21.2%
Rubber,Plstcs	76	708	11	14.5%	8.2	1.1%	9	11.5%
Stone,Clay,Gl	58	373	10	17.2%	31.3	8.3%	8	13.8%
Prim. Metals	87	771	12	13.8%	161.3	20.9%	5	5.7%
Fab. Metals	136	566	25	18.4%	45.7	8.1%	16	11.8%
Engines	59	592	6	10.2%	44.3	7.4%	3	5.1%
Computers	113	1,107	18	15.9%	53.4	4.8%	10	8.8%
Machinery	157	657	31	19.7%	143.9	21.9%	14	8.9%
Elec. Mach.	82	1,492	18	22.0%	131.9	8.8%	13	15.8%
Electronics	192	2,000	27	14.1%	173.0	8.9%	16	8.3%
Autos	77	1,357	6	7.8%	21.0	1.5%	11	14.3%
Aircraft	40	823	10	25.0%	89.3	10.8%	6	15.0%
Instruments	87	232	11	12.6%	18.1	7.8%	9	10.3%
Lumber&Wood	154	916	23	14.9%	71.3	7.8%	10	6.5%
Misc Mfg	166	957	25	15.1%	47.1	4.9%	11	6.6%
Total Mfg	2056	18,874	314	15.3%	2,088.7	11.1%	216	10.5%

NB: The sample consists of manufacturing acquisitions where both the buyer and the seller appeared on the Compustat Files.

The first two columns are totals for the manufacturing sector in 1976. All employment figures are in thousands; they include part-time and seasonal workers, and exclude any contract employees or consultants.

The next four columns are totals for the firms which were acquired between 1977 and 1986. The columns labelled percent show their share of the 1976 industry, both in number of firms, and in employment.

The final two columns describe the firms in the industry which made acquisitions of publicly traded manufacturing firms between 1977 and 1986.

Table 3a

Comparison of R&D to Sales Ratios for Acquired and Non-Acquired Firms 1977-1986

By Acquired Firm's Industry

	Number of Firms	R/S Exiters	ΔR/S Exiters	R/S Stayers	ΔR/S Stayers	R/S Avg	Diff. T-stat
Food	26	.253%	.06%	.160%	.01%	-.093%	-1.5
Textiles	11	.158	.41	.169	.02	.012	0.1
Chemicals	19	1.79	-.21	1.80	-.35	.015	0.0
Drugs	17	7.21	.23	4.87	.59	-2.34	-0.6
Petroleum	8	.322	.14	.337	.01	.016	0.1
Rubber,Plstcs	11	.573	-.04	.915	.06	.342	0.8
Stone,Clay,Gl	10	.411	.01	.372	.03	-.039	-0.2
Prim. Metals	12	.623	-.10	.269	-.01	-.354	-2.1
Fab. Metals	25	.986	.16	.563	.02	-.422	-2.3
Engines	6	.826	-.07	1.37	.11	.547	1.1
Computers	18	5.64	.48	5.32	.26	-.319	-0.1
Machinery	31	1.12	.40	1.58	.20	.455	0.7
Elec. Mach.	18	3.51	-.13	4.40	.40	.893	0.3
Electronics	27	4.07	.88	3.44	.44	-.631	-0.3
Autos	6	.782	-.12	.766	-.18	-.016	-0.0
Aircraft	10	2.12	.09	2.02	.26	-.107	-0.1
Instruments	11	4.56	.35	4.10	.43	-.455	-0.2
Lumber&Wood	23	.345	.03	.342	.32	-.004	-0.0
Misc Mfg	25	.620	.04	.340	.02	-.028	-1.6
Total Mfg	314	1.97%	.18	1.82%	.16	-.154%	-0.4
Acquisitions outside of sample	254	0.92%		1.82%		-0.90 %	-3.0

R/S is the deflated R&D to sales ratio. The deflator for sales is the Producer Price Index for Finished Goods (Bureau of Labor Statistics) and that for R&D is due to Griliches following Jaffe (see Cummins et al (1985) for details).

The column labelled Exiters contains the average R&D to sales ratio for the 314 firms which were acquired by firms in my sample, measured one year before exit and the change in R&D to sales ratio for the combined firm measured from one year before exit until one year after. The one labelled Stayers is the average R&D to sales ratio and the growth of that ratio for the firms which did not exit, averaged over the 1977 to 1986 period. It is based on several hundred observations per industry.

The last two columns are the difference in R/S for the two groups and the T-statistic for the hypothesis that the difference is zero.

Table 3b

Comparison of R&D to Sales Ratios for Acquired and Acquiring Firms 1977-1986

By Acquiring Industry

	Number	R/S	R/S	ΔR/S	R/S Diff.	
	Acquired	Acquired	Acquiring	Acquirers	Avg	T-stat
Food	30	.320%	.209%	.07%	-.111%	-1.1
Textiles	15	.276	.467	.49	.191	0.6
Chemicals	18	3.22	2.69	.18	-.532	-0.7
Drugs	14	7.33	4.77	.31	-2.56	-0.9
Petroleum	11	.864	.383	-.06	-.481	-1.5
Rubber,Plstcs	11	.841	.921	.11	.080	0.2
Stone,Clay,Gl	9	1.11	1.10	.12	-.017	0.0
Prim. Metals	7	.084	.204	-.02	.120	1.0
Fab. Metals	28	.849	.649	-.12	-.199	-0.6
Engines	3	1.18	2.11	.06	.935	1.1
Computers	10	6.61	5.76	.46	-.854	-0.6
Machinery	21	1.08	1.24	.52	.161	0.4
Elec. Mach.	23	3.34	2.00	.02	-1.34	-1.4
Electronics	17	3.92	4.07	1.88	.145	0.2
Autos	14	2.59	1.12	-.05	-1.47	-1.1
Aircraft	9	3.97	3.61	-.26	-.361	-0.3
Instruments	11	1.79	3.33	.12	1.54	1.9
Lumber&Wood	10	.520	.304	.01	-.215	-0.6
Misc Mfg	18	.656	.179	-.06	-.477	-1.3
Total Mfg	279	2.05	1.68	.22	-.369	-0.9
Non-Mfg	38	1.38	.168		-1.21	-3.4
Total	317	1.97%	1.50%		-.472%	-1.5

The two columns labelled R/S give the average R&D to sales ratio for the acquiring firms and the firms they acquired. R/S is defined the same way as in Table 2a.

The column labelled ΔR/S is the average implied change in R/S around the time of aquisition for acquisitions by firms in that industry.

The last two columns again test the difference between the two R/S ratios.

Table 4

Logit Estimates of the Probability of Acquisition[*]

21,900 Observations

Probability of Being Acquired

	All	by Private or Foreign	by Manufacturing Firms
# Acquisitions	557	229	328
Log A	-.042(.022)	-.166(.030)	.036(.028)
K/A	-.139(.144)	-.514(.314)	.058(.167)
D(Tech)	-.232(.097)	-.830(.175)	.146(.122)
Trend[**]	.125(.016)	.239(.028)	.054(.020)
$\chi^2(3)$ for A,K,Tech	12.0	60.2	3.4

Probability of Making an Acquisition

	All Years	1976-1981	1982-1986
# Acquisitions	319	167	152
Log A	.432 (.025)	.546(.036)	.320(.034)
K/A	-.314 (.266)	.218(.340)	-.994(.385)
Trend[**]	.027 (.023)	-.015(.049)	.264(.079)

Variables:

Log K - Log of deflated capital stock of the firm in the year before it is acquired or acquires.
K/A - Ratio of R&D stock to assets in the same year.
D(Tech)-Dummy for the Chemicals, Drugs, Engines, Computers, Machinery, Elec. Machinery, Electronics, Aircraft, and Instruments Industries.

Notes:

[*] Estimates are obtained by the method of Maximum Likelihood. All standard errors are heteroskedastic-consistent estimates.

[**] A dummy for 1986 was also included since the data are incomplete for that year.

Table 5

Conditional Logit Estimates of Acquisition Choice

311 Acquisitions: 1977-1986

Coefficient Estimates

Variables	Model I		Model II	
$\Delta \mathrm{logA}$	-1.04(.15)	-1.00(.17)		
$\Delta(\mathrm{K/A})$	-4.05(.60)	-3.78(.66)		
$\mathrm{LogA}_j \cdot \mathrm{LogA}_i$			.17(.02)	.17(.02)
$(\mathrm{K/A})_j \cdot \mathrm{LogA}_i$			-.31(.16)	-.18(.20)
$\mathrm{LogA}_j \cdot (\mathrm{K/A})_i$			.28(.08)	.32(.08)
$(\mathrm{K/A})_j \cdot (\mathrm{K/A})_i$			3.82(0.98)	4.05(1.09)
D(Same ind.)		2.34(.21)		2.41(.18)
LogA_i	-.72(.14)	-.73(.16)	-1.13(.13)	-1.21(.15)
$(\mathrm{K/A})_i$	3.30(.53)	3.09(.58)	-2.98(0.72)	-3.28(0.82)
Log of Likelihood	-502.3	-424.7	-557.8	-467.2

Variables:

LogA = log of deflated assets in the year before the acquisition, where assets is the sum of capital stock, inventories, and other investments.

(K/A) = Ratio of R&D stock to assets in the year before the acquisition.

$\Delta \mathrm{logA} = |\mathrm{logA}_j - \mathrm{logA}_i|$

$\Delta(\mathrm{K/A}) = |(\mathrm{K/A})_j - (\mathrm{K/A})_i|$

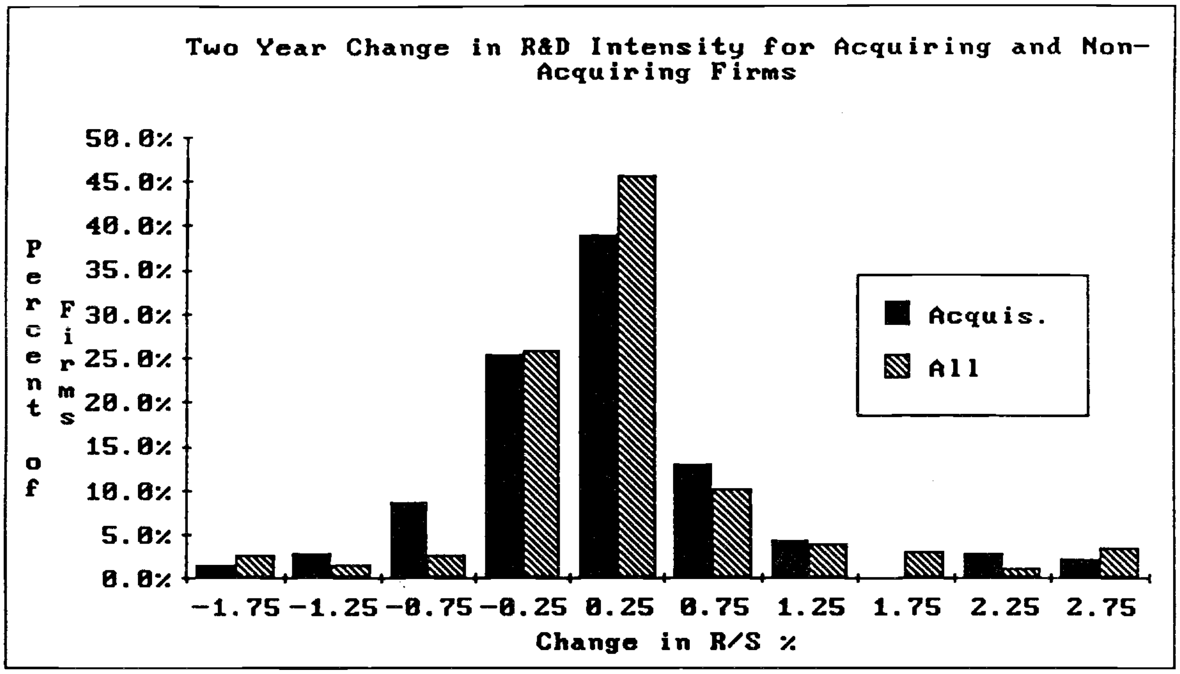
D(Same ind.) = 1 if acquiring and acquired firm are in the same two-digit industry.

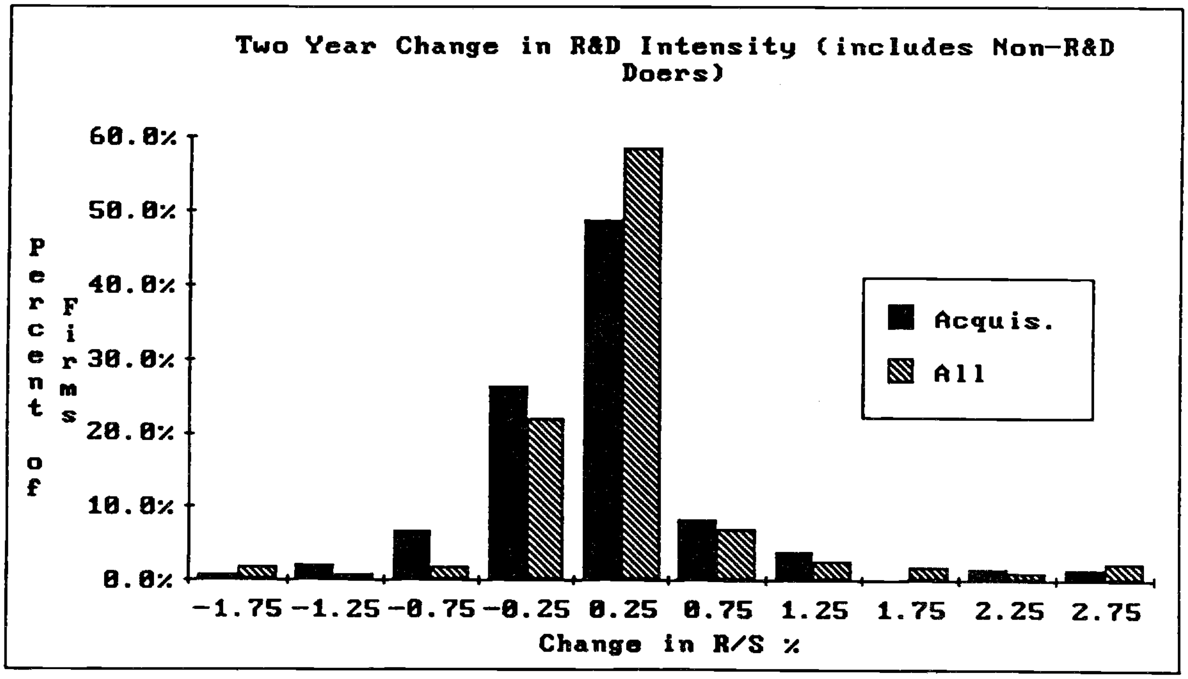
The subscript j indexes acquiring firms and i indexes target firms. The coefficient estimates are for the probability that firm j chooses firm i when it makes an acquisition. Models I and II are described more completely in the text.

Notes:

Standard error estimates are robust heteroskedastic-consistent estimates. They differ from the conventional estimates by less than ten percent in almost all cases.

Figure 1


Two Year Change in R&D Intensity for Acquiring and Non-Acquiring Firms
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Percent of Firms
Acquis.
All
-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 (includes Non-R&D Doers)
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
Percent of Firms
Acquis.
All
-1.75
-1.25
-0.75
-0.25
0.25
0.75
1.25
1.75
2.25
2.75
Change in R/S %

References

Abel, Andrew B. 1983. "Optimal Investment under Uncertainty," American Economic Review 73: 228-233.

Abel, Andrew B. 1984. "R&D and the Market Value of the Firm: A Note," in Z. Griliches, ed., R&D, Patents, and Productivity. Chicago, Illinois: University of Chicago Press.

Abel, Andrew B. 1985. "A Stochastic Model of Investment, Marginal q, and the Market Value of the Firm," International Economic Review 26:305-322.

Addanki, Sumanth. 1985. "Innovation and Mergers in U. S. Manufacturing Firms: A First Look," Harvard University, mimeo.

Asquith, P., R. F. Bruner, and D. W. Mullins. 1983. "The Gains to Bidding Firms from Mergers", Journal of Financial Economics. 11:121-139.

Auerbach, Alan and David Reishus. 1985. "Taxes and the Merger Decision," mimeo.

Auerbach, Alan and David Reishus. 1987. "The Effects of Taxation on the Merger Decision", this volume.

Berkovic, James and John Rust. 1985. "A Nested Logit Model of Automobile Holdings for One Vehicle Households," Trans. Res.-B 19B: 275-285.

Bound, J. C. Cummins, Z. Griliches, B. H. Hall, and A. Jaffe. 1984. Who Does R&D and Who Patents?", in R&D, Patents, and Productivity, Z. Griliches (ed.), Chicago: University of Chicago Press, 1984.

Cosslett, Stephen R. 1981. "Maximum Likelihood Estimator for Choice-Based Samples," Econometrica 49:1289-1316.

Cummins, Clint, Bronwyn H. Hall, Elizabeth S. Laderman, and Joy Mundy. 1984. "The R&D Master File: Documentation," National Bureau of Economic Research, mimeo.

Debreu, Gerard. 1960. "Review of R. Luce, Individual Choice Behavior," American Economic Review 50:186-188.

Gilson, Ronald J., Myron S. Scholes, and Mark A. Wolfson. 1985. "Taxation and the Dynamics of Corporate Control: The Uncertain Case for Tax Motivated Acquisitions," Stanford University, mimeo.

Griliches, Z. 1981. "Market Value, R&D, and Patents," Economics Letters 7.

Griliches, Z. and J. Mairesse. 1981. "Productivity and Growth at the

Firm Level," National Bureau of Economic Research Working Paper no. 826.

Griliches, Z. and J. Mairesse. 1983. "Comparing Productivity Growth: An Exploration of French and U. S. Industrial and Firm Data," European Economic Review 21: 89-119.

Grossman, S. and J. Stiglitz. 1977. "On Value Maximization and Alternative Objectives of the Firm," Journal of Finance May 1977.

Hall, Bronwyn H. 1987. "The Relationship between Firm Size and Firm Growth in the U. S. Manufacturing Sector," Journal of Industrial Economics 35:583-606.

Hall, Bronwyn H. 1987a. "The New R&D Master File: 1959-1985." Mimeo (in preparation).

Hall, Bronwyn H. 1987b. "Equilibrium in the Market for Acquisitions," Mimeo.

Hall, Bronwyn H., Clint Cummins, and Rebecca Schnake. 1986. TSP Version 4.1 Reference Manual. Stanford, California: TSP International.

Hall, Bronwyn H., Zvi Griliches, and Jerry A. Hausman. 1986. "Patents and R&D: Is There a Lag?", International Economic Review 27: 265-283.

Hausman, Jerry, and Daniel McFadden. 1984. "Specification Tests for the Multinominal Logit Model", Econometrica 52:1219-1240.

Jarrell, Gregg A. 1983. "Do Acquirers Benefit from Corporate Acquisitions?" University of Chicago, mimeo.

Hayashi, Fumio. 1982. "Tobin's Marginal q and Average q: A Neoclassical Interpretation," Econometrica 50: 213-254.

Jensen, Michael and Richard Ruback. 1983. "The Market for Corporate Control," Journal of Financial Economics. 11:1-53.

Jensen, Michael. 1986. The Takeover Controversy: Analysis and Evidence," Harvard Business School Working Paper 9-786-001.

Lucas, Robert E. 1967. "Adjustment Costs and the Theory of Supply," Journal of Political Economy 75: 321-334.

Lucas, Robert E. 1967. "Optimal Investment Policy and the Flexible Accelerator," International Economic Review 8: 78-85.

Lucas, Robert E. and Edward C. Prescott. 1971. "Investment under Uncertainty," Econometrica 39: 659-681.

Mannering, F. and C. Winston. 1985. "A Dynamic Empirical Analysis of Household Vehicle Ownership and Utilization," Rand Journal of Economics 16: 215-236.

Manski, Charles F. and Daniel McFadden. 1981. Structural Analysis of Discrete Data with Economic Applications. Cambridge, Massachusetts: The MIT Press.

Manski, C. F. and L. Sherman. 1981. "An Empirical Analysis of Household Choice among Motor Vehicles," Trans. Res. Rec. 202: 84-112.

McFadden, Daniel. 1973. "Conditional Logit Analysis of Qualitative Choice Behavior," in Frontiers in Econometrics, P. Zarembka (ed.), New York: Academic Press, 1973.

McFadden, Daniel. 1978. "Modelling the Choice of Residential Location," in Spatial Interaction Theory and Residential Location, A. Karlqvist (ed.), Amsterdam: North Holland, 1978.

McFadden, Daniel. 1984. "Qualitative Response Models," in Handbook of Econometrics, Volume II, Z. Griliches and M. D. Intriligator (eds.), Amsterdam: North Holland, 1984.

Mussa, Michael. 1974. "Market Value and the Investment Decision in an Adjustment Cost Model of Firm Behavior," Department of Economics, University of Rochester Discussion Paper 74-15 (July).

Poulsen, Annette B. and Gregg A. Jarrell. 1986. "Motivations for Hostile Tender Offers and the Market for Political Exchange," Contemporary Policy Issues IV, Number 3: 30-45.

Ravenscroft, David and F. M. Scherer. 1986. "The Profitability of Mergers," mimeo, January 1986.

Roll, Richard. 1986. "The Hubris Hypothesis of Corporate Takeovers," Journal of Business April 1986.

Ruud, Paul A. 1984. "Tests of Specification in Econometrics," Econometric Reviews 3:211-242.

San Miguel, Joseph. 1977. "The Reliability of R&D Data in Compustat and 10-K Reports", Accounting Review LII: 638-641.

Schankerman, Mark, and M. Ishaq Nadiri. 1984. "Investment in R&D: Costs of Adjustment, and Expectations," in Z. Griliches, ed., R&D, Patents, and Productivity. Chicago, Illinois: University of Chicago Press.

Schary, Martha. 1986. "Exit, Investment and Technological Diffusion in a Declining Industry: An Empirical Study." Mimeo, October.

Schwartz, Steven. 1982. "Factors Affecting the Probability of Being Acquired," Economic Journal 92:391-398.

Securities and Exchange Commission, Office of the Chief Economist. 1985. "Institutional Ownership, Tender Offers, and Long-Term Investments," SEC Study, April 1985.

Summers, Lawrence H. 1981. "Taxation and Corporate Investment: A q-

Theory Approach," Brookings Papers on Economic Activity 1981: 67-140.

Train, Kenneth. 1986. Qualitative Choice Analysis, Cambridge, Massachusetts: The MIT Press.

Wildasin, David E. 1984. "The q Theory of Investment with Many Capital Goods," American Economic Review 74: 203-210.