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EFFECTS OF ACQUISITIONS ON R&D INPUTS AND OUTPUTS

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Making acquisitions, although a popular strategy, may not always lead to positive firm performance. Researchers have offered several explanations for this relationship. One is that acquisitions lead to lower investments in R&D and curtail the championing process whereby organization members internally promote new products and processes in firms. The current research found that acquisitions had negative effects on "R&D intensity" and "patent intensity."

Making acquisitions has been a popular strategy in U.S. firms for many years (Leontiades, 1986). The resources invested in acquisitions—growing from $43.6 billion in 1968 to $246.9 billion in 1988 (Weston & Chung, 1990)—reflect this popularity. Furthermore, the almost $250 billion invested in acquisitions accounted for approximately 40 percent of U.S. corporations' 1988 capital expenditures (Weiner, 1989). These data suggest executives believe that acquisitions create value.

However, the outcomes of acquisitions may not fully support this belief (Roll, 1986). Some evidence suggests that shareholders in acquired firms derive significant value from acquisitions (Jensen, 1988), but results regarding the value of acquisitions for the shareholders of acquiring firms have been decidedly mixed (Amihud, Dodd, & Weinstein, 1986; Fowler & Schmidt, 1988; Lubatkin, 1987; Lubatkin & O'Neil, 1987). Some researchers have found evidence of benefits for acquiring shareholders only in specific types of acquisitions: Hopkins (1987) found such evidence where there was "strategic fit," or similar strategic characteristics between acquiring and target firms; Singh and Montgomery (1987) found it for related acquisitions.

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Porter (1987) reported that acquisitions often did not yield anticipated outcomes and eventually led to divestitures. Additionally, Ravenscraft and Scherer (1987) conservatively estimated that acquirers had divested one-third of all acquisitions made in the 1960s and 1970s by the early 1980s. Both Porter and Ravenscraft and Scherer also suggested that the divestitures have largely been the result of inadequate performance. Roll (1986) concluded that acquirers may have overestimated the expected gains from acquisitions. Finally, Jensen (1988) observed that returns from acquisitions to acquiring firms vary closely around zero.

Several rationales may explain these less-than-desired outcomes. For example, Barney (1988) argued that without the rare presence of a unique and private synergy[1] between an acquiring and a target firm, the acquiring firm will bid the target's price to an amount equal to or beyond its value. Roll (1986) ascribed the latter situation to the hubris of managers bent on making specific acquisitions. As a result of acquiring firms' paying such premiums, their shareholders often gain no value, or even lose value from an acquisition.

A second rationale concerns the significant investments acquisitions require. Because of those expenditures, executives may trade investments in acquisitions for investments in other areas, such as advertising, R&D, and quality control. Franko (1989) showed that R&D investments are positively related to long-term performance, a finding suggesting that such a trade-off may have significant consequences. A third rationale for the poor outcomes of acquisitions is that they may intervene in the R&D process by affecting the "championing culture," a pattern of organizational activity that fosters innovation (Burgelman, 1986). Acquisitions would thereby lower managers' incentives for first developing new product and process ideas and then carrying them to fruition. Thus, acquisitions may reduce both investment in R&D and R&D outputs, reductions that in turn can have a negative effect on a firm's long-term performance. In total, the logic and research results cited suggest that the link between acquisitions and improving an acquiring firm's performance may be more tenuous than some executives believe.

To date, little research has examined these general issues and the more specific question of acquisitions' effects on R&D inputs and outputs. The National Science Foundation commissioned Charles River Associates to review and evaluate all data regarding acquisitions' effects on R&D. In its final report, Charles River Associates concluded that "[the] available data do not permit rigorous testing of hypotheses concerning the effects of mergers and acquisitions on private R&D activity" (1987: 51). The primary purpose of the present study was to examine one aspect of the relationship between acquisitions and performance—the effects of acquisitions on R&D inputs and outputs.

[1] Private synergy refers to synergy between acquiring and target firms that is due to unique resource complementarity not found among other potential bidders for a specific target.

THEORETICAL BACKGROUND AND HYPOTHESES

Acquisitions and R&D Inputs

Burgelman (1986) argued that firms grow and develop through acquisitions or innovations. Generally, however, resource constraints dictate an emphasis on one or the other mode of growth. As noted previously, U.S. firms are investing significant amounts of resources in acquisitions. As is the case with virtually every organizational action, a commitment of resources to acquisitions may produce unintended consequences. For example, regardless of how acquisitions are financed, the resources remaining for managerial allocation may become constrained, causing managers to forgo other investment opportunities. One opportunity that may be slighted is R&D.

In light of this logic, Hitt, Hoskisson, and Ireland (1990) argued that firms may substitute acquisitions for innovation. In such cases, managers will likely decrease investments in R&D. Acquisitions offer immediate entrance to a new market, a larger share of a market served currently, or both (Balakrishman, 1988; Shelton, 1988). They may therefore be an attractive—although possibly a short-term-oriented—alternative to R&D investments. Although risks exist, the outcomes of acquisition are more predictable than the outcomes of internal development.

In summary, the evidence suggests that making acquisitions, although a popular strategy, may not produce the positive returns executives and shareholders desire. A managerial decision to substitute investments in acquisitions for investments in R&D may contribute to that outcome. This possibility, coupled with the evidence presented herein, suggests the following:

> *Hypothesis 1: A negative relationship exists between a firm's acquisitions and its relative R&D intensity, measured as R&D investment divided by sales and adjusted for average industry R&D intensity.*

Acquisitions and R&D Outputs

Acquisitions may also affect R&D outputs. Hitt and colleagues (1990) proposed that acquisitions have a negative effect on managerial commitment to innovation, defined as managerial willingness to allocate resources and champion activities that lead to the development of new products, technologies, and processes consistent with marketplace opportunities. Regardless of their level, R&D resources must be managed effectively. Furthermore, new product and process ideas must be championed if they are to develop into patentable products or processes (Burgelman & Maidique, 1988). Patents reflect a firm's intention to commercialize a product idea. An acquisition may intervene in the championing process and reduce managerial commitment to innovation. If top-level managers have a low commitment to innovation, they will provide few rewards and incentives for creating and championing innovations. Thus, lower-level managers will be less likely to champion new product and process ideas that lead to patentable outcomes than they would in an organization committed to innovation. As a result, transformations of ideation into marketable products become less likely:

Hypothesis 2: A negative relationship exists between a firm's acquisitions and patent intensity, measured as its number of patents divided by sales.

METHODS

Firms and Data

Acquired companies were identified through Standard and Poor's COMPUSTAT research files and studied if they had reported R&D expenditures in at least one of the three years prior to their acquisition. We then matched these companies to their acquirers using *Moody's Industrial Manual* and the *Large Merger Series*, a publication of the Federal Trade Commission. We used the primary, supplementary, tertiary, and over-the-counter research files distributed by COMPUSTAT Services to obtain data on R&D expenditures.

Patent data were collected from two data bases, BRS Information Technologies PATDATA and CASSIS/CDROM, both of which are based on information provided by the Patent and Trademark Office of the U.S. Department of Commerce. We used two data bases to ensure the data's accuracy, currency, and effective aggregation to a firm level.

Data on R&D expenditures and patents were required for both the acquiring and the acquired firms in the preacquisition periods and for the acquiring firms in the post-acquisition periods. Of the 278 acquisitions identified, approximately one-third had inadequate data, resulting in a final group of 191 acquisitions completed from 1970 through 1986. The firms studied represent 29 industries; a list of the distribution of acquiring and target firms by industry is available from the authors.

Data were collected on the acquiring and target firms for up to three years prior to the acquisitions and for three years after the years in which the acquisitions were completed. Because of differences in the way companies report financial information during transition, data from the years of acquisition were excluded. The number of acquisitions included in each statistical test varied depending on data requirements and availability (see Table 2 for the degrees of freedom associated with each analysis).

Independent and Dependent Variables

Figures from financial statements for the acquiring and acquired firms were combined in the preacquisition periods. Using these combined statements, we measured firm R&D intensity, defined as total R&D expenditures divided by total sales. As expected, there was a strong positive relationship between firm R&D intensity and industry R&D intensity. Thus, we controlled industry influences by subtracting average industry R&D intensity from the combined R&D intensity of each acquiring and acquired firm. The referent industries were the dominant industries of each firm defined using the two-digit Standard Industrial Classification (SIC) system; however, we also conducted secondary tests using three-digit industry data (Baysinger & Hoskisson, 1989; Keats & Hitt, 1988). Because acquiring and acquired firms often are involved in different dominant industries, industry R&D intensity was defined as the weighted average of the two industries. To maintain comparability with the preacquisition periods, we used sales figures for the last years before acquisitions as industry weights for all the post-acquisition years. Studied firms were not used in calculating their industry averages.

Acquisitive growth (acquisitions) was measured using a dummy variable, with annual firm data in the before-acquisition period set equal to zero and data in the after-acquisition period set equal to one. This procedure is similar to Hoskisson's (1987) approach to measuring the longitudinal effects of M-form structural change.

It is difficult to construct meaningful measures of innovative output (Pakes, 1985). Several researchers (e.g., Acs & Audretsch, 1988; Pakes & Griliches, 1980) have used the number of patents a firm holds as a measure of inventive activity. Of course, not all R&D activity leads to patents, and not all innovations are patented. Nonetheless, patent count is one of the most direct measures of innovative output available (Pakes & Griliches, 1980). In our data set, there was a strong relationship between total number of patents and firm size. Thus, we measured patent intensity by dividing the total number of patents a firm held by its annual sales.

Control Variables

A number of other variables potentially related to acquisitions may also affect R&D (Charles River Associates, 1987). Primary among these variables are diversification, leverage, size, liquidity, and performance. Acquisitions are a primary means of diversification that may be undertaken to reduce a firm's overall risk and consequently, its CEO's employment risk (Amihud & Lev, 1981; Harrison, 1987; Hill, Hitt, & Hoskisson, 1988). Although there is also evidence to the contrary (Kamien & Schwartz, 1982), some research has suggested a negative relationship between diversification and R&D intensity (Baysinger & Hoskisson, 1989; Hoskisson & Hitt, 1988). We calculated the level of acquisition-firm diversification using the entropy measure (Baysinger & Hoskisson, 1989; Jacquemin & Berry, 1979; Palepu, 1985). This diversification measure has two components—related and unrelated diversification—with each component defined as:

$$\Sigma P_1 \ln(1/Pi),\ i = 1,$$

where P_1 is the share of segment i in firm sales and $(1/Pi)$ is the weight for each segment (the logarithm of the inverse of its share). This measure takes into account the number of segments in which a firm competes and the importance of each segment to its total revenues. Related diversification is defined as the diversification arising from operating in four-digit segments within a two-digit industry group, with industry group sales defined as the sales reference, as in the formula above. Unrelated diversification is defined as diversification arising from operating between two-digit industry groups, with total firm sales used as the sales reference. Total diversification is the sum of the related and unrelated components; we used Standard and Poor's COMPUSTAT business segment file to calculate those components. Because these data are only available for years after 1979 and not available for all firms, the number of observations for the entropy measure was reduced by almost two-thirds.

As a result of the significant reduction in data for total diversification measured by the entropy formula, we added a second measure of diversification, labeled diversifying acquisitions. This variable was a dummy with related acquisitions (those in the same two-digit industry as an acquirer's primary industry) set equal to zero and unrelated acquisitions (those in a different two-digit industry) set equal to one in the post-acquisition periods. This variable had a value of zero during the preacquisition periods. Data on this variable, diversifying acquisitions, were available for all firms.

Financial theorists have encouraged the use of leverage since the pioneering work of Modigliani and Miller (1958), but its use involves trade-offs for firms. Smith and Warner (1979) argued that as firms increase their levels of debt, managers tend to become increasingly risk-averse. Baysinger and Hoskisson's (1989) finding of a negative relationship between amount of long-term debt and investment in R&D supports this argument. In the present study, we defined leverage as long-term debt divided by equity.

Schumpeter (1961) hypothesized that large firms are more innovative than small firms because large firms have sustained and efficient R&D programs. Presenting contrary evidence, Kamien and Schwartz (1982) suggested that the relationship between firm size and innovation is a nonlinear, inverse-U relationship. Regardless of the shape of the relationship between firm size and R&D, it has been shown to be reasonably strong (Hitt et al., 1990). We defined size as a firm's total number of employees.

Liquidity influences R&D investments by limiting the discretionary resources a firm can expend in a given period without incurring additional debt. Additionally, profitability affects decision makers' optimism and the funds available for R&D. Previous research has found a relationship between degree of liquidity and levels of profitability and R&D (Elliott, 1971; Grabowski, 1968). We used the current ratio (current assets divided by current liabilities) to control for liquidity influences (Baysinger & Hoskisson, 1989). Profitability was defined as after-tax return on total assets, or ROA, which was measured as net income divided by total assets.

Data on industries' patent intensity were not available. Therefore, to control for potential industry influences on patents, we used industry R&D intensity as a control variable in the models with patent intensity as the dependent variable.

Finally, to control for within-acquisition variance across the firms studied as well as interdependence (autocorrelation) across time, we took a very conservative approach, creating a categorical variable for each acquisition to control for these possible intervening influences. This is a common approach in repeated-measures designs (Winer, 1974), and it has been used in both psychological (e.g., Hitt & Barr, 1989) and strategy (e.g., Hoskisson, 1987) research. Our method essentially produced a pooled cross-sectional time series; we had separate entries for each firm for each year up to a maximum of six.

RESULTS

Table 1 shows the means, standard deviations, and intercorrelations for all variables. Table 2 shows results of the regression models used to test the hypotheses.

The results presented in the first regression model (model 1, Table 2) show that after size, leverage, ROA, and liquidity are controlled, the acquisitions variable is a statistically significant, negative predictor of R&D intensity adjusted for industry. Because of the 60 percent loss of data for the entropy measure of diversification, we entered it into a separate model containing all the other control variables to control for total diversification of the acquiring firms. The result, model 2, is quite similar to model 1. Acquisitions remain a negative predictor of adjusted R&D intensity ($t = 7.07$, $p < .01$); ROA and size were the only other statistically significant independent variables. Total diversification was not a statistically significant predictor of adjusted R&D intensity ($t = 1.58$, n.s.). Therefore, these results provide strong support for Hypothesis 1.[2]

Table 2 also shows the results of the testing of Hypothesis 2, in which patent intensity was the dependent variable. The results are similar to those for R&D intensity. Both acquisitions and ROA were found to have statistically significant, negative effects on patent intensity (model 4). As with the R&D intensity models, we developed a second model including total firm diversification (the entropy measure with significantly reduced data). In this model (model 5), total firm diversification was the only statistically significant independent variable ($p < .01$), and its relationship with patent intensity was negative. Approximately two-thirds of the acquisitions made were outside of the acquiring firms' primary two-digit SIC codes (see Table 1). As a result, we examined the effects of diversifying acquisitions on patent intensity (model 6). The results show diversifying acquisitions to have a statistically significant negative effect ($p < .01$) on patent intensity. Thus, we may conclude that acquisitions negatively affect patent intensity primarily to the extent that they increase diversification. The results suggest that the

[2] A hierarchical regression model was developed with acquisitions as the last variable, entered after all control variables, for both the R&D intensity and patent intensity models. The changes in R^2 (.013 for R&D intensity and .014 for patent intensity) for both models were statistically significant at $p < .01$. Most of the control variables were statistically significant predictors in the restricted models without the acquisitions variable. Therefore, it is not surprising that the change in R^2 for the addition of the acquisitions variable in each model, although statistically significant, is not large.

TABLE 1
Intercorrelations for All Variables[a]

Variables	Means	s.d.	1	2	3	4	5	6	7	8	9	10
1. Adjusted R&D intensity	−0.006	0.027										
2. Patent intensity	0.023	0.034	.221**									
3. Acquisitions	0.483	0.500	−.086**	−.130**								
4. Size[b]	42,369	55,453	.053	−.080*	.054							
5. ROA	0.065	0.040	.084**	.051	−.087**	.061*						
6. Leverage	0.434	0.562	−.028	−.069*	−.048	−.056	−.307**					
7. Liquidity	2.167	0.661	.027	.237**	−.152**	−.352**	.123**	−.092				
8. Diversifying acquisitions	0.300	0.458	.003	−.028	.677**	.038	−.008	.006	−.142**			
9. Total diversification	1.628	0.502	−.219**	.113*	.034	.161**	−.017	.176**	−.211**	.204**		
10. Average industry R&D intensity	0.036	0.027	−.554**	−.015	.160**	.071*	.017	−.160**	.099**	−.010	−.084	

[a] N = 1,021 except for patent intensity (N = 852) and total diversification (N = 386).
[b] Size was measured as number of employees.
* $p < .05$
** $p < .01$

TABLE 2
Results of Regression Analysis[a]

	R&D Intensity			Patent Intensity		
Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	.434**	.865**	.413**	−.613*	−.780**	−.705*
Acquisitions	−.134**	−.241**		−.185**	.018	
Total diversification		.117			−.148**	
Diversifying acquisitions			−.108**			−.162**
Size	.092	.351*	−.004	−.014	−.086	−.090
Leverage	−.019	−.006	−.022	−.003	.002	−.014
ROA	−.061**	−.128**	−.043*	−.148**	.028	−.133**
Liquidity	−.004	.032	.023	.070	−.054*	.099*
Average industry R&D intensity				−.059	−.086*	−.167*
F	30.52**	20.62**	28.82**	9.60**	19.52**	9.45**
R^2	.878	.903	.872	.731	.907	.728
df	195,825	120,265	195,825	189,666	118,236	189,666

[a] Variables controlling for autocorrelation and firm effects are not shown because of their number. As a whole they had a statistically significant effect on the dependent variable in each model.

* $p < .05$
** $p < .01$

relationship between acquisitions and patents is more complex than predicted in Hypothesis 2.

DISCUSSION

The results provide strong support for the negative effects of acquisitions on R&D investments and of diversifying acquisitions on R&D outputs, or patents. These results are quite important because previous research (e.g., Baysinger & Hoskisson, 1989; Hoskisson & Hitt, 1988) concluded that firm diversification has negative effects on investments in R&D. However, the present results suggest that mode of entry—here, acquisition—may have a stronger effect on R&D investments than diversification. Additionally, the interaction of mode and type of entry (diversifying acquisitions) has important effects on R&D outputs. Thus, acquisitive growth strategies may have a negative effect on firm innovation (Hitt et al., 1990). In fact, managers may use acquisitions as a substitute for innovation. Managers can acquire technology or products that are new to their firms but not necessarily new to the market (Clarke, Ford, & Saren, 1989). However, the reduction in relative R&D expenditures and resulting outputs following acquisitions suggests that over time, the innovativeness of acquired firms may decline. For instance, target firms may not pursue patents because of a loss of innovation champions. This loss may occur because target firms experience high turnover (Walsh, 1988, 1989). Furthermore, the reduction in relative numbers of patents following acquisitions suggests that acquiring firms are not fully exploiting acquired technologies or that they are not acquiring young technologies.

Franko's (1989) findings highlight the potential significance of these results. Franko examined global competition through changes in the shares of world markets (American, European, and Asian) held by leading firms in 15 major industries for the 1960–86 period. He found the amount of resources allocated to R&D to be the primary predictor of subsequent sales growth performance relative to competition. Firms with lower R&D investments than their competitors lost global market share. These findings, coupled with the results of this study, suggest that executives following an acquisitive growth strategy may be making trade-offs with significant implications.

Interestingly, Pakes (1985) found a strong positive relationship between stock market returns and unexpected (not predictable from historical trends) changes in patent applications. Given the frequency of the market's negative reaction to diversifying acquisitions (Hoskisson & Hitt, 1988) and the negative relationship between diversifying acquisitions and patent intensity found in this study, Pakes's results are not surprising. The market may react negatively to diversifying acquisitions as well as to sudden reductions in patent applications that diversifying acquisitions could precipitate. In combination, these results suggest that diversifying acquisitions may have negative effects on a firm's long-term performance.

One explanation often given for the reduction in R&D expenditures following acquisitions is that firms achieve a synergy based on economies of scale, scope, or both. According to the logic of Schumpeter (1961), R&D intensity should decrease following an acquisition because firms gain economies of scale from the integration of R&D units. This logic suggests that acquisitions should have either no effect or a positive effect (because of potential R&D synergy) on R&D outputs. Also, there should be little relationship or a negative relationship between R&D investments and the number of patents achieved, at least for some time after acquisitions. However, a statistically significant, positive relationship between R&D intensity and patent intensity emerged in this study, a finding that previous research supports (Acs & Audretsch, 1988; Jaffe, 1986; Schmookler, 1966). Additionally, the negative relationship between acquisitions and patents suggests that neither more nor even the same relative level of R&D outputs is achieved. Therefore, the results of this study do not support the existence of synergistic gains from economies of scale or scope in R&D activities from acquisitions and, in fact, suggest the opposite. Although absolute R&D inputs increased slightly after acquisitions, they decreased relative to competitors' R&D inputs, and the absolute number of patents and number of patents adjusted for size decreased after acquisitions. Furthermore, the average annual change in patents before acquisitions was positive (+1.69), but the average annual change after acquisitions was negative (−1.88). These results support the argument that innovative outputs decline after acquisitions (Hitt et al., 1990).

The present results primarily reflect outcomes that are being achieved, not the reasons for their achievement. However, Hitt and colleagues (1990) argued that managers engaging in acquisitions become more risk-averse than they have been and thus less committed to innovation. The statistical models reported herein offer some evidence in support of that argument. In most of the regression models, ROA, used as a control variable, had a negative relationship with R&D inputs and outputs. On the surface this finding might seem curious, but it supports both prospect theory (Kahneman & Tversky, 1979) and our arguments. Fiegenbaum and Thomas (1988) found that when firms perform well, they take fewer risks. Our results, showing a negative relationship between ROA and R&D activities in terms of inputs and outputs, suggest that managers indeed take a more risk-averse stance as their firms' performance increases.

Although acquisitions may have independent effects on R&D inputs and outputs, their real effects may be broader. For example, Hitt and colleagues (1990) argued that acquisitions are a primary mode of diversification and are often financed by debt. Previous research has shown that diversification (Baysinger & Hoskisson, 1989; Hoskisson & Hitt, 1988) and leverage (Baysinger & Hoskisson, 1989) have negative effects on R&D intensity. Therefore, to the extent that an acquisition strategy increases diversification and leverage, it also affects R&D inputs and outputs. Thus, our results may understate the full effect of acquisitions on R&D inputs and outputs.

CONCLUSIONS

We have offered a number of potential explanations for the results reported herein. However, future research is required not only to confirm the findings of this study but also to test and extend theoretical rationales for the reported outcomes.

Acquisitions also likely benefit firms. For example, a target firm's stockholders often gain significant value from an acquisition. Furthermore, acquiring firms may replace inefficient managers, thereby improving the value of target firms' outputs following acquisitions. However, the results reported herein suggest that acquiring firms' managers should be prepared to accept what may prove to be significant trade-offs, including the substitution of investments in acquisitions for investments in discretionary activities like R&D. These trade-offs are important for all firms; however, they may be critical for firms in industries in which innovation is important. Thus, executives can make informed judgments only when they recognize and carefully analyze potential trade-offs. Acquisitions may produce efficiencies but may also increase managerial risk aversion. As previous research has indicated (Hitt & Hoskisson, 1991), over time such risk aversion may affect the strategic competitiveness of a firm.

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