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**Abstract**

Firms obtain new technology either through internal R&D or through acquisitions. These two approaches are usually labeled as "make" and "buy" strategies. In this paper, I examine the relation between a firm's choice of "make" or "buy" and the performance measures used in the firm's CEO compensation contract. I focus on the two major differences between "make" and "buy" strategies: the risk levels and accounting treatments. I then examine the differential implications of accounting-based and stock-based performance measures on managers' incentive in choosing between the two strategies. Using data from US high tech industries, I find that, firms relying on "buy" approach to obtain technology tend to depend more on the accounting-based performance measures, while those firms who innovate through R&D activities skew toward stock-based pay especially stock options.

*JEL Classification*: M41- Accounting; J33 - Compensation Packages; O31 - Innovation and Invention: Processes and Incentives; G34 – Mergers and Acquisitions.

*Keywords*: R&D; Acquisition; Compensation; Technology

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## 1. Introduction

Innovation is crucial to a firm's survival and growth in high-tech industries. Companies innovate either through in-house research and development (R&D) or through external acquisitions and licensing. These two approaches to acquiring new technology, that is, internal vs. external, are often labeled as "make" and "buy" strategies. In this paper, I examine the relation between CEO compensation contracts and firms' choice between "make" and "buy". I find evidence consistent with the hypothesis that firms relying on "bought" technologies tend to use more accounting-based compensation, while those firms who develop technologies internally compensate their CEOs more by stock based pay.

Previous literature has long noticed the importance of managerial incentives in a firm's innovation process (e.g. Smith and Stulz, 1985; Smith and Watts, 1992), but the focus has been on the research and development (R&D) activities. In reality, firms view Mergers and Acquisitions (M&A) as an equally important means to obtain innovation. For example, in its 2001 annual report, the pharmaceutical company Cephalon states:

> "Innovation takes place at every level in our business, not just in R&D …… but also in the discipline of mergers and acquisitions. One measure of our M&A success today is that each of our past acquisitions has become rapidly accretive to Cephalon's earnings"

Firms rely on managers' expertise to make an optimal choice between the two strategies and achieve success in the innovation activities. If a manager's only task is to pick between the "make" and "buy" strategies, a flat fee will be enough to achieve the "first best" solution for the shareholders, because there is no reason why the manager would not choose the optimal strategy. But managers are usually involved in various aspects of a firm's operation, and an incentive pay is necessary to motivate managers to exert optimal level of effort (Holmstrom, 1989). The incentive pay is likely to induce agency costs due to the differential attributes of "make" and "buy". In a complete contracting setting, a firm's board of directors is expected to mitigate these agency costs and appropriately motivate managers' optimal choice between "make" and "buy" while designing a compensation contract. In this paper, I focus on the two major differences between "make" and "buy" strategies – riskiness and the accounting treatment – and study their implications for managers' incentives and how they are incorporated into the compensation contracts.

Performing internal R&D is in general more risky than acquiring ready technology (e.g. patents) externally[1]. However, much of the R&D uncertainty represents idiosyncratic risk. We know from asset pricing theories that shareholders price only the systematic risk because they can diversify away the idiosyncratic risk. Therefore, the higher risk associated with R&D compared with technology acquisitions should not make "buy" more beneficial than "make". Unlike shareholders, managers are sensitive to the idiosyncratic risk associated with firm-specific activities such as R&D. Because managers typically have their human capital as well as a large portion of personal wealth invested in the same firm, they are under-diversified. This under-diversification can lead to risk-averse investment behavior. Managers may pass up some risky investment opportunities even if such investments are in the best interests of the shareholders. Thus, in the context of choosing between "make" and "buy" approaches to innovation, risk-averse managers may prefer "buy" over "make." To overcome this risk-aversion, stock options can be used to provide managers with risk-seeking incentives. (Smith and Stulz 1985, Guay 1999)

In addition to differential risk levels, "make" vs. "buy" approaches also differ in their accounting treatment. Because of the great uncertainty associated with the return on R&D

[1] See section 2.1 and Table 1 for detailed discussion of this issue.

expenditures, the US GAAP requires that firms expense their R&D expenditures as incurred. This treatment negatively affects a firm's accounting earnings and offers a bad matching between benefit and cost associated with R&D activities. Accounting earnings are therefore not a very informative measure of R&D investment's economic value (Healy, Myers, and Howe 2002). In contrast, for acquisition activities, accounting earnings try to match the cost and benefit associated with the acquired assets under either the pooling-of-interest or the purchase method[2]. In terms of valuing the returns from innovation investments, accounting earnings are more relevant for acquisitions than for R&D activities.

Recognizing the "make" and "buy" strategies' implications for managers' incentives, a firm's board of directors is expected to select performance measures that best align the manager's interests with those of investors. In this paper, I focus on the two most widely used performance measures – accounting earnings and stock prices. I hypothesize that firms relying on "buy" strategies to obtain technology will use more accounting-based performance measures in their compensation contracts, whereas firms depending on R&D in their innovation process will skew toward stock-based compensation.

Because both the compensation policy and the choice between "make" and "buy" strategies are a firm's choice, the two aspects are likely to be endogenous. I use a two-stage-least-squared framework to address the endogeneity problem in this paper. My empirical results suggest that, a firm tends to attain technology through acquisitions instead of R&D if its CEO receives more accounting-

[2] FASB Statement 141 and 142 recently changed the accounting treatment of merger and acquisition. Effective July 1 2001, the pooling-of-interest method is prohibited, and the goodwill and indefinite-lived intangible assets are no longer amortized and should be tested for impairment utilizing a new methodology. This change is likely to enhance the value relevance of the accounting measures.

based compensation, while CEO's stock-based compensation encourages the firm to pursue innovation through R&D. These results are robust to several robustness checks.

The relation between firm risk and managers' investment behavior has attracted lots of attention from academia. (e.g., Jensen and Meckling, 1976; Smith and Stulz, 1985; Core, 1999) In this paper, I study the issue in a specific setting – firms' innovation process. This paper contributes to the literature in two ways. First, it studies managerial incentive's role in one of the most important corporate investment activities – achieving innovations – and sheds light on the determinants of a firm's choice among various strategies of obtaining technology. Second, it enhances our understanding of accounting information versus stock prices as performance measures in CEO compensation contracts, and provides evidence that the use of accounting information in contracting can have a real impact on corporate investment decisions.

The rest of the paper is organized as follows. The next section develops the hypotheses by analyzing the relation between a firm's CEO compensation contract and investment decision-making process. Section Three presents the factors other than compensation that could affect a firm's "make" or "buy" strategies and that should be controlled in the regression analyses. Section Four describes the sample selection and the research design. The empirical results are described in Section Five. Section Six addresses some possible concerns regarding the results and provides the robustness tests. Section Seven offers concluding remarks.

## 2. Hypothesis Development

This section analyzes how different performance measures (i.e. accounting earnings and stock prices) affect managers' incentives in a firm's innovation process, and how the board can construct an optimal compensation contract in order to motivate the desired investment behavior from the managers. The analyses focus on two aspects: the different risk levels of "make" vs. "buy," and the contrasting accounting treatment of the two innovation methods.

## 2.1 Differential risk levels of "make" and "buy"

The most prominent difference between "make" and "buy" approaches is the risk level. As alternative approaches to innovations that could lead to new marketable products, internal R&D is much more risky than acquiring ready technologies (such as patent). The high-risk nature of R&D increases the volatility of both earnings and returns. Chan, Lakonishok and Sougiannis (1999) find evidence that R&D intensity is positively associated with return volatility. The return volatilities reported in Table 1 illustrate the high riskiness of R&D compared with acquisitions. The sample is drawn from US high tech industries as defined by the SDC merger and acquisition database. The sample period is from 1992 to 2000. Dividing firm years into quartiles based on total assets, table 1 reports the monthly stock return volatilities of firm years with acquisition activities and those with high R&D-to-sales intensity. The return volatilities of the whole sample are also provided as the benchmark. Except for the highest quartile, where the return volatilities of the two groups are almost equal, the stock returns of firm years with high R&D intensity tend to be more volatile than the observations with acquisition activities. Table 1 also suggests that although acquisitions are in general less risky than R&D, they are more risky than average investment activities – the return volatilities of acquisition firm years are higher than the quartile average.

**[Insert Table 1 here]**

Smith and Stulz (1985) show that managers may pass up a positive net-present-value (NPV) but risk-increasing project and shareholders can mitigate this problem by using stock options or common stocks.   Guay(1999) finds that by increasing the convexity of the relation between firm performance and managers' wealth, equity-based compensation packages, especially stock options, can encourage risk-increasing investment activities such as R&D.

Compared to accounting-based compensation, the equity-based compensation, especially stock options, provides significantly more risk-taking incentives to managers.  Therefore, if a manager's compensation is skewed toward accounting-based pay, he will favor "buy" over "make" because of the risk-aversion.  On the other hand, if stock-based pay, especially stock options, dominates the manager's compensation package, he will be motivated to adopt the "make" approach.

### 2.2 US GAAP treatment and the relevance of accounting performance measures

In addition to the risk level, two features of the U.S. GAAP exacerbate the negative impact on reported earnings from R&D (make) compared with acquisitions (buy).  First, because of the great uncertainty associated with the return on R&D expenditures, the US GAAP requires that firms expense their R&D expenditures as incurred.  Since revenues from the R&D investments are not recognized until realized, this incomplete matching of revenues and costs will reduce the firm's short-run reported earnings.  Accounting earnings are therefore not a very informative measure of R&D investment's economic value. (Healy, Myers, and Howe 2002)

Second, in contrast to R&D's negative impact on reported earnings, obtaining technology through acquisitions usually results in little effect on a firm's current period earnings.  Compared with the treatment of R&D, for acquisition transactions, accounting earnings better match the cost and benefit associated with the acquired assets under either the pooling-of-interest or the purchase method[3].

[3] FASB Statement 141 and 142 recently changed the accounting treatment of merger and acquisition.  Effective July 1 2001, the pooling-of-interest method is prohibited, and the goodwill and indefinite-lived intangible assets are no longer

Under the pooling-of-interest method, the acquirer recognizes no R&D expenses. Under the purchase method, the acquirer may amortize the cost of technology over a period of up to forty years. In terms of valuing investment in innovations, accounting earnings are more relevant for acquisitions than R&D activities.

As a result of the above differences, an accounting-based bonus plan encourages acquisitions relative to internal R&D. And the accounting-based performance measures are more relevant for acquisition transactions than R&D activities.

Theoretically, an equity-based incentive contract should align managers' interests with those of investors, because in an efficient market, stock prices reflect short-term as well as long-term shareholder benefits. Stock-based pay represents a better matching of revenue and cost from certain investment activities. Stock based compensation schemes have their own drawbacks. As a performance measure, stock prices are very noisy. The market value of a firm's equity is affected by so many factors that it may not be sensitive to managers' efforts (Sloan, 1992). This explains why stock-based pay does not completely replace accounting-based compensation.

### 2.3 Summary and hypotheses

In summary, when a manager chooses between "make" and "buy" strategies to obtain technology, his compensation contract could play an important role. The main reasons are: the high-risk nature of internal R&D increases the volatility of the firm's earnings and stock returns compared with acquisitions; the differential accounting treatment lowers the reported earnings if a firm chooses to invest in R&D instead of acquisitions; and although a fair performance measure for acquisitions,

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amortized and should be tested for impairment utilizing a new methodology. This change is likely to enhance the value relevance of the accounting measures.

accounting earnings are not good performance measures for R&D investment. A manager whose pay heavily depends on accounting performance measures will tend to acquire technology through acquisitions rather than R&D in order to avoid these negative impacts. On the other hand, a manager who holds a myriad of stock options or stocks is more likely to invest in R&D because R&D's disadvantages due to accounting treatment and managerial risk-aversion have been mitigated.

The association between a CEO compensation contract and the firm's "make" or "buy" strategies does not necessarily imply that the managers are acting opportunistically and the firm is not operating optimally. The board of directors of a firm may recognize this possible agency problem and design the optimal CEO compensation contract to induce the desired investment behaviors. The correlation between CEO compensation and a firm's innovation decision may suggest that, at different optimal R&D vs. acquisition investment levels, the board of directors (the principal) and the CEO (the agent) agree on the corresponding optimal compensation schemes to alleviate the agency problem.

Because the "make or buy" strategies are usually determined at the firm level, in this paper, I only focus on the CEO compensation contracts and ignore the compensation contract for other executives.

The following two hypotheses conclude this section:

> ***Hypothesis 1:*** Ceteris paribus, the accounting-based compensation a firm's CEO receives is positively correlated with the firm's propensity to acquire and negatively correlated with the firm's investment in internal R&D.
>
> ***Hypothesis 2:*** Ceteris paribus, the stock-based compensation granted to a firm's CEO, especially the risk-taking incentives from this stock-based compensation, are negatively correlated with the firm's propensity to acquire and positively correlated with the firm's investment in internal R&D.

## 3. Other Factors Determining A Firm's Choice of "Make" or "Buy"

Other than CEO compensation contracts, many firm characteristics could affect a firm's investment decision on "make or buy." These factors should be controlled in the regression analysis. In this section, I discuss the following important factors: growth opportunity, ownership structure, cash constraints, size, R&D intensity, industry, and market environment.

***Growth Opportunity***

A firm's R&D intensity is usually highly correlated with its growth opportunities. On the one hand, a firm with more opportunities naturally has more R&D spending. On the other hand, higher R&D spending leads to more growth opportunities. The market-to-book ratio (denoted by Q in the regression models) is used in the model as a proxy for this factor. The market-to-book ratio is predicted to be positively correlated with internal R&D.

***Ownership Structure***

In addition to CEO compensation contracts, alternative corporate governance mechanisms such as equity block holders and high management ownership could also mitigate agency problems.

Francis and Smith (1995) find that firms with a high concentration of management ownership or a significant equity block holder are more innovative, while the diffusely held firms are more intent on growing by acquisition. As evidence of agency cost, this finding also suggests that a compensation contract as a remedy to agency cost could have different effects under various ownership structures. In a diffusely held firm, because information asymmetry between owners and managers is relatively big, managers have more leeway in extracting their private interests, while in a firm with concentrated ownership, the shareholders usually have more control over the firm's operation, and executive compensation might not be as important a factor in determining the innovation strategy.

Due to the limitation in data availability, two measures are used as proxies for the alternative corporate governance mechanisms: a dummy variable controlling for whether the CEO’s equity ownership of the firm is greater than 5% (OWN), and a dummy variable controlling for whether the CEO is a member of the board of directors (DIR).

***Information Asymmetry***

The information characteristics of R&D versus acquisition may also affect firms' choices of investment. R&D activity usually involves severe information asymmetry between management and outside investors; hence it is restricted by a firm's internal financing capacity (Myers and Majluf, 1984). A previous study (Himmelberg and Petersen, 1994) finds an economically large and statistically significant relation between R&D investment and internal financing. A firm’s acquisition activities are also restricted by cash capacity and profitability. For example, Jensen (1986) suggests that firms with more cash flow are more willing to acquire. But since R&D faces a more serious information asymmetry problem than acquisitions, the internal capital restriction on R&D is stricter.

Two variables are used to control for this effect in the regressions. The first is CASH, defined as the company’s cash plus marketable securities divided by current liabilities. I also run regressions using different definitions of cash (cash plus marketable securities divided by current liabilities, or cash plus marketable securities minus current liabilities, or just cash plus marketable securities), and find that the empirical results are not sensitive to these variations.

The second variable controlling for the information asymmetry problem is the leverage ratio (LEVERAGE), defined as the firm’s total liabilities divided by its total assets.

***Size and R&D Intensity***

A firm's size and original R&D-intensity may also affect its "make" versus "buy" strategies. Hall (1988) models takeover 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. Synergy generated in takeovers solves this non-optimality problem. A firm with more assets will have a greater potential for synergy with another firm's assets because of market power and economies of scale. A firm's ability to absorb acquired technology also depends on its own R&D intensity. Hall finds that the shadow price for the R&D intensity of the target is an increasing function of the size and the R&D intensity of the bidding firm. She also finds that firms of like size and R&D intensity are more likely to merge. The logarithm of a firm's market value of equity at the fiscal year-end is used to control for the firm size (SIZE), while R&D-intensity is defined as the R&D expenditures divided by sales (RD).

***Industry and Market Structure***

A firm's choice between "make" and "buy" may also differ across industries. On the one hand, firms in different industries have different capacities in absorbing new technology; on the other hand, the existing industry organization may alter a firm's competition strategy. Gans and Stern (2000) build a patent race model starting with an incumbent firm and an entrant firm. They find that in a market where the incumbent has monopoly power, both firms benefit more from licensing/acquisition than from duopoly competition. The finding suggests that in a certain market environment, the best strategy for an incumbent firm is to acquire any new firm with superior technology. Dummy variables constructed based on the two-digit SIC code are used in the regressions to control for these industry specific effects (INDUST).

***Stock Market***

Stock market valuation may also play a role in a firm's investment decision-making process. In the late 1990s, the US as well as the world economies experienced a strong wave of mergers and acquisitions. Unlike the 1920s "mergers for oligopoly" (Stigler, 1968), the conglomerate mergers in the 1960s, and the hostile takeovers in 1980s, the parties involved in a merger and acquisition activity in the 1990s were usually in the same industry, and the medium of payment was often stock rather than cash (Shleifer and Vishny, 2001). Also, a big percentage of this wave of mergers and acquisitions happened in the high tech industry. These phenomena suggest that more and more technologies are acquired through takeovers. This trend coincided with the stock market boom in the 1990s. As evidenced by the market downturn in 2000, many tech stocks were overvalued in the late 1990s. This may abet firms' willingness to acquire using stocks as opposed to investing in R&D using cash. But on the other hand, since many small high-tech firms were also over-valued, the final decision to "make" or "buy" could be determined by the relative valuation of the firms.

One could argue that over-valued firms can also invest in R&D by raising money through equity issuance. In reality, firms seldom issue equity for R&D funding purposes, while stock becomes the major medium of payments in acquisition transactions. There are at least tow reasons. First, because R&D is an on-going activity requiring steady streams of investment and the funding needs for each period are not high, it may not be economically efficient for firms to raise money whenever there is a need for R&D investment. Second, equity issuances for R&D and in acquisitions are quite different. In acquisitions, the new equities are issued to the owners of the target firms. If a firm wants to raise money for R&D, the new issuances are going to be sold to the general public. The information asymmetry problem is more severe in the latter case, and therefore the costs are higher.

Because it is difficult to control precisely for the under- or over-valuation of specific firms by the stock market for specific firms, the time trend is used in the regression models trying to capture this effect (YEAR).

## 4. Sample Selection and Research Design

### 4.1 Sample Selection

Since the focus of this paper is firms' innovation processes, I sample US firms in the high-tech industries as defined by the SDC merger and acquisition database, including biotech, computer equipment, electronics, communications, and others. The compensation data are from Standard and Poor's Execucomp database, the acquisition data are from the SDC merger and acquisition database and the Compustat database, the financial data are also from Compustat. The acquisition transactions are recognized as of their announcement dates. By assuming that all acquisitions made by high-tech firms are for "buying technologies", it's likely to introduce noise. To reduce the noise, I drop those transactions where the acquirer firm owns less than 50% of the target post-acquisition. The period covered is from 1992 to 2000. The dataset has 4,113 firm-year observations.

Because not every acquisition transaction is included in the SDC database, I also check the "goodwill" and other acquisition related items in the Compustat database.[4] According to the US GAAP regarding consolidation, a firm recognizes goodwill only if it owns more than 50% of the target firm after the acquisition. Therefore, obtaining data from Compustat does not introduce more noise. I assume that a firm in the sample industries had no acquisition activity in that year if the firm has no

[4] The acquisition related items include Compustat annual data248 (acquisitions – income contribution), data249 (acquisitions – sales contribution), and data129 (acquisitions – statement of cash flows).

record in the SDC M&A database, its goodwill account balance doesn't increase and all of its other acquisition-related accounts have zero balances or missing value.

Because firms in the industry "computer programming, data processing" (three-digit SIC code 737) have the choice of capitalizing their costs of software development under SFAS 86 (FASB 1985), firms in this industry are excluded from the sample in order to increase the power of my analysis. This step leaves 3,893 firm year observations in the sample. The expensed in-process R&D is treated the same as the acquirer's internal R&D[5]. The firm years with R&D expenditures data missing are excluded from the sample. Because small firms usually don't have the ability to acquire other firms. I also drop all firms with fiscal year-end capital stock less than $10 million, leaving 1,676 observations in the sample. After excluding missing values, the final dataset contains 1,107 firm-years of observations representing 227 firms and 316 different CEOs. 546 of the observations have acquisitions (168 of them are from the SDC database).

In the regression models, the proportion of the cash pay in the CEO's total compensation is used as a proxy for accounting-based pay (ACCT). It is defined as the sum of current period bonus and salary divided by the CEO's total pay that is comprised of the following: salary, bonus, other annual, total value of restricted stock granted, total value of stock options granted (using Black-Scholes), long-term incentive payouts, and all other total. An ideal measure of accounting-based compensation should be the incentive coming from the accounting-based pay. But because of the data limitation, I use the above measure to capture the relative importance of the accounting-based pay to the CEO's total pay. Alternative measures could be total value of accounting-based pay scaled by

[5] In-process R&D is the part of acquisition cost allocated to the R&D projects which have not yet developed a product ready for sale. Instead of capitalizing this cost as goodwill, the acquirer firms can expense this part of the acquisition cost as in-process R&D charges.

some proxies of the CEO's wealth, such as total asset value or market value of equity. The unreported analyses show that the results are not sensitive to the alternative definition of accounting-based pay.

The stock-based pay is usually composed of two parts: stock holdings and stock options. They provide two types of incentives: the pay-for-performance incentives (STKPPS) and the risk-taking incentives (STKRI). The focus of this study is on STKRI. The risk-taking incentive from stock-based pay encourages managers to engage in R&D investment instead of M&A activities in order to obtain new technology. I measure the pay-for-performance incentive by calculating the sensitivity of the CEO wealth to the changes of stock prices. The variable STKPPS is equal to the logarithm of the dollar change in CEO stock and option holdings for 1% change in stock prices. The variable (STKRI) is constructed to measure the risk-taking incentives provided by stock-based pay. STKRI is defined as the logarithm of value change in the CEO option holdings corresponding to 1% increase in the stock price volatility. If STKRI is less than zero, it is set equal to zero to avoid extreme observations. The coefficient on STKRI is designed to capture the impact on CEO incentives from the different risk levels of "make" and "buy". I calculate the stock-based compensation measures using the total stock and option holdings as of the previous fiscal year end. There are two reasons why I do not use the new grants in the current year instead: first, the whole holdings, not just the new grants, are providing incentives to CEOs; second, accounting performance measures may play a role in determining the new grants and therefore bias the regression results.

Table 2 describes the variables used in my regression models. Table 3 presents the descriptive statistics about the sample. The transaction values of SDC-reported acquisitions range from 0.98 to 89,168 million dollars, with the mean around $1,789 million. With the inclusion of additional estimated acquisition values from Compustat, the number of acquisitions more than tripled, but the mean dropped to $939 million, suggesting that the acquisition transactions not reported to SDC are usually very small ones. As many previous studies have found, the summary statistics show that the raw data of CEO compensation are highly skewed. The skewness may cause the empirical results to be driven by extreme observations. To address this problem, the logarithm of the raw data is used in the regression analyses.

**[Insert Table 2 here]**

**[Insert Table 3 here]**

Table 4 provides the Pearson correlation coefficients of the variables. The correlation between accounting-based and stock-based compensation measures is negative, and this is in line with the research purpose of studying the relative importance of accounting-based and stock-based pay to CEOs. Unsurprisingly, the level of pay-for-performance incentives from stock-based compensation is positively correlated with the risk-taking incentives provided by stock options. The leverage ratio of a firm is relatively highly correlated with its cash constraint, and firm size is correlated with several variables such as accounting compensation, stock compensation, and growth opportunity.

**[Insert Table 4 here]**

### 4.2 Research Design

#### 4.2.1 Probit and OLS models without considering endogeneity of the compensation policy

Because less than 50% of the sample has acquisitions, and only 15% of all observations have acquisition value data available from SDC, a Probit regression model (labeled Model 1) is used to estimate the compensation schemes' impacts on a firm's propensity to acquire. As discussed in section two, a firm with higher R&D intensity tends to be more capable of absorbing other firms' technology and therefore more inclined to acquire, therefore, the acquirer firm's R&D intensity is included in Model 1 as a control variable.

***Model 1 (Probit)***

$$AQ_{it} = \beta_0 + \beta_1 ACCT_{it} + \beta_2\ STKPPS_{i,t-1} + \beta_3\ STKRI_{i,t-1} + \gamma_1\ RD_{it} + \gamma_2\ SIZE_{it} + \gamma_3 OWN_{it} + \gamma_4 DIR_{it} + \gamma_5 INDUST + \gamma_6 CASH_{it} + \gamma_7\ LEVERAGE_{it} + \gamma_8 YEAR + \gamma_9 Q_{it} + \gamma_{10} OWN \times ACCT + \gamma_{11} OWN \times STKPPS + \gamma_{12} OWN \times STKRI + \varepsilon_{it}$$

The subscript i in the model indexes each individual firm and t indexes time.

Model 2 is specified below. An OLS regression on Model 2 is used to analyze how CEO compensation could affect a firm's investment in internal R&D. Since a firm's propensity to acquire doesn't have any direct impact on its R&D capacity, the acquisition data are not included in Model 2.

***Model 2 (OLS)***

$$RD_{it} = \phi_0 + \phi_1 ACCT_{it} + \phi_2\ STKPPS_{i,t-1} + \phi_3\ STKRI_{i,t-1} + \lambda_1\ SIZE_{it} + \lambda_2 OWN_{it} + \lambda_3 DIR_{it} + \lambda_4 INDUST + \lambda_5 CASH_{it} + \lambda_6 LEVERAGE_{it} + \lambda_7\ YEAR + \lambda_8 Q_{it} + \lambda_9\ OWN \times ACCT + \lambda_{10} OWN \times STKPPS + \lambda_{11} OWN \times STKRI + \eta_{it}$$

I test my two hypotheses by examining the signs on $\beta_1$, $\beta_3$, $\phi_1$, and $\phi_3$. H1 implies that $\beta_1>0$ and $\phi_1<0$, that is, accounting-based pay encourages acquisitions but depresses R&D intensity. H2 implies that $\beta_3<0$ and $\phi_3>0$, i.e. the risk-taking incentives from stock-based pay should encourage a firm to acquire technologies from R&D instead of M&A. The variable STKPPS is included in the regression models to control for the impact of pay-for-performance incentive from stock-based pay. The theory does not predict a decisive sign on this variable. If the compensation contract best aligns manager's incentives with those of the shareholders', the relation between this variable and the "make" and "buy" strategies should be zero and the coefficients on this variable in both models should also be zero.

In the face of high CEO ownership, agency problems in a firm's innovation process may be less severe; therefore, the need for incentives provided by compensation contracts is reduced. Three interactive terms between CEO ownership and the compensation variables are included in each regression model to examine these effects. Since CEO block ownership could diminish the impact from the CEO compensation contract, the signs of the interactive terms should be opposite to the signs of the corresponding compensation variables, that is, sign($\beta_1$) = -sign($\gamma_{10}$), sign($\beta_2$) = -sign($\gamma_{11}$), sign($\beta_3$) = -sign($\gamma_{12}$), sign($\phi_1$) = -sign($\lambda_9$), sign($\phi_2$) = -sign($\lambda_{10}$), and sign($\phi_3$) = -sign($\lambda_{11}$).

**4.2.2 2SLS regression for the endogeneity of CEO compensation policy**

A firm's innovation strategy and compensation policy are usually affected by the same set of macroeconomic and firm characteristics. The regression models in the previous section can not capture these effects and may report biased results. To control for the endogeneity problem, I apply a two-stage-least-square regression (2SLS) and use industry average compensation measures, CEO age, and the two variables' squared terms and interactive terms as instrument variables for the compensation variables.

The 2SLS regression models are similar to the Probit/OLS regression models presented in section 4.2.1. There are only two changes: first, because 2SLS is a linear regression technique, the acquisition measure cannot be binary as in Probit, I replace AQ with AQ1 which is a firm's total value of acquisitions in the current fiscal year divided by the market value of equity. The acquisition value is from the SDC database if available, otherwise equal to the acquisition-related cash outflows recorded in the Compustat. Second, the compensation measures (ACCThat, STKPPShat, STKRIhat) are fitted values from OLS regressions with industry (by 2 digit SIC code) average compensation measures, CEO age, the squared terms of these variables, and the interactive terms of the industry average compensation and CEO age as instrument variables.

Following are the regression models.

***First stage:***

ACCThat = F(Industry average ACCT, CEO age, squared terms of the two variables, interactive terms of the two variables)

STKPPShat = F(Industry average STKPPS, CEO age, squared terms of the two variables, interactive terms of the two variables)

STKRIhat = F(Industry average STKRI, CEO age, squared terms of the two variables, interactive terms of the two variables)

***Second stage:***

AQ1 = F(ACCThat, STKPPShat, STKRIhat, RD, SIZE, Q, CASH, LEVERAGE, OWN, DIR, YEAR, OWN x ACCThat, OWN x STKPPShat, OWN x STKRIhat)

RD = F(ACCThat, STKPPShat, STKRIhat, SIZE, Q, CASH, LEVERAGE, OWN, DIR, YEAR, OWN x ACCThat, OWN x STKPPShat, OWN x STKRIhat)

## 5 Empirical Results

### 5.1 Results from Probit/OLS regressions

Table 5 presents the empirical results from the two regression models (model1 and model2). Consistent with Hypothesis 1, the empirical results suggest that more accounting-based compensation tends to encourage technology acquisition activities and depress R&D intensity. The estimated value of $\beta_1$ is positive but not statistically significant, and the estimated value of $\phi_1$ is significantly negative. The results for equity-based compensation also support the hypotheses. The regression results show that, the risk-taking incentives provided by stock-based pay encourage a firm to obtain technologies from internal R&D investments instead of M&A activities. The correlation coefficients on the risk-taking incentive measure (i.e., STKRI) are significantly negative in model1 and significantly positive in model2.

The correlation coefficients on the interactive terms between compensation measures and CEO ownership dummy are not significantly different from zero. The results indicate that the impact of CEO ownership does not have significant impacts on the relation between compensation measures used and a firm's choice between "make" and "buy".

**[Insert Table 5 here]**

### 5.2 Results from 2SLS regressions

The regression results for the 2SLS regressions are presented in table 6 (second stage only). Most of the empirical results are the same as those found in the Probit/OLS regressions as discussed in the previous subsection. The 2SLS regression results are consistent with hypothesis 1. The accounting-based compensation tends to suppress R&D activities while does not have much impact on acquisitions.

The outcome for hypothesis 2 is not in line with the predictions. The risk-seeking incentives from stock-based compensation are positively correlated with a firm's acquisition activities and have almost no impact on R&D activities – the coefficients are not significantly different from zero.

An explanation of this positive correlation between stock-based compensation and a firm's acquisition activities could be that, although acquisitions are in general less risky than internal R&D, they are still means of innovation and therefore relatively risky compared with other operation. As illustrated by Table 1, the return volatilities of firm years with acquisitions are higher than the sample averages across quartiles. This implies that, although less risky than R&D investment, acquisitions are on average risk-increasing activities. The risk-taking incentives from stock options encourage the managers to seek innovation, resulting in more investments in both acquisitions and internal R&D.

Because a CEO's compensation has an impact on both the level of total investments in innovation and the allocation of these investments, and the first impact could be greater than the latter, running simple regressions like Model 1 and 2 cannot capture the two effects at once. To detect a firm's preference for R&D or acquisitions, we need a model controlling a firm's target level of investment in innovation.

**[Insert Table 6 here]**

## 6. Robustness Tests and Sensitivity Analyses

This section addresses some possible concerns regarding the empirical results and provides a couple of robustness tests. The tests and analyses show that the main empirical results presented in section 5 are qualitatively unchanged.

### 6.1 Endogeneity of make vs. buy strategies

If the R&D and acquisition activities are substituting strategies by which a firm achieves innovation, the optimal level of investment in the two could be determined simultaneously by the firm characteristics and the CEO incentives. To address this endogeneity problem, I run a FIML (full information maximum likelihood) regression on a simultaneous equation system including both R&D and acquisitions as endogenous variables.

To control for the endogeneity of make and buy strategies, I run a full information maximum likelihood (FIML) regression on the simultaneous equation system listed below. As discussed in section three, a firm's propensity to acquire is not very sensitive to the firm's cash constraint or growth opportunity, and the time trend is used to control for the stock market performance and therefore would not greatly affect the firm's choice of R&D intensity. Moreover, firm size is likely to have more impact on a high-tech firm's acquisition activity than R&D intensity. I use CASH, LEVERAGE, and Q as the pre-determined variables for RD and SIZE and YEAR for AQ1.

***Model 1***

$$AQ1_{it} = \beta_0 + \beta_1 ACCT_{it} + \beta_2\, STK_{i,t-1} + \beta_3\, STKRI_{i,t-1} + \gamma_1\, RD_{it} + \gamma_2\, SIZE_{it} + \gamma_3 OWN_{it} + \gamma_4 DIR_{it} + \gamma_5 YEAR + \gamma_6 OWN \times ACCT + \gamma_7 OWN \times STK + \gamma_8 OWN \times STKRI + \varepsilon_{it}$$

***Model 2***

$$RD_{it} = \phi_0 + \phi_1 ACCT_{it} + \phi_2\, STK_{i,t-1} + \phi_3\, STKRI_{i,t-1} + \lambda_1\, AQ1_{it} + \lambda_2 OWN_{it} + \lambda_3 DIR_{it} + \lambda_4 Q_{it} + \lambda_5 CASH_{it} + \lambda_6 LEVERAGE_{it} + \lambda_7 OWN \times ACCT + \lambda_8 OWN \times STK + \lambda_9 OWN \times STKRI + \eta_{it}$$

Table 7 presents the regression results for this simultaneous equation system. The primary results from the Probit/OLS regressions still hold.

**[Insert Table 7 here]**

As a side result of the FIML regression, we see that acquisition and R&D tend to be used as substitute strategies in acquiring technology. The correlation coefficients on the two variables are negative with reasonable statistical significance.

### 6.2 The in-process R&D expenditures.

After an acquisition transaction, the acquirer firm sometimes expenses a large amount of the acquisition cost as the target firm's in-process R&D instead of capitalizing them as goodwill. Since firms usually don't disclose the amount of the expensed in-process R&D in the acquisition transactions, in this paper, all the in-process R&D expenditures are treated the same as the internal R&D. In reality, the negative impact on earnings from in-process R&D could be much greater than the regular R&D expenses. Many acquirer firms expense a large amount of in-process R&D to enhance future years' earnings; this is the so-called "big bath" approach. Because a firm's compensation policy is relatively stable through time, if a CEO receives high accounting-based pay today, accounting performance measures tend to continue being important measures in the CEO's compensation contract in the future. And the accounting performance measures usually exclude extraordinary items such as in-process R&D charges. Therefore, CEOs with more accounting-based pay has a bigger incentive to use in-process R&D after acquisitions to boost the future accounting performance in order to receive more accounting-based compensation in the future. This introduces a positive correlation between accounting-based pay and R&D expenses. Regressing R&D intensity without excluding in-process R&D on a CEO's current period accounting-based compensation may decrease the power of the test and even bias the coefficient against my hypotheses.

Because expensing in-process R&D didn't become popular until the late 1990s, to test whether the empirical results are sensitive to this problem, I run the same regressions as described in the previous section on a sub sample of my dataset – from 1992 to 1996. This sub sample has 415 firm year observations and 177 of them have acquisitions. Because of the limited sample size, the industry dummies are not included in the regression models. As shown in Table 6, the regression results are consistent with the hypotheses. The correlation coefficient on the accounting-based compensation in model 1 is positive and in model 2 is significantly negative. The coefficient on the risk-taking incentives from stock options is significantly negative in model 1 and significantly positive in model 2.

**[Insert Table 8 here]**

### 6.3 Correction for the heteroscedasticity problem

A white test on model 2 shows that the empirical results suffer from a heteroscedasticity problem.[6] To correct for this problem, I apply firm fixed effect regression analyses on the sample.[7] The unreported regression results achieve the same signs for the coefficients as in the OLS regression, but the P values are much bigger. None of the correlation coefficients is significant at the 10% significance level. Because the unbalanced panel contains 221 firms but only 864 observations, with average length of about four years, the lost degrees of freedom from running the fixed effect regressions could explain the lower statistical significance.

Other ways to correct for the heteroscedasticity problem include weighted OLS or using the White standard error estimator. Since the heterogeneous variances of the error terms can be explained by the difference in firm size, a weighted OLS adjusting the error terms using firm size (logarithm of a firm's market value of equity) could correct this problem. Running a weighted OLS on Model 2, I get results qualitatively the same as those of the OLS regression. The empirical results using White estimator are also about the same.

### 6.4 Non-normality and outliers

The underlying assumption of the Probit analysis is that the error terms are normally

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[6] The white test statistic is equal to 220 with the P value less than 0.0001.

[7] The fixed effects can be easily swept away using a within estimator in a linear regression model, but this method doesn't work for non-linear models such as Probit. Therefore, linear models are used in the fixed effect analyses for both acquisitions and R&D. AQ1 is used as the dependent variable in the acquisition model (model 1).

distributed. If the normality condition is not met, the empirical results will be biased. The logistic distribution is similar to the normal distribution except for that the logistic distribution has fatter tails. I apply the Logit regression on Model 1 and find no significant difference from the Probit analysis.

As shown in Table 3, certain firm-years contain extreme values of market to book ratio (Q) or cash availability (CASH); these may raise concerns regarding the empirical results. Dropping the top and bottom one percent of observations affect neither the magnitude of the coefficients nor the P values.

### 6.5 R&D financing organizations

First employed in the mid 1970s, R&D financing organizations (RDFO) become a new approach to funding R&D investments by R&D-intensive firms.[8] This approach allows a firm (the sponsor firm) to form a separate organization in order to finance part or all of its R&D activities. Although the new organization is a separate entity, it is totally controlled by the sponsor firm's management. After new technology is developed by the RDFO, it is sold to the sponsor firm.

This RDFO approach offers tax and financial reporting benefits to the investors and the sponsor firm respectively. The tax benefit is realized by transferring the tax shield of R&D from low marginal tax rate (MTR) firms to high MTR taxpayers. The financial reporting benefits are reflected in a lower level of on-balance-sheet liabilities and higher net income during the technology-development period. These financial reporting benefits may offset the negative impact from R&D (make) with respect to acquisitions (buy) on a manager's accounting-based pay because of the US GAAP treatments. If firms can freely eliminate the GAAP treatment effect on "make or buy" strategies by forming RDFOs, ignoring RDFO formed by the sample firms may pose problems on my regression results. But these

[8] The detail about this type of organizations can be found in Beatty, Berger and Magliolo (1995).

financial reporting benefits don't come without costs. The transaction cost of forming a RDFO may be very high and unjustified by the financial benefits generated through the process; therefore, the high cost may discourage RDFO use (Shevlin, 1987; Beatty, Berger and Magliolo, 1995).

Shevlin (1987) finds support for the tax motivation of forming a RDFO but very little support for other purposes. Beatty, Berger and Magliolo (1995) find that formations of RDFO are mainly driven by debt-related concerns instead of financial reporting benefits. The findings of these two papers imply that the in-house R&D and RDFO are not perfect substitutes and that financial reporting considerations around RDFOs are not an important element affecting a firm's decision to finance its R&D activities. In addition, my sample period is from 1992 to 2000, and Beatty, Berger and Magliolo (1995) show that RDFO formations are concentrated in the early 1980s and became less popular later, partly because Tax Reform Act of 1986 eliminated most of RDFO's tax benefit. The above evidence suggests that the availability of the RDFO approach to carry out internal R&D would not pose serious questions about my empirical results.

## 7. Conclusions

By examining the relation between CEO compensation and a firm's choice of obtaining new technology (make or buy), this paper studies a firm's innovation process in a principal-agency framework. The main conclusion is that the various performance measures on which the compensation contract is built play very different roles in determining a firm's approach to innovation, that is, CEOs receiving relatively more accounting-based compensation tend to acquire technology externally instead of growing it internally through R&D; in contrast, when CEO compensation contracts are skewed toward stock-based pay, firms pursue innovation through both approaches. The empirical results also provide further evidence that firms use “make” and “buy” as substituting instead of complementing strategies to obtain new technologies.

The accounting performance measure’s impact on firms’ innovation choices is robust after several robustness tests. The relation between stock-based compensation and firms’ choices of “make or buy” is still somewhat unsettled. As discussed in section five, to further address this issue, we need a model estimating the cross-sectional variation in firms’ target level of investment in innovation, and then we can study the allocation of this investment between “make” and “buy”.

This study assumes that all acquisitions made by high-tech firms where the acquirer owns more than 49% of the target firm post-acquisition are for technology purposes. This assumption tends to introduce errors into the regression analyses. More access to firm level acquisition data may help to solve this problem.

There has been huge literature trying to explain a firm’s innovation process from various angles such as organizational behavior, technology learning process, and risk versus managers' motivation. It would be interesting to further this research in the context of financial market. As discussed in section 3, stock market valuation could alter a firm’s investment choice. If managers believe that their firm's stocks are relatively over valued, they might want to get new technologies by acquiring other firms using stocks, instead of investing in internal R&D where they have to pay cash. In their recent paper, Shleifer and Vishny (2001) present a model of mergers and acquisitions based on stock market mis-valuation. One of the key predications of the model is that a firm tends to use stocks as the medium of payment when its stocks are overvalued and cash when undervalued. The further research on the subject could be to extend the model into a firm’s innovation process. We may find that when a firm's stocks are relatively undervalued, in addition to switching the medium of payment in acquisitions from stocks to cash, high-tech firms might put more effort in growing by R&D investment as opposed to acquisitions.

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**Table 1. Monthly return volatilities of firm years with acquisitions versus firm years with high R&D intensity.**

The sample is drawn from the high tech industries as defined by the SDC database. Firms with total assets less than 10 million dollars are excluded. The sample period is from 1992 to 2000.

The observations are divided into quartiles based on total assets. For each quartile, this table reports the monthly stock return volatilities of firm years with acquisitions versus those with high R&D to sales intensity. The return volatilities of the whole sample are also provided as the benchmark.

Return volatility is defined as the standard deviation of monthly stock returns in a year.

A firm year is classified as having acquisition activities if any one of the following conditions is met in the year: i) it has one or more acquisition transactions recorded in the SDC database, ii) the firm's goodwill account balance increases, iii) other acquisition-related accounts have non zero balances.

A firm year is classified as having high R&D intensity if its R&D to sales intensity is higher than the average R&D intensity of the same quartile. Firm years with missing value in R&D investment are treated as having zero R&D intensity.

| Quartile (Based on total assets) | Whole Sample | | | Firm years with high R&D intensity | | Firm years with acquisitions | |
|---|---|---|---|---|---|---|---|
| | No.of obs. | Avg. Total Assets (MM$) | Avg. Return Volatility | No. of obs. | Avg. Return Volatility | No. of obs. | Avg. Return Volatility |
| 1 | 2,951 | 102 | 13.8% | 79 | 21.6% | 533 | 14.4% |
| 2 | 2,952 | 479 | 10.2% | 559 | 13.1% | 661 | 12.4% |
| 3 | 2,951 | 1,824 | 9.7% | 561 | 12.8% | 736 | 11.6% |
| 4 | 2,952 | 25,618 | 8.9% | 693 | 10.0% | 724 | 10.2% |

**Table 2. Description of the variables**

| | |
|---|---|
| ***Dependent variables:*** | **AQ:** equal to 1 if the firm has acquisition activities in the current fiscal year, 0 otherwise. A firm is regarded as having acquisition activities in a certain year if any one of the following conditions is met: i) it has one or more acquisition transactions recorded in the SDC database, ii) the firm's goodwill account balance increases, iii) the other acquisition-related accounts have non zero balances<br>**RD**: Ratio of R&D spending (including acquired in-process R&D) to total sales in the current year.<br>**AQ1:** The firm's total value of acquisitions in the current fiscal year divided by the market value of equity. The acquisition value is from the SDC database if available, otherwise equal to the acquisition-related cash outflows recorded in the Compustat. |
| ***Independent variables:*** | **RD:** R&D intensity. Ratio of R&D spending (including acquired in-process R&D) to total sales in the current year.<br>**ACCT:** Proportion of accounting-based pay in the CEO's total compensation. Measured by bonus plus annual change in salary divided by the total compensation comprised of the following: Salary, Bonus, Other Annual, Total Value of Restricted Stock Granted, Total Value of Stock Options Granted (using Black-Scholes), Long-Term Incentive Payouts, and All Other at the fiscal year-end.<br>**STKPPS:** The pay-for-performance incentive provided by stock-based compensation. The variable STKPPS is equal to the logarithm of the dollar change in CEO stock and option holdings for 1% change in stock prices.<br>**STKRI:** The risk incentive provided by stock-based compensation. Measured by the logarithm of dollar value change in the CEO's total equity holdings corresponding to 1% increase in the stock price volatility (using Black-Scholes model) at the previous fiscal year end. If STKRI is less than zero, it is set equal to zero to avoid extreme observations. |
| ***Control variables:*** | **SIZE**: Log of market value (in millions) at the fiscal year-end.<br>**OWN**: A dummy variable. Equal to 1 if the percentage of the company stock owned by the CEO at the beginning of the year is greater or equal to 5%, 0 otherwise.<br>**DIR:** A dummy variable. Equal to 1 if the CEO is a member of the board of the directors of the firm, 0 otherwise.<br>**INDUST**: Industry dummies (25 dummies, according to the firm's 2-digit SIC code)<br>**CASH**: Cash plus marketable securities divided by current liabilities<br>**LEVERAGE**: Leverage ratio (Total liabilities divided by total assets)<br>**YEAR**: Time trend, control for the year from which the dependent variable data are drawn. Equal to 1 to 9, corresponding to 1992 to 2000.<br>**Q**: Market to book ratio of equity at the beginning of the fiscal year (proxy for the Tobin's q)<br>**OWN x ACCT**: Interactive term of OWN and ACCT, the sign should be opposite to the sign of the coefficient on ACCT<br>**OWN x STKPPS**: Interactive term of OWN and STKPPS, the sign should be opposite to the sign of the coefficient on STKPPS<br>**OWN x STKRI**: Interactive term of OWN and STKRI, the sign should be opposite to the sign of the coefficient on STKRI |

**Table 3**. **Summary statistics**

| Variable (Units) | Mean | Median | Std Dev | Minimum | Maximum |
|---|---|---|---|---|---|
| ***Variables in the regression models*** | | | | | |
| AQ1** | 0.10 | 0.04 | 0.18 | $2.0\times10^{-6}$ | 1.28 |
| ACCT | 0.48 | 0.45 | 0.27 | 1 | 1 |
| STKPPS | 12.74 | 12.47 | 1.42 | 6.49 | 16.73 |
| STKRI | 8.70 | 10.66 | 4.62 | 0 | 13.94 |
| RD | 0.07 | 0.05 | 0.11 | 0 | 2.21 |
| SIZE | 7.98 | 7.85 | 1.64 | 2.75 | 12.58 |
| Q | 4.78 | 1.25 | 6.20 | 0.45 | 113.95 |
| LEVERAGE | 0.51 | 0.53 | 0.19 | 0.04 | 0.96 |
| CASH | 0.70 | 0.24 | 1.39 | 0 | 18.30 |
| ***Other key statistics for the sample*** | | | | | |
| Annual acquisition value (MM$) as recorded by SDC* | 1,789 | 225 | 7,893 | 0.98 | 89,168 |
| Annual acquisition value (MM$) as recorded by SDC and Compustat** | 939 | 126 | 5,172 | 0.001 | 89,168 |
| CEO ownership of the firm (%) | 2.09 | 0.25 | 4.50 | 0 | 24 |
| Research and Development Expense (MM$) | 302 | 61 | 615 | 0 | 5,152 |
| Value of restricted stock holdings (Thous$) | 1,415 | 0 | 5,191 | 0 | 85,401 |
| Black-Scholes value of the option granted to the CEO in the previous two years (Thous$) | 4,696 | 2,205 | 11,012 | 0 | 203,174 |
| Black-Scholes value of the CEO's total option holding estimated using the Core and Guay (1999) method (Thous$) | 25,839 | 8,112 | 83,920 | 0 | 1,812,755 |
| Salary (Thous$) | 724 | 660 | 371 | 0 | 3,655 |
| Bonus (Thous$) | 935 | 564 | 3,202 | 0 | 90,000 |
| Cash and Short-Term Investments (MM$) | 510 | 121 | 1,083 | 0 | 13,823 |
| Assets - Total (MM$) | 5,468 | 1843 | 11,822 | 21 | 242,223 |
| Common Equity - Total (MM$) | 2,282 | 828 | 4,987 | 10 | 103,198 |
| Fiscal Year-End Market Value (MM$) | 13,047 | 2,878 | 28,523 | 40 | 290,444 |

* Statistics in this row are only for firm-years with acquisition transactions recorded in the SDC database.

** Statistics in these two rows are only for firm-years with AQ1 greater than zero.

## Table 4. Correlation Matrix

Pearson Correlation Coefficients
(Prob > |r| under H0: Rho=0)

| | RD | AQ | AQ1 | ACCT | STKPPS | STKRI | CASH | LEVERAGE | Q | SIZE | OWN | YEAR | DIR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RD** | 1 | | | | | | | | | | | | |
| **AQ** | -0.07 (0.02) | 1 | | | | | | | | | | | |
| **AQ1** | -0.02 (0.47) | 0.34 (0.00) | 1 | | | | | | | | | | |
| **ACCT** | -0.13 (0.00) | -0.04 (0.19) | 0.027 (0.37) | 1 | | | | | | | | | |
| **STKPPS** | 0.08 (0.01) | 0.20 (0.00) | -0.0003 (0.99) | -0.23 (0.00) | 1 | | | | | | | | |
| **STKRI** | 0.14 (0.00) | 0.04 (0.16) | 0.06 (0.06) | -0.09 (0.00) | 0.25 (0.00) | 1 | | | | | | | |
| **CASH** | 0.37 (0.00) | -0.12 (0.00) | -0.07 (0.02) | -0.04 (0.18) | 0.11 (0.00) | -0.07 (0.02) | 1 | | | | | | |
| **LEVERAGE** | -0.32 (0.00) | 0.09 (0.00) | 0.13 (0.00) | -0.06 (0.84) | -0.14 (0.00) | 0.13 (0.00) | -0.52 (0.00) | 1 | | | | | |
| **Q** | 0.29 (0.00) | 0.02 (0.41) | -0.01 (0.64) | -0.21 (0.00) | 0.29 (0.00) | -0.05 (0.12) | 0.17 (0.00) | -0.09 (0.00) | 1 | | | | |
| **SIZE** | 0.12 (0.00) | 0.16 (0.00) | -0.06 (0.04) | -0.35 (0.00) | 0.58 (0.00) | 0.09 (0.00) | -0.007 (0.81) | 0.06 (0.03) | 0.34 (0.00) | 1 | | | |
| **OWN** | -0.09 (0.00) | -0.05 (0.10) | -0.02 (0.41) | 0.23 (0.00) | 0.32 (0.00) | -0.14 (0.00) | 0.07 (0.03) | -0.17 (0.00) | -0.01 (0.76) | -0.20 (0.00) | 1 | | |
| **YEAR** | -0.02 (0.47) | 0.08 (0.00) | 0.05 (0.07) | -0.22 (0.00) | 0.20 (0.00) | -0.40 (0.00) | 0.07 (0.01) | 0.004 (0.89) | 0.17 (0.00) | 0.10 (0.00) | -0.02 (0.45) | 1 | |
| **DIR** | 0.04 (0.25) | 0.07 (0.02) | 0.04 (0.23) | -0.02 (0.50) | 0.04 (0.18) | 0.01 (0.71) | 0.04 (0.19) | -0.08 (0.01) | 0.02 (0.54) | 0.01 (0.64) | 0.04 (0.15) | 0.01 (0.81) | 1 |

**Table 5. The estimated coefficients from the Probit regression on Model 1 and OLS regression on Model 2**

The sample size is 1,107. The P values of the Chi-square and the t statistics for the estimates of correlation coefficients are in parentheses.

***Model 1:***

$AQ_{it} = \beta_0 + \beta_1 ACCT_{it} + \beta_2\ STKPPS_{i,t-1} + \beta_3\ STKRI_{i,t-1} + \gamma_1\ RD_{it} + \gamma_2\ SIZE_{it} + \gamma_3 OWN_{it} + \gamma_4 DIR_{it} + \gamma_5 INDUST + \gamma_6 CASH_{it} + \gamma_7 LEVERAGE_{it} + \gamma_8 YEAR + \gamma_9 Q_{it} + \gamma_{10} OWN \times ACCT + \gamma_{11} OWN \times STKPPS + \gamma_{12} OWN \times STKRI + \varepsilon_{it}$

***Model 2:***

$RD_{it} = \phi_0 + \phi_1 ACCT_{it} + \phi_2\ STKPPS_{i,t-1} + \phi_3\ STKRI_{i,t-1} + \lambda_1 SIZE_{it} + \lambda_2 OWN_{it} + \lambda_3 DIR_{it} + \lambda_4 INDUST + \lambda_5 CASH_{it} + \lambda_6 LEVERAGE_{it} + \lambda_7 YEAR + \lambda_8 Q_{it} + \lambda_9 OWN \times ACCT + \lambda_{10} OWN \times STKPPS + \lambda_{11} OWN \times STKRI + \eta_{it}$

| | **Model 1 (Probit)** | | **Model 2 (OLS)** | |
|---|---|---|---|---|
| Dependent Variable | AQ | | RD | |
| | Predicted Sign | Estimated Coefficients | Predicted Sign | Estimated Coefficients |
| INTERCEPT | | **-3.626 (0.000)** | | **0.182 (0.046)** |
| ACCT | + | 0.170 (0.338) | **-** | **-0.052 (0.013)** |
| STKPPS | **?** | **0.186 (0.000)** | ? | -0.002 (0.764) |
| STKRI | **-** | **-0.051 (0.022)** | **+** | **0.005 (0.057)** |
| RD | - | -0.948 (0.132) | | - |
| SIZE | | 0.059 (0.108) | | **-0.012 (0.007)** |
| CASH | | **-0.162 (0.002)** | **+** | **0.012 (0.000)** |
| LEVERAGE | | 0.109 (0.706) | **-** | **-0.167 (0.000)** |
| Q | | -0.015 (0.120) | **+** | **0.006 (0.000)** |
| OWN | | -0.265 (0.884) | | -0.090 (0.635) |
| DIR | | **1.174 (0.013)** | | -0.016 (0.723) |
| YEAR | + | **0.106 (0.000)** | | -0.003 (0.266) |
| OWN X ACCT | - | -0.755 (0.215) | + | 0.044 (0.533) |
| OWN X STKPPS | ? | 0.026 (0.814) | ? | 0.005 (0.645) |
| OWN X STKRI | + | -0.010 (0.816) | - | -0.005 (0.348) |
| Pseudo $R^2$ / Adjusted $R^2$ | | 9% | | 17% |

**Table 6. 2SLS regression to address the endogeneity of compensation policy**

This table reports the results from the second stage regression of a 2SLS analysis. The 2SLS regression is applied to the regression equations similar to the two presented in Table 5. The instrument variables for compensation measures are industry (by 2 digit SIC code) average compensation measures, CEO age, the squared terms and the interactive terms of these variables. The P values of the t-statistics are in parentheses.

| Dependent Variable | | **Model 1** AQ1 | | **Model 2** RD |
|---|---|---|---|---|
| | Predicted Sign | Estimated Coefficients | Predicted Sign | Estimated Coefficients |
| Intercept | | -0.2394 (0.24) | | 0.0147 (0.91) |
| ACCT | + | 0.0049 (0.94) | - | **-0.0876 (0.02)** |
| STKPPS | ? | 0.0053 (0.57) | ? | 0.0067 (0.30) |
| STKRI | - | **0.0179 (0.02)** | + | -0.0015 (0.77) |
| RD | - | -0.2918 (0.25) | | - |
| AQ1 | | - | | - |
| CASH | | 0.0029 (0.45) | + | **0.0177 (0.00)** |
| LEVERAGE | | **0.1418 (0.00)** | **-** | **-0.0846 (0.00)** |
| Q | | **-0.0015 (0.10)** | + | 0.00003 (0.97) |
| SIZE | | -0.0053 (0.14) | | **0.0058 (0.02)** |
| YEAR | | -0.0005 (0.88) | | **-0.0063 (0.01)** |
| OWN | | 0.0355 (0.84) | | **-0.2297 (0.05)** |
| DIR | | 0.0282 (0.83) | | 0.0492 (0.58) |
| OWN X ACCT | - | -0.0737 (0.22) | + | 0.0583 (0.15) |
| OWN X STKPPS | + | 0.0025 (0.81) | - | 0.0101 (0.15) |
| OWN X STKRI | + | -0.0042 (0.33) | - | 0.0016 (0.58) |
| Adjusted $R^2$ | | 4% | | 18% |

**Table 7. Robustness test for the endogeneity of "make and buy" strategies**

A full information maximum likelihood (FIML) regression is applied to the following simultaneous equation system. Both AQ1 and RD are treated as endogenous. The P values of the t-statistics are in parentheses.

$$AQ1_{it} = \beta_0 + \beta_1 ACCT_{it} + \beta_2 STK_{i,t-1} + \beta_3 STKRI_{i,t-1} + \gamma_1 RD_{it} + \gamma_2 SIZE_{it} + \gamma_3 OWN_{it} + \gamma_4 DIR_{it} + \gamma_5 YEAR + \gamma_6 OWN \times ACCT + \gamma_7 OWN \times STK + \gamma_8 OWN \times STKRI + \varepsilon_{it}$$

$$RD_{it} = \phi_0 + \phi_1 ACCT_{it} + \phi_2 STK_{i,t-1} + \phi_3 STKRI_{i,t-1} + \lambda_1 AQ1_{it} + \lambda_2 OWN_{it} + \lambda_3 DIR_{it} + \lambda_4 Q_{it} + \lambda_5 CASH_{it} + \lambda_6 LEVERAGE_{it} + \lambda_7 OWN \times ACCT + \lambda_8 OWN \times STK + \lambda_9 OWN \times STKRI + \eta_{it}$$

| Dependent Variable | **Model 1** AQ1 | | **Model 2** RD | |
|---|---|---|---|---|
| | Predicted Sign | Estimated Coefficients | Predicted Sign | Estimated Coefficients |
| Intercept | | -0.0604 (0.25) | | **0.1947 (0.01)** |
| ACCT | + | 0.0047 (0.79) | **-** | **-0.0432 (0.04)** |
| STKPPS | ? | **0.0071 (0.05)** | ? | -0.0062 (0.15) |
| STKRI | - | 0.0030 (0.13) | **+** | **0.0052 (0.05)** |
| RD | **-** | **-0.3059 (0.00)** | | - |
| AQ1 | | - | - | -0.2183 (0.37) |
| CASH | | - | **+** | **0.0117 (0.00)** |
| LEVERAGE | | - | **-** | **-0.1955 (0.00)** |
| Q | | - | **+** | **0.0052 (0.00)** |
| SIZE | | **-0.0093 (0.00)** | | - |
| YEAR | | **0.0067 (0.00)** | | - |
| OWN | | -0.0008 (0.99) | | -0.2340 (0.22) |
| DIR | | 0.0420 (0.24) | | 0.0045 (0.92) |
| OWN X ACCT | - | -0.0556 (0.32) | + | 0.0834 (0.25) |
| OWN X STKPPS | + | 0.0016 (0.86) | - | 0.0130 (0.25) |
| OWN X STKRI | + | -0.0027 (0.51) | - | -0.0040 (0.44) |

**Table 8. Robustness test for in-process R&D.**

The same regressions as shown in table 5 are run using a sub-sample that covers the period from 1992 to 1996. The sample contains 415 firm-years of observations. The industry dummies are not included as control variables because of the limited sample size. The P values of the Chi-square and the t statistics for the estimates of correlation coefficients are in parentheses.

| Dependent Variable | **Model 1 (Probit)** AQ | | **Model 2 (OLS)** RD | |
|---|---|---|---|---|
| | Predicted Sign | Estimated Coefficients | Predicted Sign | Estimated Coefficients |
| Intercept | | -7.2274 (0.96) | | **0.1556 (0.01)** |
| ACCT | + | 0.0900 (0.24) | **-** | **-0.0435 (0.01)** |
| STKPPS | **?** | **0.1891 (0.00)** | **?** | **-0.0101 (0.01)** |
| STKRI | **-** | **-0.0330 (0.00)** | **+** | **0.0034 (0.09)** |
| RD | - | -1.4216 (0.11) | | - |
| CASH | | -0.1112 (0.12) | + | **0.0435 (0.00)** |
| LEVERAGE | | 0.3436 (0.37) | - | **-0.0793 (0.00)** |
| Q | | **-0.0313 (0.16)** | + | 0.0012 (0.41) |
| SIZE | + | 0.0063 (0.90) | | **0.0075 (0.02)** |
| YEAR | **+** | **0.1009 (0.02)** | | -0.0026 (0.39) |
| OWN | | **-0.1199 (0.96)** | | -0.1338 (0.38) |
| DIR | | 4.7630 (0.97) | | -0.0141 (0.70) |
| OWN X ACCT | - | **-1.6156 (0.09)** | + | 0.0545 (0.37) |
| OWN X STKPPS | + | 0.0698 (0.66) | - | 0.0099 (0.27) |
| OWN X STKRI | + | -0.0316 (0.62) | - | -0.0040 (0.34) |
| Pseudo $R^2$ / Adjusted $R^2$ | | 6% | | 32% |