

Agency Costs, Management Stockholding, and Research and Development Expenditures*

Shin Cho

Korea Information Society Development Institute

This paper examines the relationship between management stockholding and the level of R&D expenditures of a firm. Agency theory implies that a manager is reluctant to undertake R&D projects. Considering that management stockholding generally works to reduce agency problems between shareholders and managers, we can expect a certain relationship between management stockholding and R&D intensity, although the theory fails to predict a monotonous relationship between these two. Empirical results show that R&D intensity rises as the importance of management stockholding increases in the manager's personal wealth. These results are consistent with the agency theory that management stockholding reduces agency problem.

I. Introduction

The separation of ownership and management has been the main issue among theorists of the firm since Berle and Means (1932). According to them, the separation of ownership and management gives managers a great deal of discretionary power to act in their own interests rather than those of the stockholders. Therefore, they may not be maximizing profit. The actual degree of deviation of managers' behavior from profit maximization depends upon the effectiveness of control mechanisms over management. The content of a management compensation package, especially management stockholding, is generally considered to be an important determinant of the intensity of control over management. Various theoretical and empirical studies suggest that

*I would like to thank Lee Benham, Kenneth Lehn and John Nye for their helpful comments.

[Seoul Journal of Economics 1992, Vol. 5, No. 2]

the behavior and the performance of firms differ depending upon the degree of management stockholding (Larner 1970, McEachern 1975, Jensen and Meckling 1976, Cubbin and Leech 1983, Walkling and Long 1984, Benston 1985, and Murphy 1985).

More specifically, concerning risk-taking behavior of a firm, studies by Boudreaux (1973), McEachern (1976), and Agrawal and Mandelker (1986) show that a manager with stocks of his firm is less risk-averse than other managers. Considering the uncertainty involved in the research and development (R&D) decision (Kamien and Schwartz 1982, and Freeman 1982), it is natural to conjecture that management stockholding may be an important factor that can explain the difference in R&D intensity among firms. However, no empirical study exists on this issue until now. In fact, the potential importance of using firm theory and agency theory to explain the R&D decision has received very little attention.¹

This paper attempts to examine how management stockholding affects the R&D decision in a firm. This examination seems to be important because it can give a full understanding about the determinants of R&D intensity as well as the management stockholding as a control mechanism. In the next section, we examine the agency problems involved in R&D decision. Two agency problems are identified here: risk-reduction incentive and shirking incentive. The value of a manager's human capital is correlated to the returns of the firm he manages and this risk cannot be diversified away in the capital market. Therefore, his portfolio, including his human capital, has a higher risk than that of shareholders who can diversify their portfolios in the market. Hence, he tends to undertake less risky projects to reduce the risk of his portfolio (risk-reduction incentive, Amihud and Lev 1981). It has been also argued that, without appropriate incentive contracts, a manager may want to avoid new profitable ventures because it requires additional effort (shirking effort, Jensen and Meckling 1976). We also discuss another frequently cited argument that managers tend to focus on short-term performance at the expense of long-term profit and, therefore, they neglect the R&D projects. In section III, I investigate what happens to these incentives as a manager's stockholdings increase. Although we can conjecture that agency problems are reduced as management stockholdings increase up to a

¹Kamien and Schwartz (1982) point out the potential importance of considering management control problem in explaining difference in R&D intensity among firms.

certain limit, the exact relationship is an empirical issue because of several competing factors. The empirical results in section IV show that there is a positive relationship between management stockholding and the level of R&D expenditures. Section V examines three other possible explanations of these findings, and section VI offers some concluding comments.

II. Agency Problems in R&D Decision

This section examines agency problems involved in the R&D decision. Three managerial incentives to undertake fewer R&D projects have been argued: risk-reduction incentive, shirking incentive, and short-run focus incentive. First, we will discuss risk-reduction incentive with more emphasis because of the risks involved in R&D projects. Discussion of shirking incentive follows and we also argue that short-run focus incentive by manager cannot be clearly identified mainly because it assumes the imperfectness of stock market.

According to the results of the capital asset pricing model, a firm will undertake any profitable project regardless of its own variance in order to maximize expected profit. In other words, the fact that the firm's shareholders hold highly diversified portfolios means that the firm does not have to concern itself with diversification. When an asset is included in a well-diversified portfolio, that is, a portfolio of many assets with no individual asset accounting for a large part of the total investment, the effect of an individual asset to the variance of the portfolio return depends primarily on the covariance between this asset and other assets in the portfolio, rather than on the variance of the return on this asset itself (Fama and Miller 1972). One of the important assumptions in this model is that every asset held by investors is marketable and, therefore, all the investors have the same opportunities to invest. However, each investor also has nonmarketable assets such as human capital. This portfolio, including human capital, may not be well-diversified even if the marketable asserts are fully diversified (Hirschleifer 1970, and Mayers 1972). Mayers (1972) points out this limited diversification problem in the capital market equilibrium model with nonmarketable assets. He shows that an investor in a firm considers two kinds of risks of the firm that cannot be diversified away. The first risk is the covariance of the firm's returns with all other firms. The second one is the covariance of its returns with earnings of human capital held by the investor. While the first risk is the traditional one in the model with

marketable assets only, the second one is added to the "systematic" risk of the firm when we also consider nonmarketable assets. This second risk cannot be diversified away in the investor's portfolio because, unlike other assets, human capital cannot be traded in the market. Therefore, when the earnings on human capital is correlated to a specific firm's returns, the investor's portfolio including his human capital is imperfectly diversified and, as a result, has higher risk. By the way, the second risk is very large to a manager for the following reasons. First, the manager's earnings from the firm is typically correlated with the firm's returns although the degree of correlation depends upon the contents of compensation package. More importantly, the manager may be fired if the performance of the firm is below some acceptable level. This will give the seriously negative effect to the future value of his human capital. Due to the undiversifiable risk caused by this correlation between his human capital and the firm's performance, the manager is faced with limited diversification and higher risk compared with shareholders who can diversify their portfolios in the market.

Mayers (1972) also shows that the investor will reduce his asset holdings of the firm with which his nonmarketable returns have positive covariation. It implies that the manager might find it in his interest to sell the stocks of his firm short.² However, such short-sales will not be accepted by the firm's shareholders. Considering that the manager cannot reduce his risk in the capital market, we expect that he has an incentive to reduce the risk of his portfolio by diversifying the firm's project and/or taking only less risky projects.³

Baumol (1959) and Mosen and Downs (1965) also draw a similar conclusion regarding the managerial behavior in the modern corporation. However, they emphasize the asymmetry between rewards and punishments as Mosen and Downs state that, "although a very poor management performance may result in a rebellion, a very good one does not usually cause a powerful movement among stockholders to reward their managers with lavish bonuses" (Mosen and Downs 1965,

²In addition to short-selling, it is also possible that the manager can increase the holding of assets that are negatively correlated to returns on his human capital which, in turn, is correlated to the firm's returns. However, we cannot be sure that (1) such option is available to all the managers, and (2) the increase in the holding of such assets does not cause limited diversification in his marketable assets.

³Using similar arguments, Amihud and Lev (1981) show that managers use conglomerate mergers as a way of reducing risks of their portfolios.

p. 226). It is true that this line of reasoning leads to the same conclusion that the manager has an incentive to reduce risks. However, whether the asymmetry actually exists in the compensation structure is another empirical issue to be tested. Our argument in this section holds even if this kind of asymmetry does not exist because we focus on the limited diversification problem due to the high correlation between human capital of a manager and a firm's returns. Therefore, the Baumol-Monsen-Downs hypothesis can be considered as a special case of our argument.

A manager's effort to reduce his firm's risk can be viewed as an agency problems because these risk-reduction activities may cause the shrinkage of shareholders' wealth. More specifically, consider the example of a fully equity-financed firm facing two alternative projects, X_1 , and X_2 . Suppose that

$$E(X_1) = E(X_2) \quad (1)$$

$$\text{COV}(X_1, r_M) = \text{COV}(X_2, r_M) \quad (2)$$

$$\text{VAR}(X_1) > \text{VAR}(X_2) \quad (3)$$

where r_M is the return from market portfolio. Assuming a risk-averse manager, the manager will prefer X_2 because it decreases the risk of his portfolio. However, under the capital asset pricing model, the value of the firm will be independent of the project adopted and the shareholders will be indifferent between the two projects. Therefore, there is no conflict of interests between shareholders and the manager.

Now, suppose (1) changes to (1)' while (2) and (3) remain to hold.

$$E(X_1) > E(X_2) \quad (1)'$$

This situation may cause a conflict between shareholders and the manager. Shareholders clearly prefer X_1 over X_2 because it will give them the higher firm value. In the case of the manager, choosing X_2 would expose him to less risk, but it would also cause a lower income because we are assuming the correlation between his earnings and the firm's returns. Hence, the manager's choice is not clear. However, Fama and Jensen (1985) give two reasons to believe that the manager is more likely to choose low risk than other people who have same preference over risk and return. First, the implicit price of risk to the manager is greater than the market price of risk. In addition, the contribution of a less risky project to the risks of the manager's imperfectly diversified portfolio tends to be greater than the contribution of the same project to the risks of well-diversified portfolios held by share-

holders.

Finally, consider a firm with risky debt outstanding, which is dominantly observed in the real world compared to the fully equity-financed firm. When there are two projects which satisfy conditions (1)-(3), we expect a conflict between shareholders and the manager again. It has been shown that the choice of project X_2 would cause the equity value to be reduced, while the value of existing bond increases (Jensen and Meckling 1976, and Galai and Masulis 1976). Therefore, the choice of a less risky project induces a wealth transfer from shareholders to bondholders and risk-reduction in the manager's portfolio.

In sum, the risk-reduction activities by the manager can make him better off at the expense of shareholders' interests. This risk-reduction incentive is expected to result in a low R&D expenditures level due to the uncertainty involved in R&D projects (Kamien and Schwartz 1982, and Freeman 1982).⁴

Besides the risk-reduction incentive, there are two other frequently mentioned agency problems regarding R&D and investment. First, the manager is alleged to have an incentive to shirk efforts. (Alchian and Demsetz 1972, and Jensen and Meckling 1976). As Jensen and Meckling state,

...(The manager) may in fact avoid new profitable ventures simply because it requires too much trouble or effort on his part to manage or to learn about new technologies. Avoidance of these personal costs and the anxieties that go with them also represents a source of on the job utility to him and it can result in the value of the firm being substantially lower than it otherwise could be. (Jensen and Meckling 1976, p. 313)

Considering the costly monitoring and the asymmetric information between shareholders and the manager, this shirking problem is expected to continue to exist unless he is compensated by appropriate incentive contracts.

Second, the managers are often said to focus on short-term performance at the expenses of long-term profits (Stiglitz 1985, and Agrawal and Mandelker 1986). Frequently cited reasons for this incentive are that (1) managers' reward structures are directed at current returns, (2) their tenures are short due to promotions, job switches, firings, and retirements, and (3) the managers are afraid that poor current performance may cause the firm to become a target of takeover. It is argued

⁴Empirical analysis which is not reported here also shows that there is a positive relationship between R&D intensity and various measures of firm risk.

that these incentives to maximize short-term profits cause the manager to forego investment in long-term projects such as capital expenditures and research and development. The validity of this argument hinges upon whether the capital market is perfect or not. If the capital market is myopic, then it is plausible that only the current performance such as dividend and current accounting profit is reflected in the stock price and there will be some bias against long-term projects. However, if this is not the case, the annual rate of return on the stock will not change whether a certain amount of profit is used for cash dividend or for a long-term project because the expected return from the long-term profit will be also equally reflected in the stock price. Thus, there should be no bias toward short-term performance. Whether the capital market is imperfect or not is not a settled issue yet. However, there are some studies which do not support the short-run focus argument. They show that stock prices rise after the announcement of new R&D projects (Jarrell, Lehn, and Marr 1985). Therefore, it is not clear whether the short-run focus argument can be considered as a part of agency problem involved in the R&D decision.

Despite the managerial incentive problems that arise in the modern corporation due to the separation of ownership and management, the use of the corporate form instead of other potential alternatives seems to be prevailing, at least, up to the present. Fama and Jensen (1983a, 1983b) argue that the prevalence of the corporate form suggests that there exist effective mechanisms that reduce agency problems. The first set of such devices is the use of a competitive market mechanism in disciplining managers. The threat of takeover provided by the market for corporate control (Manne 1965) and the adjustment of managers' earning through the managerial labor market (Fama 1980) are alleged to discipline managers and induce them to serve the interests of the shareholders. Fama (1980) argues that the discipline induced by capital and managerial labor markets are sufficient to eliminate the agency problems.⁵ The other set of mechanisms seems to be developed in an effort to reduce the agency problems within the firm. First, several studies suggest that we can observe concentrated ownership by a few shareholders for the control over the managers (Stiglitz 1985, Demsetz and Lehn 1985, Shleifer and Vishny 1986, and Schranz 1988). Shareholders with a concentrated block of shares have the incentive to

⁵Amihud and Lev (1981) convincingly argue that disciplining through managerial labor market cannot entirely eliminate the risk-reduction incentives of managers.

monitor the manager's behavior due to their large stake in the firm and also have power to discipline the manager because of their voting power. Second, the existence of elaborate management compensation contracts between shareholders and managers suggest, that a management compensation package also works to align the interests of managers with those of shareholders. If a manager holds a significant portion of his wealth in the stock of the firm or his bonus and salary are related to the performance of the firm, the conflict of interest between the manager and shareholders may be alleviated because the manager also bears the consequences of actions deviating from the interests of shareholders. Recent evidence suggests that management stockholdings play an important role in reducing agency problems (McEachern 1975, Amihud and Lev 1981, Walkling and Long 1984, Benston 1985, Coughlan and Schmidt 1985, Murphy 1985, and Agrawal and Mandelker 1986, 1987).

However, the role of this control mechanism in the R&D decision has rarely been discussed, either theoretically or empirically. If management stockholding alleviates the agency problems involved in the R&D decision such as risk-reduction and shirking incentives, then there could be a positive relationship between management stockholding and R&D intensity.

III. Management Stockholding and R&D Expenditures: Hypothesis

This section examines the effect of management stockholding on the agency problems involved in the R&D decision. By doing so, a certain relation between management stockholding and R&D expenditures could be identified. The management stockholding affects the risk-reduction incentive in various ways.⁶

When a manager holds a substantial fraction of his firm's equity, he may have enough voting power to guarantee his future employment with the firm and set up the compensation package so that the variation of his earnings may be small. In this case, the manager's risk related to his human capital can be negligible. Therefore, his risk-reduction incentive will be smaller than the manager without stockholding. Then, what will be the sufficient fraction of ownership of the firm's stocks in order to control the firm? Cubbin and Leech (1983)

⁶Similar analysis can be found in Agrawal and Mandelker (1987).

summarize the studies related to this issue and report that, in these studies, the stockholding of the largest shareholder which ranges from 25% down to 4% of outstanding shares has been considered necessary to maintain the control over the firm. Although these criteria are somewhat arbitrary, it is clear that management stockholding with a small fraction of the firm's equity, such as 1-2%, is not big enough to give him the power to reduce the risks of his earnings. In this sense, management stockholding is not expected to be conducive to the alleviation of risk-reduction incentive unless it represents a substantial portion of total shares.

However, besides the effect on the risk of a manager's human capital, management stockholding has two other effects on the manager's portfolio. First, in a firm with risky debt outstanding, it has been shown in section II that the value of common stock increases as the riskier project (X_1) is undertaken even when $E(X_1) = E(X_2)$, where X_2 is the less risky project. Furthermore, when $E(X_1) > E(X_2)$, the increase in the value of stockholdings will be bigger. In this situation, the marginal benefit of undertaking the less risky project to the manager is the reduction in the risks of his human capital, while its marginal costs are lower earnings and lower value of his stockholdings. When a manager has large stockholdings in the firm, the latter is likely to dominate the former.⁷ Thus, we can expect that management stockholding alleviates the risk-reduction incentive by making the risk-reduction activities more costly. Second, the effect on the risk of the manager's wealth must be also considered. By undertaking riskier project, the variance of stock returns as well as the value of stocks will also increase. Then, it will affect the variance of the manager's total wealth, although the direction of the effect is not obvious as Agrawal and Mandelker (1987) show. It depends on the correlation between stock returns and his other assets and on the relative weight of these two components.⁸ This result

⁷Benston (1985) and Murphy (1985) report that annual changes in the value of management stockholdings are often three to five times greater than the executive's total annual compensation, although there is a significant degree of variation in executive holdings among firms.

⁸Let W = total wealth of a manager

W_s = wealth invested in stocks of the firm

$W_o = W - W_s$, the wealth of other assets

Let σ_w^2 , σ_s^2 , and σ_o^2 be the variance of returns on W , W_s , and W_o respectively. Then,

$$\sigma_w^2 \equiv x^2 \sigma_s^2 + (1-x)^2 \sigma_o^2 + 2x(1-x) \text{cov}(W_s, W_o) \quad (4)$$

where $x = W_s/W$.

implies that, up to a certain limit, the increase in the variance of stock returns could be so small that its effect on the risk of his total wealth may be negligible. Beyond this limit, however, the increase in the risk of his portfolio seems to be unavoidable because of the dominance of stockholding in his portfolio. Then, the manager is faced with the trade-off between risk and return again.

In sum, management stockholding can have the following three effects on the risk-reduction incentive: (1) the risk of the manager's human capital decreases by having more voting power; (2) the cost of engaging in risk-reduction activity increases by including the stocks in his portfolio; (3) the variance of his portfolio changes as the risk of the firm's returns changes due to stockholding. Although the second effect seems to be dominant at least up to a certain limit, the effect of management stockholding on this incentive becomes an empirical issue without knowing the direction of the third effect.

Concerning the shirking incentive, existing studies (Alchian and Demsetz 1972, and Jensen and Meckling 1976) suggest that the manager's incentive to devote significant effort to search out new profit ventures will increase as his stockholding increases. It is also consistent with the implication of agency theory that management stockholding reduces the perquisites and shirking of the manager.

IV. Empirical Analysis of the Hypothesis

This paper uses the management compensation data collected by *Forbes* magazine in 1987. The survey includes the contents of compensation package of Chief Executive Officers of 265 manufacturing firms during 1986. "U.S. 1982 Census of Manufactures" is used to get market share concentration ratio. The source of other accounting data is the COMPUSTAT tape. Finally, CRSP tape is used to collect the stock price data. The sample of this study is 184 firms for which we are able to obtain all the data necessary for our study. 81 firms in the *Forbes* data are excluded from our sample primarily because we cannot

Differentiating (4) with respect to

$$\frac{\partial \sigma_w^2}{\partial \sigma_s^2} = x^2 + (1-x)^2 \left(\frac{\partial \sigma_e^2}{\partial \sigma_s^2} \right) + 2x(1-x) \left(\frac{\partial \text{cov}(W_s, W_e)}{\sigma_s^2} \right)$$

The sign of the above equation depends on the sign of the second and the third term, as well as the relative importance of W_s and W_e .

TABLE 1
DESCRIPTION OF VARIABLES

<i>RD</i>	R&D expenditures/sales
<i>HOLDING</i>	the percentage of shares held by Chief Executive Officer
<i>RATIO1</i>	the market value of stockholding by CEO divided by CEO's annual salary and bonus
<i>RATIO2</i>	the market value of stockholding by CEO divided by CEO's annual total cash compensations
<i>ASSET</i>	the book value of assets (million dollars)
<i>IF</i>	(profit before tax + depreciation)/sales
<i>ND</i>	new long-term debt/sales
<i>CAP</i>	capital expenditures/sales
<i>DIV</i>	dividend payments/sales
<i>CR</i>	four digit SIC code four firm concentration ratio

obtain the data on R&D expenditures for these firms. While we cannot be sure that such exclusion does not bias results, the omitted firms do not appear to be very different from the included ones in any observable respect. Definitions of all the variables used in this paper are summarized in Table 1 and discussed in detail below.

The measure of R&D activities (*RD*) is the ratio of R&D expenditures to sales. Three measures of management stockholding are used in the study. The first one is the percentage of stockholding held by the Chief Executive Officer (*HOLDING*). This measure is a good proxy to measure the executive's power to control the firm. In section III, the executive's control power is hypothesized to affect the risk-reduction incentive through the effect on the risk of his human capital. Further, Jensen and Meckling (1976) argue that the relative size of stockholding by manager can be used to measure the degree of agency costs. However, in this study, it is also important to know the relative importance of his stockholding, human capital and other assets in his total wealth. Following Agrawal and Mandelker (1986, 1987) and Lewellen, Loderer, and Rosenfeld (1985), this paper uses the market value of stockholdings held by the CEO divided by his annual salary and bonus (*RATIO1*), or his annual total cash compensation (*RATIO2*), respectively, to proxy the importance of the stockholding in his total wealth.⁹ The

⁹These ratios do not include the value of management's stock options. Empirical studies (Agrawal and Mandelker 1986, and Schranz 1988) show that the value of CEO's options is negligible compared to the value of his stockholdings. For example, the value of option is only 5% of that of stockholding in Agrawal and Mandelker's study. Furthermore, inclusion of stock option does not alter their results.

annual salary and bonus or total compensation can be used as a proxy of the human capital and other assets that the CEO holds. Therefore, as the value of stockholding increases relative to the size of compensation, we can assume that the importance of stockholding also increases compared to his human capital and other assets. The firm size variable (*ASSET*) is the book value of assets. The measure of internal fund (*IF*) is the sum of income before extraordinary items and depreciation, divided by sales. New long-term debt, dividend payments, and capital expenditures, all divided by sales, are represented by *ND*, *DIV*, and *CAP*, respectively. Finally, the measure of concentration of market share (*CR*) is four-firm concentration ratio based upon four digit SIC (Standard Industrial Classification) codes. Since almost all the firms engage in the production in more than one four-digit SIC code industry, the choice of correct measure of monopoly power is not an easy task and any criteria to be used should be arbitrary. We use the concentration ratio of the industry which represents the largest portion of the firm's production.

In the regression to be conducted later, R&D intensity (*RD*) is a dependent variable and the management compensation variables (*HOLDING*, *RATIO1*, and *RATIO2*) are the main independent variables. Other variables are the ones that are typically included in R&D literature. Firm size and four-firm concentration ratio are included as independent variables to test the Schumpeterian hypothesis which claims that monopoly power and firm size are positively related to innovation. The importance of internal funds in financing R&D projects can be tested by looking at the significance of the coefficients of internal funds and new debt. Capital expenditures and dividend payments are included because they are considered as competing alternatives of R&D in the allocation of resources.

Table 2 describes the summary statistics of the variables. In this sample, the mean value of the portion of CEO stockholding is only 1.3%. Also the maximum value (35.1%) is consistent with Fama and Jensen's (1983a) argument that firms where management also has complete control by owning more than 50% of the equity will have a difficulty in surviving as organizations. The mean value of *RATIO1* and *RATIO2* are 37.2 and 32.3, respectively. This means that the portion of stockholding represents quite a large portion of CEO's total wealth, which is consistent with previous studies (Benston 1985, Murphy 1985, and Agrawal and Mandelker 1986).

Before doing a regression analysis for our hypothesis, we perform a

TABLE 2
SUMMARY STATISTICS OF VARIABLES

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
<i>RD</i>	0.037	0.036	0.000	0.253
<i>HOLDING</i>	1.284	4.293	0.000	35.1
<i>RATIO1</i>	37.25	123.5	0.000	1079.9
<i>RATIO2</i>	32.25	117.6	0.000	1077.0
<i>ASSET</i>	5466.3	9577.1	297.4	72593
<i>IF</i>	0.075	0.022	-2.703	0.304
<i>ND</i>	0.083	0.172	-0.007	1.212
<i>CAP</i>	0.071	0.048	0.008	0.410
<i>DIV</i>	0.028	0.071	0.000	0.953
<i>CR</i>	42.59	21.52	7.000	92.00

TABLE 3
COMPARISON OF THE AVERAGES OF *RD* ACROSS 4 PORTFOLIOS, WHERE EACH PORTFOLIO CONTAINS 25% OF SAMPLE FIRMS WHICH ARE SORTED IN AN ASCENDING ORDER OF *RATIO1*

Portfolio	1	2	3	4
<i>RD</i>	0.022	0.035	0.037	0.056
<i>RATIO1</i>	1.509	4.780	10.27	132.4
<i>RATIO2</i>	1.223	3.712	7.594	116.5
<i>HOLDING</i>	0.085	0.181	0.328	3.867
<i>N</i>	46	46	46	46

simple empirical examination. We first rank the sample firms in an ascending order of *RATIO1*. We form four quartile portfolios so that portfolio 1 contains the 25% of the sample firms with the smallest *RATIO1* and portfolio 2 contains the next 25% firms, and so on. If management stockholding is conducive to R&D activity, the level of R&D intensity will rise with the value of *RATIO1* over the four quartile portfolios. Table 3 presents the mean of *RATIO1* and *RD* in each of these portfolios. The table shows that the mean *RD* for portfolio 1 through 4 is 0.022, 0.035, 0.037, and 0.056 respectively, which increases consistently with *RATIO1*. This result is consistent with the argument that management stockholding reduces the agency problem involved in the R&D decision. Table 4 and 5 represent the results when a similar quartile analysis is done using *RATIO2* and *HOLDING*, respectively. They show that the similar pattern as is found in Table 3 can be also found in the sense that the mean value of *RD* maintains the increasing trend across the portfolios although the intensities of *RD* in portfolio 2

TABLE 4

COMPARISON OF THE AVERAGES OF *RD* ACROSS 4 PORTFOLIOS, WHERE EACH PORTFOLIO CONTAINS 25% OF SAMPLE FIRMS WHICH ARE SORTED IN AN ASCENDING ORDER OF *RATIO2*

Portfolio	1	2	3	4
<i>RD</i>	0.022	0.036	0.036	0.057
<i>RATIO1</i>	1.112	3.414	7.120	117.4
<i>RATIO2</i>	1.746	5.952	11.12	130.2
<i>HOLDING</i>	0.086	0.190	0.393	3.792
<i>N</i>	46	46	46	46

TABLE 5

COMPARISON OF THE AVERAGES OF *RD* ACROSS 4 PORTFOLIOS, WHERE EACH PORTFOLIO CONTAINS 25% OF SAMPLE FIRMS WHICH ARE SORTED IN AN ASCENDING ORDER OF *HOLDING*

Portfolio	1	2	3	4
<i>RD</i>	0.032	0.036	0.036	0.047
<i>RATIO1</i>	0.033	0.131	0.302	3.996
<i>RATIO2</i>	9.481	6.469	9.812	123.2
<i>HOLDING</i>	7.665	4.905	6.750	109.7
<i>N</i>	46	46	46	46

and 3 are same.

As a next step, we conduct a regression analysis. Table 6 reports the OLS estimates of the independent variables on which *RD* is regressed. *RATIO1* and *RATIO2* have positive signs and they are all statistically significant at 1% level. *HOLDING* also has positive sign although it is not significant. Overall results reinforce the belief that management stockholding induces high R&D intensity. The Schumpeterian hypothesis does not seem to be supported because firm size and concentration ratio are not significant. A puzzling result is the negative significance of internal funds. Previous studies report that the availability of internal funds raises R&D intensity. Any reasonable rationale for this result cannot be found. New long-term debt and dividend are not significant, while the coefficient of capital expenditures is positively significant. The final result seems to imply that the conditions for high intensity of R&D and capital expenditures are same.¹⁰ Table 7 presents

¹⁰Agrawal and Mandelker (1986) actually show that capital expenditures rise as management stockholding increases.

TABLE 6

THE OLS ESTIMATES OF THE COEFFICIENTS OF INDEPENDENT VARIABLES ON WHICH RD IS REGRESSED WITHOUT INDUSTRY DUMMY VARIABLES

Intercept	0.02992** (4.115)	0.02689** (3.925)	0.02742** (3.961)
ASSET	-7.48×10^{-8} (-0.280)	-8.74×10^{-8} (-0.035)	-1.77×10^{-8} (-0.070)
CR	-0.00005 (-0.401)	-0.00002 (-0.174)	-0.00002 (-0.211)
IF	-0.04092** (-3.293)	-0.02658* (-2.218)	-0.02616* (-2.142)
ND	-0.01478 (-0.934)	-0.00684 (-0.442)	-0.00741 (-0.473)
CAP	0.19355** (3.490)	0.14630** (2.782)	0.15003** (2.824)
DIV	-0.02079 (-0.497)	-0.00906 (-0.257)	-0.00789 (-0.222)
HOLDING	0.00079 (1.489)	—	—
RATIO1	—	0.00010** (5.116)	—
RATIO2	—	—	0.00010** (4.678)
R ²	0.1842	0.2834	0.2679
Adjusted R ²	0.1519	0.2549	0.2388
F	5.709	9.944	9.200

Note: *t*-statistics are in parentheses, *: significant at 5% level, **: significant at 1% level.

the OLS estimates when a series of industry dummy variables are included in the regression model. The coefficients of *RATIO1* and *RATIO2* remain to be negatively significant and *HOLDING* becomes also significant at the 5% level now.

The discussion of section III, however, implies the possibility that R&D intensity increases up to a certain level of management stockholding and decreases beyond that level because the dominance of stockholding in CEO's total wealth causes the risk of his wealth to rise as more R&D projects are undertaken. To test the possibility of this

TABLE 7

THE OLS ESTIMATES OF THE COEFFICIENTS OF INDEPENDENT VARIABLES ON WHICH RD IS REGRESSED WITH INDUSTRY DUMMY VARIABLES

Intercept	0.00972 (0.659)	0.00906 (0.657)	0.00975 (0.700)
ASSET	-4.89×10^{-8} (-0.213)	1.64×10^{-8} (0.076)	7.58×10^{-8} (0.035)
CR	-0.00011 (-0.894)	-0.00007 (-0.626)	-0.00007 (-0.658)
IF	-0.03619** (-3.534)	-0.02566* (-2.594)	-0.02511* (-2.489)
ND	-0.02295 (-1.781)	-0.01279 (-1.014)	-0.01352 (-1.061)
CAP	0.21436** (4.582)	0.16881** (3.787)	0.17242** (3.831)
DIV	-0.02601 (-0.764)	-0.01454 (-0.508)	-0.01388 (-0.480)
HOLDING	0.00178* (2.404)	—	—
RATIO1	—	0.00008** (4.901)	—
RATIO2	—	—	0.00008** (4.485)
R ²	0.5149	0.5718	0.5627
Adjusted R ²	0.4591	0.5222	0.5121
F	9.219	11.527	11.109

Note: *t*-statistics are in parentheses, * : significant at 5% level, **: significant at 1% level.

nonlinear relationship, we perform two empirical test. First, the following dummy variables are created using four portfolios in Table 3.

$RATIO11 = 1$, if the value of $RATIO1$ is included in the lowest quarter
= 0, otherwise

$RATIO12 = 1$, if the value of $RATIO1$ is included in the second quarter
= 0, otherwise

$RATIO13 = 1$, if the value of $RATIO1$ is included in the third quarter
= 0, otherwise

TABLE 8

THE OLS ESTIMATES OF THE COEFFICIENTS OF INDEPENDENT VARIABLES ON WHICH RD IS REGRESSED (THE MANAGEMENT STOCKHOLDING VARIABLES ARE FOUR DUMMY VARIABLES WHICH ARE CREATED FROM *RATIO1*)

ASSET	5.88 × 10 ⁻⁸ (0.233)
CR	-0.00004 (-0.380)
IF	-0.03837** (-3.299)
ND	-0.01595 (-1.014)
CAP	0.19782** (3.761)
DIV	-0.00932 (-0.263)
RATIO11	0.00979 (1.132)
RATIO12	0.02582** (3.325)
RATIO13	0.02974** (3.882)
RATIO14	0.04457** (5.472)
R ²	0.6570
Adjusted R ²	0.6372
F	33.324

Note: *t*-statistics are in parentheses, * : significant at 5% level, **: significant at 1% level

RATIO14 = 1, if the value of *RATIO1* is included in the top quarter
= 0, otherwise

In the previous regression, *RATIO1* is replaced with the above four dummy variables in order to see whether there is a nonlinear relationship between management stockholding and R&D intensity. The OLS estimates of the regression is reported in Table 8.¹¹ This shows that

¹¹Note that intercept term is excluded in this regression to avoid linear dependence.

TABLE 9

THE OLS ESTIMATES OF THE COEFFICIENTS OF INDEPENDENT VARIABLES ON WHICH RD IS REGRESSED (THE SQUARE TERMS OF MANAGEMENT STOCKHOLDING VARIABLES ARE ADDED IN THE REGRESSION)

Intercept	0.02768** (3.986)	0.02453** (3.393)
ASSET	-1.86×10^{-8} (-0.074)	3.95×10^{-8} (0.151)
CR	-0.00002 (-0.183)	-0.00004 (-0.352)
IF	-0.02749* (-2.279)	-0.03733* (-3.082)
ND	-0.00667 (-0.183)	-0.01014 (-0.658)
CAP	0.14445** (2.740)	0.17139** (3.161)
DIV	-0.00582 (-0.164)	0.06981 (1.441)
RATIO1	0.00007 (1.215)	—
(RATIO1) ²	4.87×10^{-8} (0.748)	—
HOLDING	—	0.00676** (3.615)
(HOLDING) ²	—	-0.00024** (-3.435)
R ²	0.2845	0.2354
Adjusted R ²	0.2530	0.2007
F	8.749	6.774

Note: *t*-statistics are in parentheses, * : significant at 5% level, ** : significant at 1% level

the coefficients of the four dummy variables increase monotonously. It implies that R&D intensity increases as management stockholding increases, which rejects the possibility of nonlinearity.¹²

The other way to test nonlinearity is to include the squared term of

¹²Same analysis has been done using *RATIO2* and *HOLDING* instead of *RATIO1* and the basic results remain same.

management stockholding variables. In other words, $(HOLDING)^2$, $(RATIO1)^2$, or $(RATIO2)^2$ is included in the above regression and the result is presented in Table 9.¹³ The coefficients of $RATIO1$ and $(RATIO1)^2$ are not significant, implying the misspecification of the model. An interesting result can be found in the second column. The significance of $HOLDING$ increases compared to the previous regression results and $(HOLDING)^2$ has a negative sign and is highly significant. This result implies that $HOLDING$ has a nonlinear relationship with R&D intensity. However, considering the result of Table 8, we cannot be sure that this nonlinearity causes the reduction of R&D intensity at the highest level of management stockholding.

In sum, we cannot find any nonlinearity in the case of $RATIO1$ and $RATIO2$, while we cannot rule out the possibility that the rate of increase in R&D intensity becomes slower as the portion of management stockholding ($HOLDING$) increases.

One restriction to the above argument is in order. We implicitly assume that the firm addresses the R&D problem after the desired management compensation package is set up. However, it is possible that other mechanisms may lead to a reversed causality. This possibility of reversed causality remains an open question, although such a mechanism would not be inconsistent with our hypothesized positive relation between R&D and management stockholding.

V. Tests of Some Other Alternative Explanations

This section examines three other possible alternative hypotheses which may explain our empirical results from a different view. The first possible explanation is that the characteristics of the industry determine both the management compensation package and R&D activity. It is possible that firms in an industry that requires high R&D intensity simultaneously employ the compensation package with large stockholding to facilitate R&D activities.

To test the "industry effect" hypothesis, I choose five industries where there are more than 15 sample firms and arrange them in an ascending order of average R&D intensity of each industry and present it in Table 10. If the "industry effect" hypothesis is correct, a large amount of management stockholding would be observed in higher R&D

¹³The result when $(RATIO2)^2$ is added to the regression is similar to the one when $(RATIO1)^2$ is added. Thus, the result is not reported here.

TABLE 10
COMPARISON OF THE AVERAGES OF *RD*, *HOLDING*, *RATIO1*, AND
RATIO2 ACROSS 5 INDUSTRIES

Industry	<i>RD</i>	<i>HOLDING</i>	<i>RATIO1</i>	<i>RATIO2</i>
Food	0.006	1.852	42.76	40.63
Machinery	0.027	0.233	5.380	3.932
Transportation equipment	0.032	2.122	20.26	14.55
Chemical	0.057	1.683	46.54	35.64
Electrical equipment	0.060	1.360	83.14	78.07

TABLE 11
THE OLS ESTIMATES OF MANAGEMENT STOCKHOLDING VARIABLES IN THE
REGRESSION MODEL WHERE *RD* IS A DEPENDENT VARIABLE

Industry	<i>N</i>	<i>HOLDING</i>	<i>RATIO1</i>	<i>RATIO2</i>
Food	15	0.00022 (0.700)	0.00001 (0.669)	0.00001 (0.724)
Chemical	35	0.00557 (1.590)	0.00019** (2.816)	0.00041** (2.779)
Machinery	17	0.01959 (1.124)	0.00122* (2.127)	0.00267* (2.275)
Electrical equipment	37	0.00165 (0.719)	0.00005* (2.102)	0.00006* (2.115)
Transportation equipment	24	0.00159 (0.521)	0.00003 (0.176)	0.00003 (0.173)

Note: *t*-statistics are in parentheses, * : significant at 5% level, ** : significant at 1% level

industries and vice versa. In other words, *RATIO1*, *RATIO2*, and *HOLDING* would increase as we move from the first row toward the last row. However, such regularity is not found in Table 10.

Another way to test this hypothesis is including a series of industry dummy variables in the regression model. The coefficient of *RATIO1*, *RATIO2*, and *HOLDING* should be insignificant after including the dummy variables if the above argument explains the true relationship. However, as we have seen from Table 7, they are still significant even after industry dummy variables are included.

The best way to test the hypothesis will be running the regression for each industry separately. The coefficients of managements stockhold-

TABLE 12

COMPARISON OF THE AVERAGES OF *RD* AND MANAGEMENT STOCKHOLDING VARIABLES ACROSS FOUR PORTFOLIOS, WHERE EACH PORTFOLIO CONTAINS 25% OF SAMPLE FIRMS WHICH ARE SORTED IN AN ASCENDING ORDER OF THE DIVIDEND PER SHARE

Portfolio	1	2	3	4
Dividend per share	0.169	0.773	1.254	3.737
<i>RD</i>	0.055	0.030	0.029	0.035
<i>HOLDING</i>	2.056	0.353	1.105	0.948
<i>RATIO1</i>	102.8	9.525	25.86	10.75
<i>RATIO2</i>	91.48	5.811	23.02	8.699
<i>N</i>	46	46	46	46

ing variables from the regression in the five industries mentioned above are reported in Table 11. The coefficients of *RATIO1* and *RATIO2* are significantly positive in chemical, machinery, and electrical equipment industries and they have positive signs in other industries although they are not significant. The results imply that R&D intensity and management stockholding have a positive relation even within the same industry.

The second potential explanation of our results is related to a manager's tendency to hold more retained earnings. When a manager held large stockholdings, until 1986, he had to pay more tax when high dividends were distributed compared to the case when same amount of profit was kept as retained earnings. Therefore, he was less likely to initiate high dividends for reasons of personal taxes. Considering the argument that firms often rely on retained earnings for financing R&D projects, the payment of low dividends may result in higher R&D expenditures. Therefore, our empirical results may be a spurious relationship which is driven by "dividend effect".

In order to test this argument, we calculate the dividend per share during 1986 and form another four quartile portfolios based upon the dividend per share as we did before in making Tables 3-5. Table 12 present the average R&D intensity and stockholding variables for each portfolio. If the "dividend effect" is correct, both R&D intensity and the value of stockholding variable should be decreasing as we move from portfolio 1 to portfolio 4. However, these do not present a decreasing pattern as we can see from Table 12.

A final possible explanation is that both *RATIO1* (*RATIO2*) and *RD* are affected by the firm's performance. High R&D intensity is again alleged

TABLE 13

COMPARISON OF THE AVERAGES OF RD AND MANAGEMENT STOCKHOLDING VARIABLES ACROSS FOUR PORTFOLIOS, WHERE EACH PORTFOLIO CONTAINS 25% OF SAMPLE FIRMS WHICH ARE SORTED IN AN ASCENDING ORDER OF THE STOCK PRICE

Portfolio	1	2	3	4
Stock price	19.15	35.81	48.70	81.22
RD	0.032	0.031	0.029	0.057
RATIO1	40.59	17.76	43.31	47.21
RATIO2	38.60	14.37	38.46	37.57
N	46	46	46	46

to be related to large retained earnings which in turn requires good performance. This good performance will also be reflected in high stock price. Then, high RATIO1 (RATIO2) and R&D intensity could be simply due to good performance of the firm.

We conduct two empirical analysis to test this hypothesis. First, we simply find out how stock price at the end of 1986 is related with RD and management stockholding variables. We form four portfolios in an ascending order of stock price at this time. Following this argument, the mean value of RD and RATIO1 (RATIO2) should have an increasing pattern. The result in Table 13 does not support this hypothesized tendency.

Next, we could test this explanation by comparing the size of abnormal stock returns. To examine the stock price performance of the sample firms, we compute the monthly abnormal stock returns during 1986 using market model. They are calculated as follows:

$$e_{it} = R_{it} - \hat{\alpha}_i - \hat{b}_i R_{mt} \quad (5)$$

where e_{it} = monthly return of firm i in month t of 1986 in excess of its return predicted by the market model

R_{it} = actual monthly return of firm i in month t of 1986

$\hat{\alpha}_i = E(R_i) - \hat{b}_i E(R_m)$

$\hat{b}_i = \text{COV}(R_i, R_m) / \text{VAR}(R_m)$

R_{mt} = monthly return on a market index in month t

The parameters $\hat{\alpha}_i$ and \hat{b}_i are estimated using monthly returns for the period of 1982-86. The value of e_{it} is considered as the measure of the abnormal returns on month t . Using this data, the average abnormal returns during 1986 is calculated for each firm. High average abnor-

TABLE 14

COMPARISON OF THE AVERAGES OF *RD* AND MANAGEMENT STOCKHOLDING VARIABLES ACROSS FOUR PORTFOLIOS, WHERE EACH PORTFOLIO CONTAINS 25% OF SAMPLE FIRMS WHICH ARE SORTED IN AN ASCENDING ORDER OF THE MONTHLY ABNORMAL STOCK RETURNS DURING 1986

Portfolio	1	2	3	4
Abnormal returns	-1.2×10^{-4}	-0.3×10^{-4}	0.6×10^{-4}	1.9×10^{-4}
<i>RD</i>	0.039	0.031	0.037	0.031
<i>RATIO1</i>	46.47	7.859	28.09	11.97
<i>RATIO2</i>	42.54	5.407	17.42	10.55
<i>N</i>	42	42	42	43

mal returns imply that the firm has done well during 1986. Table 14 shows the mean value of average abnormal returns, *RD*, and management stockholding variables for four quartile portfolios which are formed in an ascending order of average abnormal returns. In order to support this "stock performance" effect, *RD*, *RATIO1*, and *RATIO2* should be increasing as we move from portfolio 1 to portfolio 4. However, the result in Table 14 does not show the increasing pattern at all.

In sum, the data does not seem to support any of three alternative hypotheses. These results reinforce our argument that management stockholding reduces the agency problems in the R&D decision.

VI. Concluding Comments

This paper examines the relationship between management stockholding and the level of R&D expenditures of a firm. Agency theory implies that a manager is reluctant to undertake R&D projects because of the following reasons: First, he wants to reduce the risk of his human capital, which cannot be diversified away, by undertaking fewer R&D projects. Second, he wants to avoid new ventures that require additional efforts. Considering that management stockholding generally works to reduce agency problems between shareholders and managers, we can expect a certain relationship between management stockholding and R&D intensity, although the theory fails to predict a monotonous relationship between these two variables because of several competing factors.

Empirical results generally show that R&D intensity rises as the importance of management stockholding increases in the manager's

personal wealth, although we cannot exclude the possibility that R&D intensity and the portion of management stockholding in total outstanding shares of the firm may have nonlinear relationship. These empirical results are consistent with the agency theory that management stockholding reduces agency problem. We also discussed and examined three other alternative explanations to our empirical findings: "industry effect," "dividend effect," and "stock performance effect." But the data does not support these alternative hypotheses.

References

- Agrawal, A., and Mandelker, G. "Managerial Stockholdings and Corporate Expenditures." Presented at the annual meeting of American Economic Association, 1986.
- . "Managerial Incentives and Corporate Investment and Financing Decisions." *Journal of Finance* 32 (1987): 823-37.
- Alchian, A., and Demsetz, H. "Production, Information Costs, and Economic Organization." *American Economic Review* 62 (1972): 777-95.
- Amihud, Y., and Lev, B. "Risk Reduction as a Managerial Motive for Conglomerate Mergers." *The Bell Journal of Economics* 12 (1981): 605-17.
- Baumol, W. *Business Behavior. Value and Growth*, New York: McMillan, 1959.
- Benston, G. "The Self-Serving Management Hypothesis: Some Evidence." *Journal of Accounting and Economics* 7 (1985): 67-84.
- Berle, A., and Means, G. *The Modern Corporation and Private Property*, New York: MacMillan, 1932.
- Boudreaux, K. "Managerialism and Risk-Return Performance." *Southern Economic Journal* 39 (1973): 366-72.
- Corporate Data Exchange, Inc., *CDE Stock Ownership Directory: Fortune 500*. New York, 1980.
- Coughlan, A., and Schmidt, R. "Executive Compensation, Management Turnover and Firm Performance: An Empirical Investigation." *Journal of Accounting and Economics* 7 (1985): 43-66.
- Cubbin, J., and Leech, D. "The Effect of Shareholding Dispersion on the Degree of Control in British Companies: Theory and Measurement." *The Economic Journal* 93 (1983): 351-69.
- Demsetz, H., and Lehn, K. "The Structure of Corporate Ownership: Causes and Consequences." *Journal of Political Economy* 93 (1985): 1155-77.
- Fama, E. "Agency Problems and the Theory of the Firm." *Journal of Political Economy* 88 (1980): 288-307.
- Fama, E., and Jensen, M. "Separation of Ownership and Control." *Journal*

- of *Law and Economics* 26 (1983): 301-25. (a)
- _____. "Agency Problems and Residual Claims." *Journal of Law and Economics* 26 (1983): 327-49. (b)
- _____. "Organizational Forms and Investment Decisions," *Journal of Financial Economics* 14 (1985): 101-19.
- Fama, E., and Miller, M. *The Theory of Finance*. New York: Holt, Rinehart and Winston, Inc., 1972.
- Forbes*. "What the boss Makes." June 15, 1987.
- Freeman, C. *The Economics of Industrial Innovation*. 2nd ed. Cambridge: The MIT Press, 1982.
- Galai, D., and Masulis, R. "The Option Pricing Model and the Risk Factor of Stock." *Journal of Financial Economics* 3 (1976): 53-82.
- Hirshleifer, J. *Investment, Interest, and Capital*. Englewood Cliffs: Prentice Hall, 1970.
- Jarrell, G., Lehn, K., and Marr, W. "Institutional Ownership, Tender Offers, and Long Term Investments." The Office of Chief Economist, Securities and Exchange Commission, Washington D.C., 1985.
- Jensen, M., and Meckling, W. "The Theory of the Firm Management Behavior, Agency Costs and Ownership Structure." *Journal of Financial Economics* 3 (1976): 305-60.
- Kamien, M., and Schwartz, N. *Market Structure and Innovation*. New York: Cambridge University Press, 1982.
- Larner, R.J. *Management Control and the Large Corporation*. New York: Dunellen Publishing Co., 1970.
- Lewellen, W., Loderer, C., and Rosenfeld, A. "Merger Decisions and Executive Stock Ownership in Acquiring Firms." *Journal of Accounting and Economics* 7 (1985): 209-31.
- Manne, H. "Mergers and the Market for Corporate Control." *Journal of Political Economy* 73 (1965): 110-20.
- Mayers, D. "Nonmarketable Assets and Capital Market Equilibrium under Uncertainty," In M. Jensen (ed.), *Studies in the Theory of Capital Markets*. New York: Praeger, 1972.
- McEachern, W. *Managerial Control and Performance*. Massachusetts: Lexington Books, 1975.
- _____. "Corporate Control and Risk." *Economic Inquiry* 14 (1976): 270-8.
- Monsen, J., and Downs, A. "A Theory of Large Managerial Firms." *Journal of Political Economy* 73 (1965): 221-36.
- Murphy, K. "Corporate Performance and Managerial Renumeration." *Journal of Accounting and Economics* 7 (1985): 11-42.
- Schranz, M. "Maintaining Corporate Efficiency: Evidence from the Banking Industry." Unpublished Ph. D. dissertation, Washington University, St. Louis. 1988.

Shleifer, A., and Vishny, R. "Large Shareholders and Corporate Control." *Journal of Political Economy* 95 (1986): 461-88.

Stiglitz, J. "Credit Markets and the Control of Capital." *Journal of Money, Credit, and Banking* 17 (1985): 133-52.

Walking, R., and Long, M. "Agency Theory, Managerial Welfare, and Takeover Bid Resistance." *Rand Journal of Economics* 15 (1984): 54-68.