On the trade-off between the future benefits and riskiness of R&D: A bondholders' perspective[;]

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Abstract

Existing studies on the value-relevance of R&D tend to overstate the R&D benefits and shed little light on the trade-off between the R&D benefits (mean effect) and their riskiness (variance effect). This study shows that the variance effect of R&D is on average more significant than their mean effect in bond valuation. Hence, for creditors, the R&D risk dominates their benefits. Furthermore, this study documents that R&D measures alone explain approximately 80 percent of cross-sectional variations in bond ratings and risk premium. These findings contribute to the debate over R&D accounting and the bond pricing literature.

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1. Introduction

Accounting for R&D follows Statement of Financial Accounting Standards (SFAS) No. 2, which mandates that R&D outlays be expensed as incurred (the expensing rule, hereafter). Critics point to evidence that R&D expenditures, on average, generate future benefits (e.g., Hirschey and Weygandt, 1985; Cockburn and Griliches, 1988; Bublitz and Ettredge, 1989; Lev and Sougiannis, 1996); they contend that recognition of value-creating R&D investments as assets will enhance the value-relevance of financial statements (Elliott and Jacobson, 1991; Chambers et al., 1998). On the other hand, the Financial Accounting Standards Board (FASB) and proponents of the expensing rule are more concerned with the measurement error of expected R&D benefits resulting from the high degree of uncertainty in R&D outcomes; they argue that recognizing such unreliable and noisy estimates in the financial statements may mislead investors and creditors (e.g., CFO, February 1999, p. 30).

The debate about the alternative accounting treatments of R&D investments reflects trade-offs between the future benefits of RD and its riskiness.[1] In general, if the uncertainty regarding future benefits is not so high that it disqualifies the measurability criterion of asset recognition, then one may argue in favor of capitalizing R&D expenditures (as is typical for tangible investments). Conversely, if future outcomes are risky and unpredictable, the expensing treatment may be warranted.[2]

[1] Statement of Financial Accounting Concepts No. 6, *Elements of Financial Statements* (1985), defines two asset recognition criteria: a transaction is qualified for asset recognition only if (1) the transaction will generate future benefits, and (2) the future benefits can be quantified with a reasonable degree of precision. The measurability criterion is adversely affected by the uncertainty associated with the future benefits.

[2] Concern over the uncertainty of R&D benefits is used by the FASB in support of the expensing rule. (See par. 39 and 40 of SFAS No. 2.)

The extant R&D literature generally has focused on the benefits aspect of R&D by examining the relation between R&D variables and equity valuation, that is, the value-relevance of R&D.[3] Researchers have interpreted the significantly positive association between R&D constructs and stock prices/returns as evidence that R&D investments do generate net future benefits (e.g., Hirschey and Weygandt, 1985; Cockburn and Griliches, 1988; Bublitz and Ettredge, 1989; Lev and Sougiannis, 1996). This interpretation, however, is questionable because the benefits *and* the riskiness of R&D have impacts in the same direction on the equity valuation of levered firms (Merton 1973, 1974). In other words, an increase[4] in the uncertainty of future cash flows that is attributed to R&D investments will increase the stock price, even if the expected future cash flows remain unchanged. Hence, the existing *equity-based* research tends to overstate the expected future benefits of R&D.[5] Furthermore, the existing literature primarily examines R&D benefits, and, thus, sheds little light on the benefit-risk *trade-off*.

This paper contributes to the R&D literature by assessing which effect dominates, the future benefits of R&D or its riskiness, in the context of the bond market. The advantage of using the bond market setting for this assessment is that, in contrast to their same directional effects on equity value, changes in the mean and the variance of future cash flows from investments affect bond prices in opposite directions (Merton 1973, 1974). This offsetting feature of mean and variance effects on bond valuation provides a unique setting to estimate the trade-off between the

[3] A notable exception is Kothari et al. (2002). Their paper assesses the uncertainty of future earnings from R&D investments relative to that from PP&E and shows that the future benefits of R&D are indeed much riskier than those of tangible investments.

[4] "Increase" and "unexpected increase" are used interchangeably hereafter with an understanding that only *unexpected* changes in the R&D benefits and their riskiness will change equity/bond prices.

[5] According to the estimates of Sougiannis (1994), a one-dollar increase in R&D expenditures results in a two-dollar increase in earnings and a five-dollar increase in market value. To the extent that accounting earnings capture the expected future benefits of R&D, Sougiannis's finding supports the argument that *inferred* R&D benefits using equity market valuation (five dollars) are likely to be overstated with respect to the true underlying future benefits of R&D (two dollars).

benefits and risks of R&D investments. Specifically, an increase in the *mean* of future cash flows arising from the firm's investments increases the value of the firm's bonds by reducing the probability of default. On the other hand, an increase in the *variance* of future cash flows decreases the value of the firm's bonds by increasing the probability of default (see section 2 for more discussion). Relying on the implications of this theory, I examine the associations among bond risk measures and R&D investments to determine whether their mean effect (expected future benefits) or their variance effect (riskiness) is more significant in pricing bonds. In general, from the perspective of bondholders, a negative correlation between bond risk parameters and R&D investments would indicate a stronger mean effect; that is, the expected future benefits of R&D investments are more than enough to compensate for the added risk of R&D. Conversely, a positive correlation would imply a stronger variance effect that swamps the mean effect of future benefits from R&D investments.

The bondholders' perspective is important for two additional reasons. First, creditors are one of the key constituents served by financial reporting.[6] However, no research has been conducted, to my knowledge, on bondholders' assessments of R&D investments. Second, among the three primary external financing channels – the issuance of bonds, common stocks, and preferred stocks, the bond market remains the most significant external financing channel.[7] Given the significance of debt financing to the U.S. economy, the perspective of bondholders on R&D investments should be an important consideration in setting accounting standards and in disclosure regulations.

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[6] The primary objectives of financial reporting are to "provide information that is useful to present and potential investors and creditors and other users in making rational investment, credit and similar decisions." (Statement of Financial Accounting Concepts No. 1, par. 34).

[7] For example, proceeds from the issuance of bonds constitute 87.1 percent of the total three offerings in the 1938 –1941 period, and the share of bond financing continues to be above 80 percent in the 1990 – 1993 period (Anderson et al., 1994).

Based on a sample of 132 new issues of industrial bonds issued between 1991 and 1994 by firms in five R&D-intensive industries, this study documents significantly positive contemporaneous correlations between R&D investments and both bond default risk (proxied by Moody's bond ratings) and risk premium, controlling for other common bond risk determinants. This result remains unchanged when the sample is augmented by bonds issued in the late 1980s or by bonds issued for firms in non-R&D-intensive industries. In addition, the results are also robust to alternative measures of the firm's investments in R&D.

These findings suggest that, from the viewpoint of creditors, the adverse effect caused by the high volatility and uncertainty (the variance effect) of the firm's R&D activities outweighs, *on average,* the favorable impact of the firm value increments (the mean effect). That is, even when the expected mean value of the firm's R&D outlays is positive, it may not necessarily overcome the huge variance of the future cash flows. Therefore, for creditors, R&D expenditures reflect less asset-like characteristics but more risk attributes. This result contrasts with the implications of equity-based studies that suggest equity investors consider R&D investments as assets (e.g. Lev and Sougiannis 1996).

While the results are not sensitive to the choice of the alternative R&D measures, the R&D variables constructed from multi-year observations demonstrate incremental power over the naïve R&D measure – annual R&D expenditures – in explaining bond risk premium. Moreover, this study documents that the trade-offs between the benefits and risks of R&D vary across industries, implying differential impacts of R&D investments on bond risk measures.

Finally, this paper contributes to bond pricing literature in finance by examining the role of R&D variables in bond ratings and risk premium. Investment in R&D alone explains approximately 80 percent of cross-sectional variations in bond ratings and risk premium.

Inclusion of other bond risk determinants does not appear to dampen the significance of the coefficients of R&D investment. This evidence demonstrates that R&D variables, overlooked by the bond literature, play a crucial role in bond valuation. Furthermore, since the R&D constructs turn out to be correlated with some of the common bond risk determinants, inclusion of R&D variables in bond pricing models mitigates the problem of correlated omitted variables.

The remainder of the paper is organized as follows. Section 2 discusses option pricing theory and its implications for the paper's research design. Research methodology is laid out in section 3. The sample selection appears in section 4. The empirical results are presented in section 5. Section 6 contains concluding remarks.

2. Option Pricing Theory and Its Implications for Research Design

This section explains the *differential* impacts of a firm's R&D investment on its equity and debt valuation using an option pricing theory framework.[8] Then the implications of this theory for the paper's research design are discussed. Suppose that a levered firm undertakes an R&D project that is expected to result in an increase in the *mean* of its future cash flows distribution. Doing so also increases the *variance* of its expected future cash flows distribution due to increased uncertainty resulting from the risky R&D investment. Option pricing theory stipulates that a change in the mean of the future cash flows affects the value of equity and debt in the same direction. However, the change in the variance of the cash flows distribution impacts the value of equity and debt in opposite directions (Merton 1973, 1974).

Intuition for the opposite variance effects stems from the combination of two factors. First, the owners of the firm, who have a residual claim to the firm, benefit from a large payoff if the

[8] The option pricing theory which guides my research design and interpretations of the regression results is applicable not only to R&D investment but also to other investments, including relatively low-variance projects such as PP&E. For additional applications of option pricing to securities valuation, see Cox and Rubinstein (1985) and Barth et al. (1998). I thank the referee for providing the references and pointing out the need to state the general applicability of the option pricing theory.

investment pans out. However, if the project turns sour, the owners may not be responsible for the whole loss because of a limited liability provision protecting the owners. Therefore, owners have an incentive to undertake riskier projects at the expense of debt holders. Rational bondholders recognize the stockholders' incentives to engage in risk-enhancing projects after the bonds are issued. Therefore, risk premiums charged by bondholders reflect their anticipation of subsequent wealth transferring actions by stockholders. Since the agency costs of debt are borne solely by the stockholders, it would pay the stockholders to offer the bondholders covenants restricting their own future wealth-transferring ability (Jensen and Meckling, 1976; Smith and Warner, 1979).[9] Bonds are valued at prices commensurate with bondholders' anticipation of the wealth-transferring capability of R&D investments and with restrictions on such investments imposed by bond covenants.

The option pricing framework provides a theoretical foundation for R&D-related empirical research. Since both the mean and variance of future cash flows from R&D investments have impacts in the same direction on stock prices, prior research that associated R&D variables with equity metrics to make inferences about R&D future benefits overestimates the value of these benefits.

In contrast, the mean and variance effects in bond valuation operate in the opposite direction. This makes the bond market a unique setting for the investigation of a fundamental question underlying the on-going debate on R&D accounting: Is it the future benefits or the riskiness of

[9]Covenants restricting dividend distribution, financing decision, and investment policy are typically specified in terms of accounting numbers such as leverage, net worth, times interest earned and profitability ratios. Direct restrictions on the stockholders' R&D investment decisions are rarely observed in practice (as a check, I examined bond covenants for eight issuers randomly selected from my sample, and found no such covenants) for a couple of reasons: First, the task of writing and enforcing such a contract is not only difficult but also very costly (Jensen and Meckling, 1976). For example, it is very difficult for the outside bondholders to compare the riskiness of two pipeline drugs. Hence, simply limiting the amount of R&D expenditures does not offer effective restrictions on the riskiness of projects that the firm can undertake. Second, a covenant can be written in a way to serve a similar function by linking the firm's financing and investment policy to observable accounting numbers, making it easier and less expensive to enforce (Smith and Warner, 1979).

R&D that dominates in bond pricing? This question is examined operationally by regressing bond risk proxies on R&D measures, after controlling for other determinants of bond risk. Generally, a significantly positive association between the R&D measures and the bond risk proxies would imply that, from the bondholders' point of view, R&D risks dominate R&D expected future benefits, whereas a significantly negative association would indicate that the favorable impact of the firm value increments from its R&D projects outweighs the adverse effect of R&D uncertainty.

3. Research Methodology

To investigate how the expected future benefits and riskiness of R&D investments are priced in bond valuation, the following system of two linear equations is examined:

$$\text{Bond Rating}_{i,\,t+1} = f\,(\text{R\&D Measures}_{i,t},\ \text{Other Bond Risk Determinant Set 1}_{i,t}) \qquad (1)$$

$$\text{Risk Premium}_{i,\,t+1} = f\,(\text{R\&D Measures}_{i,t},\ \text{Other Bond Risk Determinant Set 2}_{i,t}) \qquad (2)$$

where subscript i denotes bond issue, and subscripts $t+1$ and t indicate that dependent variables take values which are one year ahead of those of independent accounting variables. This is because bond premium and ratings are affected more by past accounting information than by current accounting information (Ederington and Yawitz 1986).

The R&D coefficients in the equations above reflect the bondholders' assessment of the *relative* mean and variance effects of R&D investment on bond risk measures – bond rating and risk premium. The firm's R&D investments cause changes in the mean and variance of its future cash flows. In turn, the mean and variance effects affect the probability of bond default in *opposite* directions. Since bondholders rationally incorporate the mean and variance effects in bond pricing, one should expect bond rating and risk premium to vary cross-sectionally as a function of these effects. Further, prior research shows that R&D investments are, on average, positively associated with the risks and benefits of R&D (e.g., Sougiannis 1994; Chan et al. 2001). That is, R&D investments vary cross-sectionally with, and hence reflect, the mean and variance effects of R&D. Therefore, the sign of the R&D coefficients estimated from the regressions (1) and (2) indicates the *net* off-setting impact of the riskiness and benefits of R&D on bond valuation.

Although bond rating and risk premium are two highly correlated bond risk measures, I choose to use both variables as dependent variables for two reasons. First, the use of two equations allows a clearer understanding of the role of R&D investment in determining the risk premium. Theoretically, the extent of R&D investment should affect the default risk and, through it, the risk premium. The two-equation model reflects this notion. The first regression (in which the bond rating is the dependent variable) is needed because it establishes that R&D investment affects default risk (as captured by bond rating). It further indicates the importance of R&D investment and other accounting measures as determinants of default risk. These measures are then used collectively to represent default risk (bond rating) in the premium regression. The second reason for presenting two regressions, despite the high correlation between bond rating and risk premium, is that both variables are of considerable interest to academic researchers and practitioners. This interest apparently accounts for the use of both variables in many bond studies (e.g., Ziebart and Reiter, 1992; Sengupta, 1998).

The disturbance terms in equations (1) and (2) are likely to contain common unspecified factors. For example, macroeconomic shocks, such as a change in a government monetary policy, affect both default risk and risk premium. Estimating the above two equations simultaneously accommodates the possibility that the error terms of the two equations are contemporaneously correlated and improves the efficiency of parameter estimates. The results from Lagrange multiplier tests, discussed in section 5, indeed show a significant correlation between the error terms of the two equations. Therefore, to improve estimation efficiency, the analyses are carried out using the seemingly unrelated regressions (SUR) model in place of OLS.

3.1. Dependent Variables

The dependent variable in equation 1, bond rating (RATING), is measured by integer values 1 through 5 representing Moody's ratings of Aaa, Aa, A, Baa, and Ba and below, respectively. Following the classic bond paper by Fisher (1959) and recent studies such as Reiter (1991), I gauge the risk premium (PREM, measured in basis points) as the difference between the yield to maturity on industrial bond and the daily average of the constant maturity yields on U.S. Treasury bonds of comparable maturity on the issuance date. If an industrial bond cannot be matched with a Treasury bond with the exact same maturity, a benchmark Treasury bond yield is constructed by linearly interpolating the yields of two adjacent Treasury bonds with maturity closest to the corporate bond maturity.

3.2. R&D Constructs

The variable of interest in this study is the firm's R&D investments. Four different R&D proxies are employed: annual R&D expenditures (RD1), the summation of past five-year R&D expenditures (RD2), the R&D asset estimate based on capitalization of R&D and a five-year straight-line amortization (RD3), and the R&D asset estimate based on capitalization of R&D and industry-specific amortization schedules (RD4). The industry-specific amortization schedules are those developed by Lev and Sougiannis (1996) who use the same industries as those in this study.[10] To control for size, all RD variables are scaled by year-end market value of equity.

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[10] The specific amortization period for RD4 ranges from five years in the Scientific Instruments industry to nine years in the Chemical and Pharmaceutics industry, with varying rates of annual amortization. For example, the estimated R&D asset of a firm belonging to the Scientific Instruments industry is amortized over five years (the

3.3. Other Bond Risk Determinants

The selection of control variables is based on the literature on bond premium and ratings (e.g., Fisher, 1959; Ziebart and Reiter, 1992; Sengupta, 1998). The determinants of bond premium typically include (1) default risk variables proxied by accounting information, (2) issue characteristics of maturity, call provision, convertibility and subordination status, and (3) macroeconomic conditions such as the effect of the business cycle. Specifically, the control variables used for the risk premium equation and the hypothesized sign of their respective coefficients are presented below:

Default risk:

DE = Ratio of long term debt to book value of equity. The higher this ratio, the higher the default risk and bond premium.

PROFIT = Net income to net sales. Profitability is expected to be negatively correlated with default risk.

TIMES = Income before interest expense divided by interest expense. Times interest earned ratio is expected to be inversely associated with default risk and bond premium.

LOGASSET = Log of total assets. Firm size proxies for default risk and bond marketability. Larger firms are expected to have lower default risk and hence lower risk premium.

Issue Characteristics:

LOGMAT = Log of years to maturity. The longer years to maturity, the higher interest rate risk exposure. Hence, this variable is expected to be positively correlated with risk premium.

LOGSIZE = Log of issue size. This variable may be viewed as a measure of marketability, and is expected to be inversely correlated with risk premium. On the other hand, the larger a bond issue size, the higher the debt burden, hence, the higher the probability of default. Therefore, the impact of issue size is ambiguous.

CALL = Years to first call over years to maturity. Call provision exposes bondholders to interest risk. Lower call ratio implies a higher level of call protection to the issuer and

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expected useful life of the R&D benefits) at a varying annual rate of 14%, 21%, 24%, 24%, and 17% from year 1 to year 5, respectively. (See section 3 of Lev and Sougiannis, 1996 for further details.)

hence higher interest risk exposure to bondholders. This variable is expected to be negatively associated with risk premium.

CONV = 1 for convertible bonds and 0 otherwise. Other things equal, convertible bonds result in lower risk premium. This variable is expected to be negatively correlated with risk premium.

SUBO = 1 for subordinated bonds and 0 otherwise. Subordination status is expected to be associated with higher bond premium.[11] This variable is expected to be positively associated with risk premium.

Macroeconomic Conditions:

ECYC = Average yield on Moody's Aaa bonds for the month of issue less average yield on 30-year U.S. Treasury bonds for the month of issue. This variable is intended to control for the time-series variation of risk premiums over the economic cycle. This variable is expected to have a positive association with bond premium.

Regarding control variables for the bond rating equation, the same set of four accounting variables used in the risk premium equation to gauge the probability of default risk is included. Prior studies also find bond maturity, issue size and subordination status important in explaining ratings (e.g., Ziebart and Reiter, 1992; Sengupta, 1998). LOGASSET is replaced with log of year-end market value of equity (LOGMVE) as a firm size measure in the rating equation. This manipulation is intended to ensure that the regressors in RATING equation are not a subset of those in PREM equation, taking full advantage of the efficiency gain of the seemingly unrelated regressions model (Conniffe, 1982). In addition, since the sample bonds were issued from 1991 to 1994, year specific indicators are introduced in both RATING and PREM equations to account for the time-series effects.

3.4. Regression Models

The primary version of the two models used in the analysis is:

$$RATING_{i,t+1} = \sum_{t=90}^{93} a_{0t} YR_{it} + a_1 RD(k)_{it} + a_2 DE_{it} + a_3 PROFIT_{it} + a_4 TIMES_{it} + a_5 LOGMVE_{it}$$

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[11] This variable is dropped from PREM (risk premium) equations because it happens to be highly correlated with CONV for my sample. The Pearson correlation coefficient between the two variables is 0.962.

$$+a_6 LOGSIZE_{i,t+1} + a_7 LOGMAT_{i,t+1} + a_8 SUBO_{i,t+1} + e_{it} \quad (3)$$

$$PREM_{i,t+1} = \sum_{t=90}^{93} b_{0t} YR_{it} + b_1 RD(k)_{it} + b_2 DE_{it} + b_3 PROFIT_{it} + b_4 TIMES_{it} + b_5 LOGASS_{it}$$
$$+ b_6 LOGSIZE_{i,t+1} + b_7 LOGMAT_{i,t+1} + b_8 CALL_{i,t+1} + b_9 CONV_{i,t+1} + b_{10} ECYC_{I,T=1} + e_{it} \quad (4)$$

where RD(k), k=1, 2, 3, and 4, denotes four different R&D constructs.

One common reservation about using linear probability models in bond rating studies has to do with the fact that the approach assumes that the average quality difference between any two adjacent ratings, such as Aa and A, is the same as that between any other two adjacent ratings, such as Baa and Ba. Several studies compare the performance of the linear probability model and the probit model (e.g., Kaplan and Urwitz 1979; and Noreen 1988). Their results show that the conceptually superior probit model performs no better than the simplistic linear probability model in terms of rating prediction. Furthermore, an important problem with applying the ordered probit model is ambiguity in interpreting the coefficient signs, because the directional marginal effects of changes in regressors are not always the same as the coefficient signs (Greene 1993). Hence, after comparing the pros and cons of alternative models in relationship to the nature of this study, I choose to use the linear probability model. Model specification tests reported in section 5 support the choice of the linear probability model.

3.4.1. Assessing Incremental Explanatory Power of Multi-year R&D Constructs

As explained in section 3.1, four R&D constructs are used as independent variables. Recall that RD1 is the annual R&D expenditures, while the other three measures, RD2, RD3 and RD4, are formed from multi-year observations. R&D expenditures presumably generate value-creating economic assets whose benefits are long-lived, rather than limited to one year as implied by the single-year R&D measure. For example, the average R&D payoff periods for my sample range from five years in the Scientific Instruments industry to nine years in the Chemical and

Pharmaceutics industry (based on the estimates of Lev and Sougiannis, 1996). The multi-year R&D variables recognize and reflect this long-lived nature of R&D investment, resulting in the greater precision of these variables over the single-year (naïve) measure as the estimates of the economic asset arising from the firm's R&D investment. Hence, I hypothesize that these multi-year variables are *potentially* more informative than the single-year R&D construct in explaining bond risk measures.

Since these R&D variables are highly correlated, their joint appearance as regressors creates a severe multicollinearity problem. To circumvent this problem, a two-stage estimation is employed. In the first stage, the following auxiliary regression is estimated. Specifically, each of the three multi-year constructs is regressed on RD1 using an OLS estimation:

$$RD(k)_{i,t} = a(k) + b(k)RD1_{i,t} + m(k)_{i,t} \quad (5)$$

where k = 2, 3, and 4. Hence, the corresponding error terms are orthogonal to RD1 and capture potential excess information of RD (k) over RD1. In the second stage, the fitted value of the error terms, *m*(k), is added to the following regressions:

$$RATING_{i,t+1} = \sum_{t=90}^{93} a_{0t}YR_{it} + a_1RD1_{it} + a_{2,k}m(k)_{it} + a_3DE_{it} + a_4PROFIT_{it} + a_5TIMES_{it} + a_6LOGMVE_{it} + a_7LOGSIZE_{i,t+1} + a_8LOGMAT_{i,t+1} + a_9SUBO_{i,t+1} + e_{it} \quad (6)$$

$$PREM_{i,t+1} = \sum_{t=90}^{93} b_{0t}YR_{it} + b_1RD1_{it} + b_{2,k}m(k)_{it} + b_3DE_{it} + b_4PROFIT_{it} + b_5TIMES_{it} + b_6LOGASS_{it} + b_7LOGSIZE_{i,t+1} + b_8LOGMAT_{i,t+1} + b_9CALL_{i,t+1} + b_{10}CONV_{i,t+1} + b_{11}ECYC_{I,T=1} + e_{it} \quad (7)$$

The coefficients of *m*(k) gauge the incremental explanatory power of the individual multi-year constructs over RD1.

3.4.2. Discriminative Feature of Lev and Sougiannis (LS) Measure

Among the alternative R&D constructs, the LS measure (RD4) is the only one that reflects the variations in the economic useful life spans of R&D across industries. This distinctive characteristic of the LS measure enables discrimination between firms from different industries and allows researchers to assess the differential impacts of the firms' R&D activities on the bond risk parameters. The sample is partitioned into two sub-groups based on the useful life spans (long and short) of R&D. The industry-specific R&D useful lives are determined by the amortization schedules in the sense that the quicker the amortization rate, the shorter the R&D life. Specifically, I sum up the three most recent amortization rates of each industry, and then use the median of the summations as a cutoff to form the two below and above the median sub-samples. I hypothesize that the smaller the summations of the annual amortization rates, the longer the useful life of R&D, the longer it takes to derive R&D benefits, hence the more risky the future benefits of R&D.[12] The resulting sample of long useful life spans consists of 65 bonds with SIC codes of 28 and 37 (Chemicals and Pharmaceutics, and Transportation Vehicles). The remaining 67 bonds with SIC codes of 35, 36 and 38 (Machinery and Computer Hardware, Electrical and Electronics, and Scientific Instruments) form the sample of short useful life spans. To test the differential impacts across the two sub-samples, a categorical variable (CV) is added to the regression equations (3) and (4). CV is set equal to one for the sample of long useful life spans and zero otherwise. The categorical variable is also allowed to interact with the RD4 variable. A significantly positive coefficient on the slope interaction term (CV*RD4) would suggest that the risk and uncertainty of R&D is higher for R&D investments with longer useful life spans, indicating the LS measure does have discriminative power.

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[12] For example, R&D projects which take longer to derive their benefits are more likely to expose the investing firm to competition from new technological advancements or the introduction of a better competing product. Further, this argument implicitly assumes an equal expected rate of return on investment across firms. This is a plausible assumption because economic theory suggests that, in a competitive economy, resources are allocated such that investment projects earn the same competitive rate of return in equilibrium.

4. Sample Selection

This study examines five R&D-intensive industries with two-digit SIC codes of 28, 35, 36, 37 and 38 as used in the LS paper. The initial sample consists of 3,946 firm years available on the Compustat files, dating from 1990 to 1993 with the desired SIC codes and accounting information required to estimate firm-specific R&D variables and to construct the control variables specified in the previous section. Then, each firm in year t is checked against new industrial bond issues of year t+1 as published in Moody's Bond Survey. If a firm had multiple issues in a given year, only the first issue of that year is included. The matching process yields 134 new bonds. Two issues are dropped due to lack of year-end price information. The final sample comprises 132 new bonds issued by 81 firms from 1991 to 1994.[13]

Limiting the sample to new bond issues reduces the sample size. However, a sample of new bond issues has advantages over seasoned bonds: information on bond yields and ratings is up-to-date, and common problems associated with use of seasoned bonds, such as infrequent trading, lack of bond price/yield data, and lags in rating revisions, are avoided.

Offering yields and bond ratings on the issuance date are collected from Moody's Bond Survey. Information on the constant maturity yield on U.S. Treasury bonds is retrieved from the Federal Reserve Board of Governors' Statistical Release.

5. Empirical Results

5.1. Descriptive Statistics

Panel A of Table 1 provides the industry composition of bond issues and industry means of some key variables: bond premium, bond ratings and four R&D constructs. The number of bonds included in each industry varies from 15 for Scientific Instruments to 48 for Chemicals and

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[13] The sample is smaller than those used by typical equity-based studies, but it is comparable in size to the samples used in recent bond papers. For instance, Sengupta (1998) contains 114 new bond issues from 1987 to 1991.

Pharmaceutics. Except for Transportation Vehicles, the R&D measures of the other four industries have comparable values. For example, the LS measure (RD4), normalized by year-end market value of equity, fluctuates around 20 percent, while the Transportation Vehicles industry has an average value of RD4 up to 52 percent of the market value of equity. A similar pattern is also observed for average risk premiums: Transportation Vehicles show the highest risk premiums of 127.71 basis points, yet the other industries vary within a relatively narrow range from 58.5 to 80.6. There are few variations in average bond rating across industries. Since the five industries have different R&D investment strategies, the risks and uncertainties associated with the R&D projects vary among the industries. One would therefore expect that the cross-sectional relationships among the bond risk measures and the R&D variables to be different. Later analysis in section 5 shows that indeed there are differential associations across the industries.

[Table 1]

As shown in Panel B of Table 1, each sample year (1991 to 1994) had approximately 40 issues except for 1994, which had only 13 issues. A sharp decline in bond issues in 1994 was likely attributable to an increase in expected borrowing costs because long-term interest rates increased as the U.S. economy started to recover from the recession of the early 90s.

Both risk premium and ratings generally follow a steadily increasing pattern over time, while the R&D variables are quite stable over time. Year dummies are built into the models to control for time-series effects.

[Table 2]

Descriptive statistics for selected variables are given in table 2. There is substantial cross-sectional variability of risk premium and bond ratings around the medians of these variables of

78.3 basis points and A rating, respectively. The four R&D constructs also have considerable variation. For instance, RD4 ranges from the 25% quartile of 9 percent to the 75% quartile of 26 percent. Sufficient cross-sectional variations in the R&D measures are critical to detect the impact of the variables and to increase the power of my analysis. Size measures indicate that the sample consists of large firms with median reported total assets and the market value of equity of 6.1 billion and 4.4 billion, respectively. The relatively large size of the sample firms is likely due to the fact that reliance on public debt is more pronounced among large firms.[14]

5.2. Association of Bond Risk Measures with R&D Constructs

To allow for the possibility that the error terms in RATING and PREM equations may contain the same unspecified factors, both equations are estimated jointly using the seemingly unrelated regressions (SUR) model. To check the correlation between the error terms of RATING and PREM equations, Lagrange multiplier tests are employed. The Lagrange multiplier statistics for the models, distributed as chi-squared with one degree of freedom, are all significant at the conventional level, suggesting that the SUR improves estimation efficiency relative to OLS.

While SUR analysis allows error terms of the two equations to be contemporaneously correlated, each equation still has to satisfy classical OLS assumptions. Since a panel data set is employed in this study, a typical violation of the OLS model is heterogeneity across observations. The White (1980) tests conducted for each equation reveal no significant heteroscedasticity and suggest that the linear specification for both models is reasonable (see

[14] Firms from the same five R&D-intensive industries that did not issue bonds in the sample period 1991 to 1994 have median total assets and market value of equity equal to $37.2 million and $41.6 million respectively, much smaller than those for the firms that issued bonds. Moreover, the non-bond issuers are also less profitable than the bond issuers, as indicated in profitability (net income over sales) of two percent for the non-bond issuers as opposed to four percent for the issuers.

White 1980, p. 823), hence justifying the use of linear probability model in place of nonlinear ordered probit model for RATING equations.

Table 3 summarizes the SUR results for the association of annual R&D expenditures (RD1) with bond ratings and premiums for the cases of no control variables, partial controls and full controls. The purpose of reporting comparative results is to highlight the importance of the variable of interest (RD1), which is absent from the extant bond literature, in explaining bond risk parameters. As shown by the table, RD1 alone, without any other bond risk determinants as regressors, can explain approximately 80 percent of cross-sectional variations of bond ratings and bond risk premium. Adding risk determinants that are used by previous research to explain default risk or bond ratings does not diminish the significance of the R&D variable. In fact, the coefficients on RD1 become more significant for both RATING and PREM equations. In other words, RD1 does not appear to substitute for the traditional explanatory variables. The significant F statistic provides corroborative evidence that RD1 does have incremental explanatory power over the commonly documented bond risk determinants.

[Table 3]

Controlling for all other bond determinants, the SUR estimation yields the coefficientsof 2.31 (p-value=0.005) and 284.95 (p-value=0.01) for the variable RD1 in the RATINGand PREM equations, respectively. To make some economic sense of these coefficients on RD1, consider the PREM equation with full controls. Recall from Table 2 that the mean of bond issue size is $233 million and that the mean and standard deviation of RD1 are 0.08 and 0.07, respectively. This implies that a sample firm with an average level of R&D intensity pays a risk premium of 22.8 (284.95*0.08) basis points. Further, a change of one standard deviation in R&D intensity is associated with a change in bond premium of 20 (284.94*0.07) basis points. For a firm with an average bond size of $233 million, an increase in risk premium by 20 basis points would result in approximately half a million dollars of additional interest expense per annum.

The significantly positive coefficients of RD1 imply that the adverse effect of R&D risks on the probability of bond default more than offsets the favorable impact of R&D benefits. Hence, creditors appear to regard R&D investments less as assets but more as risk proxies. Moreover, firm size measures (LOGMVE and LOGASSET) are significantly negatively correlated with RATING and PREM, which is consistent with larger firms typically having lower default risk and paying lower risk premiums. The negative coefficient of LOGASSET (total reported assets primarily consisting of *tangible* assets) also suggests that, in contrast to R&D investments, future benefits from tangible investments dominate their variance effect.[15] The coefficients of the other three accounting variables proxying for default risk, DE, PROFIT, and TIMES, have the expected signs. However, only debt-to-equity (DE) in PREM equation is significant. In general, the other control coefficients have the expected directional effects. The system weighted R^2 is 0.95, comparable to those documented in prior bond studies, such as Ziebart and Reiter (1992).[16]

R&D measures are often used as proxies for investment opportunity set (IOS). IOS affects firm leverage. As a result, the main finding of this paper – the stronger risk effect of R&D – may

[15] Note that LOGASSET represents both a size effect and a tangible-assets effect. To better assess the impact of tangible assets on bond default risk, I use the ratio of the sum of cash, inventory, and net PP&E to total assets, all measured at year-end balances. This variable gauges how much percentage of a firm's assets come from tangible components. Analysis adding this new construct indicates that the coefficients on this new tangible variable have values of –1.08 (p-value=0.03) and –71.15 (p-value=0.31) for RATING and PREM equations, respectively. When I use only cash, the "hardest" component of tangible assets, in the numerator of this new construct, the coefficients become significant at levels less than five percent for both RATING and PREM equations.

[16] As a comparison, RATING and PREM equations are separately estimated using OLS. The results are qualitatively similar. However, concurring with the notion that SUR improves estimation efficiency when the errors terms of the two equations are correlated, some of the coefficients from the SUR estimation have higher significance levels. For instance, as to PREM equation, the OLS coefficients on RD1 and LOGASSET are 257 (p-value of 0.03) and -12.8 (p-value of 0.07) as opposed to 285 (0.01) and –15.8 (0.03) from the SUR estimation. Moreover, the OLS adjusted R^2s for PREM and RATING equations are 0.60 and 0.97 respectively. These numbers are in line with those reported in other bond studies (e.g., Fung and Rudd, 1986; Ziebart and Reiter, 1992; Sengupta, 1998).

reflect the fact that firms with more growth options are viewed as more risky by bond investors. To check the validity of the main finding, I re-run the regressions (3) and (4) by including an IOS proxy. Two alternative IOS proxies, the price-to-earnings ratio and market-to-book ratio, are used. The R&D coefficients remain significantly positive with magnitudes comparable to those R&D coefficients estimated without the additional IOS proxies. The result alleviates the concern that the net risk effect of R&D is potentially attributable to the higher perceived risk of growth options.

Regressions using three multi-year R&D constructs instead of annual R&D expenditures yield similar results (not tabulated), indicating that the findings are not sensitive to the choice of R&D estimates. This is not surprising given that pair-wise correlation coefficients between the four R&D constructs are greater than 0.95 with a significance level of 0.0001.

[Table 4]

Prior research shows that investors appear to adjust reported accounting numbers to reflect an R&D asset in equity valuation (e.g., Lev and Sougiannis, 1996; Chambers et al., 1998). To incorporate the possibility that investors make a similar adjustment in pricing bonds, I rerun regressions (3) and (4) with adjusted accounting numbers. The adjustments are made by first computing as-if earnings and R&D assets assuming that R&D were capitalized. Then the four accounting variables (DE, PROFIT, TIMES, and LOGASSET) are adjusted for the as-if earnings and R&D assets. Table 4 reports the results of SUR estimation when the four accounting variables are constructed assuming that the bond market capitalized R&D using the LS amortization schedules. The magnitude and significance levels of RD4 are similar to those obtained when the unadjusted accounting variables are used. Therefore, the results are robust with respect to alternative accounting treatments of R&D expenditures.

5.2.1. Correlated Omitted Variables

The decision to issue bonds and undertake R&D projects is endogenous and may be impacted by some factors that are not fully controlled by the bond risk determinants in the bond valuation model of equations (3) and (4). If this were the case, the R&D variable would be correlated with the error terms. The regression equations (3) and (4) would yield inconsistent and biased estimates of the R&D coefficients. To gauge the effects of *potentially* correlated omitted variables, the instrumental variable method is employed. (For expositional brevity, only the results using RD4 are reported.) Following LS (1996), I select as the instrumental variable for each firm-specific RD4 the industry RD4, computed for each firm year as the average RD4 of all *other* firms in the firm's 2-digit SIC industry. Industry average R&D investments are likely to be unaffected by firm idiosyncratic shocks (e.g., a corporate governance overhaul), thus reducing their correlation with the residual terms of equations (3) and (4). At the same time, this instrumental variable is highly correlated with the firm-level R&D (for a detailed discussion on suitability of the industry average R&D as an instrumental variable, see LS, 1996, p. 113-114). To apply the instrumental variable method, I first regress each firm's RD4 against its 2-digit industry average, IND_RD4, yielding the following results:

$$RD4_{i,t} = 0.061 + 0.673 * IND\_RD4_{i,t} \qquad (8)$$

The above regression has 132 observations and produces an adjusted R^2 equal to 0.26. Both the slope coefficient and the adjusted R^2 are comparable to those reported in the LS paper. The slope coefficient is significant at the level of less than one percent, indicating that the instrumental variable is indeed highly correlated with RD4.

Based on the estimates from (8), I calculate the fitted value of RD4, FITTED_RD4, which is then substituted for RD4 in the SUR equations (3) and (4). The regression results are tabulated in Table 5.

[Table 5]

As indicated in Table 5, the coefficients of FITTED_RD4 remain significantly positive, taking values of 0.99 (p_value = 0.04) and 243.19 (p_value = 0.002) for RATING and PREM equations, respectively, with a system weighted R^2 equal to 0.95. Overall, the use of the instrumental variable generates results qualitatively similar to those obtained from the SUR estimations of equations (3) and (4). Therefore, the findings alleviate the concern that the SUR models suffer from the problem of correlated omitted variables.[17]

5.2.2. Generalizability of the Results

Finance theories suggest that R&D-intensive firms generally do not use debt financing as often as low-R&D or non-R&D industries (Jensen and Meckling, 1976; Harris and Raviv, 1991).[18] This raises the question of whether the findings based on the sample of R&D-intensive firms that issue bonds are generalizable to bond issuers in other industries.

To address this question, I expand the number of industries examined. Specifically, I add new bonds issued from 1991 to 1994 by all other industries, excluding financial institutions, regulated utilities, and public administration. This results in a supplementary sample of 447 bonds

[17] This is further corroborated by the Hausman test, which fails to reject the null hypothesis that RD4 is contemporaneously *uncorrelated* with the residual terms of equations (3) and (4).

[18] There are other considerations that give R&D firms an incentive to favor debt to equity. Myers and Majluf (1984) show that the use of equity to finance new projects results in underinvestment due to information asymmetries between firm insiders and prospective investors. The underinvestment issue can be mitigated if the firm finances their new projects with internal funds and/or debt (a "pecking order" theory of financing). The theory suggests that, to the extent that R&D-intensive firms are more subject to information asymmetries, those firms have an incentive to issue debt. This is especially true of large firms that can rely on their established credit reputations to off-set the general perception of high operating risk associated with the R&D investments (Diamond 1989). Firms will find debt a preferable financing option over equity if the marginal costs of debt are lower than the marginal costs of equity, which is likely for some large R&D-intensive bond issuers.

(limiting one issue per firm-year and requiring availability of other bond information and accounting variables), of which 136 issues belong to low-R&D firms and 311 issues belong to non-R&D firms. Descriptive analysis of the firm characteristics (not tabulated) indicates that, in comparison to the other bond issuers, the original 132 high-R&D bond issuers have, on average, lower debt-to-equity ratios, higher total assets and higher market values of equity, yet similar profit margins. These characteristics of R&D-intensive bond issuers, while consistent with the implications of the finance theories that high-R&D firms are less likely to issue debt (Jensen and Meckling, 1976), suggest that the issuance of bonds remains a viable financing option for large high-R&D firms since they can rely on their established credit records to gain access to the bond markets without paying excessive risk premiums (Diamond, 1989).

To test whether the results derived from firms that belong to the R&D-intensive industries can be generalized to other industries, the SUR estimations of equations (3) and (4) are re-run using the original sample augmented with the 136 low-R&D bonds and with the whole supplementary sample of 447 new bond issues, respectively. To capture differential bond pricing implications of various risk determinants between high- and low-R&D firms, a dummy variable is created to interact with the four firm attribute variables – DE, PROFIT, TIMES and LOGASSET. The dummy variable is set equal to one if the firm belongs to a high-R&D industry and 0 otherwise. This procedure generates four additional regressors in equations (3) and (4). The SUR analyses based on the expanded samples yield significantly positive R&D coefficients, indicating that the findings for the five R&D-intensive industries can be generalized to the other industries.

Another issue regarding the generalizability of the conclusions is that the sample period of 1991 to 1994 coincides with a recession. A potential concern is whether the results are influenced by that economic downturn. For example, a gloomy economy may exacerbate investors' pessimistic sentiment. As a result, investors may tend to overestimate (underestimate) the risks (future benefits) of R&D investments. To alleviate the concern that the results of this study are influenced by the uniqueness of the sample period, I have enlarged the original sample by adding bonds issued by the five R&D industries from 1988 to 1990. This procedure generates additional 63 new bond issues. Regression analysis using the expanded sample still yields significantly positive coefficients for RD1, which are equal to 212.31 (p-value = 0.01) and 1.73 (p-value = 0.01) for PREM and RATING equations, respectively. Hence, the conclusions do not appear to be driven by the overlap between the sample period and the economic recession.

In summary, the analyses of this section indicate that the results using the primary sample of 132 bonds issued by the five R&D-intensive industries during the period of 1991 to 1994 can be generalized to bond issuers in other industries and to other years.

5.3. Incremental Explanatory Power of Multi-Year R&D Constructs

Table 6 presents results investigating the incremental effects of multi-year constructs over annual R&D expenditures (RD1) based on the initial sample of 132 issues. Recall that the three residual variables (RESIDUAL2, RESIDUAL3, and RESIDUAL4) are the fitted values of error terms from the auxiliary regressions of individual multi-year R&D constructs on RD1 [equation (5)], gauging the incremental explanatory power over RD1. The coefficients of the residual variables are all positive but are significant only for PREM equations. That may be because RATING is a scale variable, while PREM is a continuous variable providing a much finer measure of bond default risk than RATING. Given that all four R&D variables are highly correlated, only the finer measure PREM can detect the incremental information captured by the multi-year R&D constructs over the annual R&D variable. Overall, the finding suggests that the multi-year R&D measures are more informative in explaining bond risk premium.

[Table 6]

5.4. Discriminative Feature of the LS Measure

The differential associations of the LS measure with bond ratings and premium across the samples of long versus short useful life spans are given in Table 7. Recall that regression equations (3) and (4) are estimated with additions of a categorical variable CV and an interaction variable (RD4*CV). The categorical variable CV takes on a value of 1 for a long-useful-life sample and 0 otherwise. Hence, the slope interaction term (RD4*CV) measures the incremental association of the long-useful-life sample over the short-useful-life sample between RD4 and the bond parameters. As reported in Table 7, the coefficients of RD4 for RATING and PREM equations are not significant; however, the coefficients of the slope interaction term for RATING and PREM equations are significantly positive. This is consistent with the argument that, from creditors' point of view, the longer the useful life span of R&D, the higher level of excess risk of R&D over its future benefits. The evidence also shows that the amortization schedules derived by LS are useful in discriminating among the varying degrees of trade-off between the risk and future benefits of R&D.

[Table 7]

5.5. Other Econometric Considerations

Following Belsey et al. (1980), the sensitivity of the results to the influences of multicollinearity and outliers is assessed. Condition indices reveal that the data may suffer from a multicollinearity problem. However, the regression conclusions are not changed qualitatively after deleting collinear variables. To test the presence of influential observations, the DFFITS statistic was used. The application of a size-adjusted cutoff, suggested by Belsley et al. (1980), identifies approximately five percent of the sample as potential outliers. Nonetheless, the findings reported in earlier sections are similar to those obtained when the regressions are reestimated by excluding these outliers, as well as by employing weighted least squares regressions.

6. Conclusions

The debate surrounding the accounting for R&D expenditures evolves around the trade-off between the expected benefits of the expenditures – which might qualify them as an asset, and the uncertainty surrounding these benefits – which precludes them from being recorded as assets. This study contributes to the debate on R&D accounting by assessing this benefit-risk trade-off from the perspective of bondholders. The results indicate that R&D investments are significantly positively associated with bond default risk and bond risk premium, controlling for other bond risk determinants. This evidence suggests that, from the perspective of bondholders, the risks and uncertainties of R&D appear to dominate its expected future benefits. Hence, creditors view R&D investments as less asset-like in nature and see them more as useful measures of risk.

Furthermore, this study contributes to the bond pricing literature by showing the significant incremental explanatory power of R&D constructs over common bond risk determinants for bond valuation. Given the increasing importance of R&D investments, the finding in this study highlights the necessity of including R&D variables, heretofore unacknowledged in existing bond research, as one of the key bond risk determinants.

Several caveats are in order. First, the finding that, for bondholders, the uncertainty effect of R&D investments dominates their expected benefits effect does not imply that R&D investments, on average, generate negative net present value. This study does not address the question of whether R&D investments, on average, increase the *total* value of the firm (the sum of the debt and equity).[19] Second, the larger impact of R&D risk on bond valuation derives in

[19] Taking the bondholders' perspective has the potential to address the question. If it turns out that the bond market reacts positively to R&D investments, then, this evidence, combined with the positive reaction of the equity market,

part from the perception that R&D intangibles generally have negligible liquidation values and thus have less collateral value than tangible assets. Third, a larger portion of R&D firms do not issue bonds, hence they are not included in the sample; the results of this study hold only for the sample of the R&D bond issuers. Creditors' assessment on the risk-benefit trade-off for the R&D firms that do not use public bond financing awaits future research. Therefore, although the findings of this study add a new dimension to the debate over R&D accounting from the perspective of an important class of stakeholders – bondholders, the evidence itself is not sufficient to buttress the FASB's expensing R&D rule.

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would unambiguously imply that R&D investments must, on average, generate positive expected net present values, resulting in an increase in the total value of the firm (equity plus debt). Hence, R&D is a value-creating economic asset.

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Table 1

Panel A: Sample Composition and Averages of Some Key Variables by Industry

Industry	Number of Bond Issues	PREM	RATING	RD1	RD2	RD3	RD4
Chemicals and Phamaceutics (28)	48	58.49	2.60	0.05	0.21	0.09	0.14
Machinery and Computer Hardware (35)	30	68.80	3.80	0.07	0.31	0.13	0.18
Electrical and Electronics (36)	22	58.95	3.27	0.09	0.44	0.18	0.25
Transportation Vehicles (37)	17	127.71	3.29	0.17	0.77	0.32	0.52
Scientific Instruments (38)	15	80.57	3.53	0.08	0.32	0.14	0.15

Panel B: Sample Composition and Averages of Some Key Variables by Sample Year

Year	Number of Bond Issues	PREM	RATING	RD1	RD2	RD3	RD4
90	41	59.33	2.95	0.08	0.33	0.14	0.21
91	38	70.07	3.13	0.08	0.38	0.15	0.23
92	40	87.95	3.23	0.08	0.35	0.15	0.21
93	13	80.31	3.92	0.08	0.41	0.17	0.24

Sample consists of 132 bonds issued from 1990 to 1993 by five R&D-intensive industries with two-digit SIC codes of 28, 35, 36, 37 and 38.

PREM = Bond yield to maturity minus yield on U.S. Treasury bond of comparable maturity on the issuance date (measured in basis points).
RATING = Moody's bond ratings, with integer values 1 through 5 representing the ratings of Aaa, Aa, A, Baa, and Baa below.
RD1 = Annual R&D expenditures over year-end market value of equity.
RD2 = Year-end estimated R&D assets estimated by the sum of the past five-year R&D expenditures, normalized by year-end market value of equity.
RD3 = Year-end estimated R&D assets assuming a five-year straight-line amortization schedule, normalized by year-end market value of equity
RD4 = Year-end estimated R&D assets based on LS amortization schedule, normalized by year-end market value of equity.

Table 2

Descriptive Statistics for Selected Variables

Variable	Mean	25% Quartile	Median	75% Quartile	Standard Deviation
RATING	3.18	2.00	3.00	4.00	1.18
PREM	72.33	37.55	78.25	111.50	87.00
RD1	0.08	0.03	0.06	0.10	0.07
RD2	0.35	0.14	0.23	0.43	0.33
RD3	0.15	0.06	0.10	0.18	0.14
RD4	0.22	0.09	0.15	0.26	0.21
DE	1.01	0.22	0.50	0.85	3.14
PROFIT	0.03	0.02	0.04	0.07	0.19
TIMES	4.38	1.54	2.99	5.31	11.33
TOTASSET	18,431.19	2,737.07	6,108.40	11,917.50	39,838.78
MVEQITY	9,286.86	1,584.22	4,371.20	13,552.93	10,999.08
MATURITY	15.23	7.50	10.00	30.00	10.44
SIZE	233.35	102.33	200.00	300.00	182.52
CALL	0.96	1.00	1.00	1.00	0.165
CONV	0.11	0.00	0.00	0.00	0.31
SUBO	0.11	0.00	0.00	0.00	0.32
ECYC	58.47	53.00	60.00	65.00	11.31

The table reports descriptive statistics for selected variables of the final sample of 132 bonds issued from 1990 to 1993 by five R&D-intensive industries with two-digit SIC codes of 28, 35, 36, 37 and 38.

RATING = Moody's bond ratings, with integer values 1 through 5 representing the ratings of Aaa, Aa, A, Baa, and Baa below.
PREM = Bond yield to maturity minus yield on U.S. Treasury bond of comparable maturity on the issuance date (measured in basis points).
RD1 = Annual R&D expenditures over year-end market value of equity.
RD2 = Year-end estimated R&D assets estimated by the sum of the past five-year R&D expenditures, normalized by year-end market value of equity.
RD3 = Year-end estimated R&D assets assuming a five-year straight-line amortization schedule, normalized by year-end market value of equity
RD4 = Year-end estimated R&D assets based on LS amortization schedule, normalized by year-end market value of equity.
DE = Ratio of long term debt to book value of equity. PROFIT = Income before extraordinary items to net sales.
TIMES = Income before interest expenses over interest expenses.
TOTASSET = Total reported assets (denominated in millions of dollars).
MVEQITY = Market value of common stock measured at fiscal year end (denominated in millions of dollars).
MATURITY = Years to maturity of bond issues.
SIZE = Bond issue size (denominated in millions of dollars).
CALL = Years to first call over years to maturity.
CONV = 1 for convertible bonds and 0 otherwise.
SUBO = 1 for subordinated bonds and 0 otherwise.
ECYC = Average yield on Moody's Aaa bonds for the month of issue less average yield on 30-year U.S. Treasury bonds for the month of issue.

Table 3
Results of Seemingly Unrelated Regressions (SUR) Estimation:

Annual R&D Expenditures (RD1), with and without Control Variables

Variable	Expected Sign	RATING	PREM	RATING	PREM	RATING	PREM
RD1	+/-	2.07	255.31	3.25	241.64	2.31	284.95
		(0.15)	**(0.02)**	**(0.01)**	**(0.01)**	**(0.005)**	**(0.01)**
DE	+					0.003	4.94
						(0.87)	**(0.02)**
PROFIT	-					-0.39	4.12
						(0.28)	**(0.93)**
TIMES	-					-0.004	-0.75
						(0.59)	**(0.35)**
LOGMVE	-					-0.71	
						(0.0001)	
LOGASSET	-						-15.81
							(0.03)
LOGSIZE	+/-			-0.28	-26.36	0.34	-12.21
				(0.06)	**(0.02)**	**(0.001)**	**(0.35)**
LOGMAT	+			0.09	9.72	-0.01	11.89
				(0.53)	**(0.34)**	**(0.88)**	**(0.24)**
CALL	-				62.25		67.79
					(0.03)		**(0.02)**
CONV	-				-122.26		-167.59
					(0.0001)		**(0.0001)**
SUBO	+			1.68		0.15	
				(0.0001)		**(0.46)**	
ECYC	+				0.47		0.17
					(0.48)		**(0.81)**
No. of Observations:		132		132		132	
System Weighted R^2:		0.8076		0.8655		0.9503	
F Test for Incremental Significance of RD1:						6.203 **(0.002)**	

The table reports results of seemingly unrelated regressions (SUR) of RATING and PREM on annual R&D expenditures (RD1) with and without control variables. The regressions are run using the sample of 132 bonds issued from 1990 to 1993 by five R&D-intensive industries with two-digit SIC codes of 28, 35, 36, 37 and 38. Numbers in parentheses denote two-tailed p-values.

Dependent Variables:

RATING = Moody's bond ratings, with integer values 1 through 5 representing the ratings of Aaa, Aa, A, Baa, and Baa below.

PREM = Bond yield to maturity minus yield on U.S. Treasury bond of comparable maturity on the issuance date (measured in basis points).

Independent Variables:

RD1 = Annual R&D expenditures over year-end market value of equity.

DE = Ratio of long term debt to book value of equity .

PROFIT = Net income to net sales.

TIMES = Income before interest expenses over interest expenses.

LOGASSET = Log of total assets (denominated in millions of dollars).

LOGMVE = Market value of common stock measured at fiscal year end (denominated in millions of dollars).

LOGMAT = Log of years to maturity of bond issues.

LOGSIZE = Log of bond issue size (denominated in millions of dollars).

CALL = Years to first call over years to maturity.

CONV = 1 for convertible bonds and 0 otherwise.

SUBO = 1 for subordinated bonds and 0 otherwise.

ECYC = Average yield on Moody's Aaa bonds for the month of issue less average yield on 30-year U.S. Treasury bonds for the month of issue.

Table 4

Results of Seemingly Unrelated Regressions (SUR) Estimation: Adjusted Model

RATING (Bond Rating) Equation				PREM (Bond Premium) Equation			
	Expected		Two-tailed		Expected		Two-tailed
Variable	Sign	Coefficient	P-value	Variable	Sign	Coefficient	P-value
RD4	+/-	0.787	0.002	RD4	+/-	128.93	0.0006
ADE	+	0.209	0.014	ADE	+	29.54	0.006
APROFIT	-	-0.345	0.306	APROFIT	-	-2.45	0.950
ATIMES	-	-0.004	0.528	ATIMES	-	-0.44	0.530
LOGMVE	-	-0.703	0.0002	ALOGASS	-	-21.37	0.004
LOGSIZE	+/-	0.301	0.002	LOGSIZE	+/-	-11.84	0.352
LOGMAT	+	-0.017	0.828	LOGMAT	+	9.90	0.308
SUBO	+	0.085	0.668	CALL	-	66.78	0.022
				CONV	-	-181.02	0.0002
				ECYC	+	0.21	0.762

Number of Observations = 132

System Weighted R^2 =0.954

The table reports results of seemingly unrelated regressions (SUR) of RATING and PREM on RD4, adjusted accounting numbers, and other control variables. The adjustments are made by first computing as-if earnings and as-if R&D assets assuming that R&D were capitalized using the LS amortization schedules, then the four accounting variables (ADE, APROFIT, ATIMES, and ALOGASS) are adjusted accordingly to incorporate the as-if earnings and R&D assets. The regressions are run using the sample of 132 bonds issued from 1990 to 1993 by five R&D-intensive industries with two-digit SIC codes of 28, 35, 36, 37 and 38.

Dependent Variables:

RATING = Moody's bond ratings, with integer values 1 through 5 representing the ratings of Aaa, Aa, A, Baa, and Baa below.

PREM = Bond yield to maturity minus yield on U.S. Treasury bond of comparable maturity on the issuance date (measured in basis points).

Independent Variables:

RD4 = Year-end estimated R&D assets based on LS amortization schedule, normalized by year-end market value of equity.

ADE= Adjusted debt-equity ratio. Ratio of long term debt to the sum of book value of equity and yearend R&D asset.

APROFIT = Adjusted profitability. (Income before extraordinary items + R&D expenditures – amortization of R&D assets)/net sales.

ATIMES = (Income before interest expenses + R&D expenditures – amortization of R&D assets)/interest expenses.

ALOGASS = Log of the sum of total reported assets and R&D assets.

LOGMVE = Market value of common stock measured at fiscal year end (denominated in millions of dollars).

LOGMAT = Log of years to maturity of bond issues.

LOGSIZE = Log of bond issue size (denominated in millions of dollars).

CALL = Years to first call over years to maturity.

CONV = 1 for convertible bonds and 0 otherwise.

SUBO = 1 for subordinated bonds and 0 otherwise.

ECYC = Average yield on Moody's Aaa bonds for the month of issue less average yield on 30-year U.S. Treasury bonds for the month of issue.

Table 5

Results of Two-stage Seemingly Unrelated Regressions (SUR) Estimation

Using the Instrumental Variable Method

RATING (Bond Rating) Equation				PREM (Bond Premium) Equation			
Variable	Expected Sign	Coefficient	Two-tailed P-value	Variable	Expected Sign	Coefficient	Two-tailed P-value
FITTED_RD4	+/-	0.99	0.04	FITTED_RD4	+/-	243.19	0.0002
DE	+	0.01	0.76	DE	+	2.75	0.19
PROFIT	-	-0.23	0.53	PROFIT	-	-7.65	0.86
TIMES	-	-0.01	0.09	TIMES	-	-1.27	0.08
LOGMVE	-	-0.70	0.0001	LOGASS	-	-14.96	0.02
LOGSIZE	+/-	0.37	0.0002	LOGSIZE	+/-	-14.07	0.27
LOGMAT	+	-0.003	0.96	LOGMAT	+	6.17	0.54
SUBO	+	0.10	0.64	CALL	-	132.87	0.002
				CONV	-	-172.51	0.0001
				ECYC	+	0.23	0.74

Number of Observations = 132

System Weighted R-Square = 0.9488

The table reports the results of two-stage seemingly unrelated regressions (SUR) estimation using the instrumental variable method. In the first stage, firm-specific RD4 (year-end estimated R&D assets based on LS amortization schedule, normalized by year-end market value of equity) is regressed on the instrumental variable, the firm's two-digit industry average level of RD4, excluding the firm itself, then the fitted value of RD4, FITTED_RD4, is derived from the first-stage regression. In the second stage, RATING and PREM are regressed on FITTED_RD4 and the other bond risk control variables using the SUR estimation.

The regressions are run using the sample of 132 bonds issued from 1990 to 1993 by five R&D-intensive industries with two-digit SIC codes of 28, 35, 36, 37 and 38.

Dependent Variables:

RATING = Moody's bond ratings, with integer values 1 through 5 representing the ratings of Aaa, Aa, A, Baa, and Baa below.

PREM = Bond yield to maturity minus yield on U.S. Treasury bond of comparable maturity on the issuance date (measured in basis points).

Independent Variables (Except FITTED_RD4):

DE = Ratio of long term debt to book value of equity.

PROFIT = Net income to net sales.

TIMES = Income before interest expenses over interest expenses.

LOGASSET = Log of total assets (denominated in millions of dollars).

LOGMVE = Market value of common stock measured at fiscal year end (denominated in millions of dollars).

LOGMAT = Log of years to maturity of bond issues.

LOGSIZE = Log of bond issue size (denominated in millions of dollars).

CALL = Years to first call over years to maturity.

CONV = 1 for convertible bonds and 0 otherwise.

SUBO = 1 for subordinated bonds and 0 otherwise.

ECYC = Average yield on Moody's Aaa bonds for the month of issue less average yield on 30-year U.S. Treasury bonds for the month of issue.

Table 6

Results of Seemingly Unrelated Regressions (SUR) Estimation:

Incremental Effects of Multi-year R&D Constructs Over Annual R&D (RD1)

Panel A: RATING (Bond Rating) Equation

		Sum of 5 Years (RD2)		5 Year Straight-line (RD3)		LS Measure (RD4)	
Variable	Expected Sign	Coefficient	Two-tailed P-value	Coefficient	Two-tailed P-value	Coefficient	Two-tailed P-value
RD1	+/-	2.29	0.01	2.31	0.01	2.26	0.01
RESIDUAL2	+/-	0.05	0.53				
RESIDUAL3	+/-			0.09	0.76		
RESIDUAL4	+/-					0.14	0.17
DE	+	0.002	0.89	0.003	0.87	-0.001	0.95
PROFIT	-	-0.37	0.31	-0.38	0.31	-0.31	0.41
TIMES	-	-0.004	0.59	-0.004	0.59	-0.005	0.48
LOGMVE	-	-0.71	0.0001	-0.71	0.0001	-0.71	0.0001
LOGSIZE	+/-	0.35	0.001	0.34	0.001	0.35	0.001
LOGMAT	+	-0.003	0.97	-0.01	0.91	0.003	0.97
SUBO	+	0.15	0.46	0.15	0.47	0.15	0.46

Table 6 (Continued)

Results of Seemingly Unrelated Regressions (SUR) Estimation:

Incremental Effects of Multi-year R&D Constructs Over Annual R&D (RD1)

Panel B: PREM (Bond Premium) Equation

		Sum of 5 Years (RD2)		5 Year Straight-line (RD3)		LS Measure (RD4)	
Variable	Expected Sign	Coefficient	Two-tailed P-value	Coefficient	Two-tailed P-value	Coefficient	Two-tailed P-value
RD1	+/-	272.71	0.02	281.39	0.01	282.53	0.01
RESIDUAL2	+/-	22.22	0.01				
RESIDUAL3	+/-			92.36	0.01		
RESIDUAL4	+/-					33.65	0.01
DE	+	4.81	0.03	5.02	0.02	4.13	0.06
PROFIT	-	14.96	0.74	22.81	0.61	25.78	0.57
TIMES	-	-0.74	0.35	-0.71	0.37	-1.02	0.20
LOGASSET	-	-15.49	0.03	-16.02	0.02	-18.01	0.01
LOGSIZE	+/-	-9.26	0.47	-9.53	0.46	-8.95	0.48
LOGMAT	+	16.11	0.11	15.34	0.12	15.77	0.11
CALL	-	74.97	0.01	73.01	0.01	74.87	0.01
CONV	-	-165.63	0.0001	-170.47	0.0001	-168.57	0.0001
ECYC	+	0.45	0.52	0.45	0.52	0.38	0.58
No. of Observations:		132		132		132	
System Weighted R^2:		0.9506		0.9505		0.9512	

The table reports incremental effects of three multi-year R&D constructs (RD2, RD3, RD4) over annual R&D expenditures (RD1), respectively. The analysis is conducted in two stages. In the first stage, each multi-year construct is regressed on RD1 using an OLS estimation:

$$RD(k)_{i,t} = a(k) + b(k)RD1_{i,t} + m(k)_{i,t}$$

where k = 2, 3, and 4. In the second stage, the fitted value of the error terms, *m*(k), is included as an independent variable in the following system of two equations:

$$RATING_{i,t+1} = \sum_{t=90}^{93} a_{0t}YR_{it} + a_1 RD1_{it} + a_{2,k} m(k)_{it} + a_3 DE_{it} + a_4 PROFIT_{it} + a_5 TIMES_{it} + a_6 LOGMVE_{it}$$
$$+ a_7 LOGSIZE_{i,t+1} + a_8 LOGMAT_{i,t+1} + a_9 SUBO_{i,t+1} + e_{it}$$

$$PREM_{i,t+1} = \sum_{t=90}^{93} b_{0t}YR_{it} + b_1 RD1_{it} + b_{2,k} m(k)_{it} + b_3 DE_{it} + b_4 PROFIT_{it} + b_5 TIMES_{it} + b_6 LOGASS_{it}$$
$$+ b_7 LOGSIZE_{i,t+1} + b_8 LOGMAT_{i,t+1} + b_9 CALL_{i,t+1} + b_{10} CONV_{i,t+1} + b_{11} ECYC_{I,T=1} + e_{it}$$

The above two equations are estimated using seemingly unrelated regressions (SUR).

The sample consists of 132 bonds issued from 1990 to 1993 by five R&D-intensive industries with two-digit SIC codes of 28, 35, 36, 37 and 38.

Dependent Variables:

RATING = Moody's bond ratings, with integer values 1 through 5 representing the ratings of Aaa, Aa, A, Baa, and Baa below.

PREM = Bond yield to maturity minus yield on U.S. Treasury bond of comparable maturity on the issuance date (measured in basis points).

Independent Variables:

RD1 = Annual R&D expenditures over year-end market value of equity.

RESIDUAL(*k*) = Fitted values of error terms, $m(k)_{it}$, from regressing RD(*k*) on RD 1, where k = 2, 3, and 4.

DE = Ratio of long term debt to book value of equity.

PROFIT = Net income to net sales.

TIMES = Income before interest expenses over interest expenses.

LOGASSET = Log of total assets (denominated in millions of dollars).

LOGMVE = Market value of common stock measured at fiscal year end (denominated in millions of dollars).

LOGMAT = Log of years to maturity of bond issues.

LOGSIZE = Log of bond issue size (denominated in millions of dollars).

CALL = Years to first call over years to maturity.

CONV = 1 for convertible bonds and 0 otherwise.

SUBO = 1 for subordinated bonds and 0 otherwise.

ECYC = Average yield on Moody's Aaa bonds for the month of issue less average yield on 30-year U.S. Treasury bonds for the month of issue.

Table 7

Results of Seemingly Unrelated Regressions (SUR) Estimation: LS Measure (RD4)
Differential Associations: Long vs. Short Useful Life Samples

RATING (Bond Rating) Equation				PREM (Bond Premium) Equation			
Variable	Expected Sign	Coefficient	One-tailed P-value	Variable	Expected Sign	Coefficient	One-tailed P-value
CV	+/-	-0.551	0.000	CV	+/-	-17.948	0.175
RD4	+	0.509	0.109	RD4	+	40.197	0.236
RD4*CV	+/-	2.161	0.0001	RD4*CV	+/-	117.049	0.022
DE	+	-0.004	0.398	DE	+	3.946	0.037
PROFIT	-	-0.282	0.208	PROFIT	-	21.210	0.323
TIMES	-	0.008	0.099	TIMES	-	-1.197	0.085
LOGMVE	-	-0.667	0.0001	LOGASSET	-	-18.271	0.012
LOGSIZE	+/-	0.295	0.002	LOGSIZE	+/-	-10.666	0.207
LOGMAT	+	0.001	0.494	LOGMAT	+	13.251	0.091
SUBO	+	0.186	0.168	CALL	-	70.585	0.009
				CONV	-	-170.401	0.0001
				ECYC	+	0.195	0.391

Number of Observations = 132

System Weighted R^2 = 0.958

The table reports the differential associations of the LS measure (RD4) with bond ratings and premiums across the samples of long versus short useful life spans. The full sample of 132 observations is partitioned into 2 sub-samples according to the median of the sums of the three recent amortization coefficients reported in Table 3 of the LS study. The observations corresponding to the sums higher (lower) than the median form the sub-sample of low (high) risk. To test the differential impacts across the two sub-samples, a categorical variable (CV) is set equal to one for the sample of long useful life span and zero otherwise. The categorical variable is allowed to interact with the intercept and the RD4 variable. The system of two regression models with the interactive terms given below is estimated using seemingly unrelated regressions (SUR):

$$RATING_{i,t+1} = \sum_{t=91}^{94} a_{0t} YR_{it} + a_1 CV_{it} + a_2 RD4_{it} + a_3 RD4_{it} * CV_{it} + a_4 DE_{it} + a_5 PROFIT_{it} + a_6 TIMES_{it} + a_7 LOGMVE_{it} + a_8 LOGSIZE_{i,t+1} + a_9 LOGMAT_{i,t+1} + a_{10} SUBO_{i,t+1} + e_{i,t}$$

$$PREM_{i,t+1} = \sum_{t=91}^{94} b_{0t} YR_{it} + b_1 CV_{it} + b_2 RD4_{it} + b_3 RD4_{it} * CV_{it} + b_4 DE_{it} + b_5 PROFIT_{it} + b_6 TIMES + b_7 LOGASS_{it} + b_8 LOGSIZE_{i,t+1} + b_9 LOGMAT_{i,t+1} + b_{10} CALL_{i,t+1} + b_{11} CONV_{i,t+1} + b_{12} ECYC_{I,T=1} + e_{it}$$

Dependent Variables:

RATING = Moody's bond ratings, with integer values 1 through 5 representing the ratings of Aaa, Aa, A, Baa, and Baa below.

PREM = Bond yield to maturity minus yield on U.S. Treasury bond of comparable maturity on the issuance date (measured in basis points).

Independent Variables:

CV = A categorical variable equal to 1 for long useful R&D life sample issues and 0 otherwise.

RD4 = Year-end estimated R&D assets based on LS amortization schedule, normalized by year-end market value of equity.

DE = Ratio of long term debt to book value of equity.

PROFIT = Net income to net sales.

TIMES = Income before interest expenses over interest expenses.

LOGASSET = Log of total assets (denominated in millions of dollars).

LOGMVE = Market value of common stock measured at fiscal year end (denominated in millions of dollars).

LOGMAT = Log of years to maturity of bond issues.

LOGSIZE = Log of bond issue size (denominated in millions of dollars).

CALL = Years to first call over years to maturity.

CONV = 1 for convertible bonds and 0 otherwise.

SUBO = 1 for subordinated bonds and 0 otherwise.

ECYC = Average yield on Moody's Aaa bonds for the month of issue less average yield on 30-year U.S. Treasury bonds for the month of issue.