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The value relevance of R&D across profit and loss firms

Laurel Franzen *, Suresh Radhakrishnan

School of Management, SM 41, University of Texas at Dallas, Richardson, TX 75083, United States

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ABSTRACT

We examine whether the valuation relevance of R&D documented for loss firms extends to profit firms. We use the residual-income valuation model and show that the valuation multiplier on R&D expenditures is likely to be negative (positive) for profit (loss) firms. This occurs because the linear information dynamics assumption of the residual-income model is more appropriate for profit firms than loss firms. Earnings of profit firms are likely to contain information on the future benefits of R&D activity, however, earnings of loss firms do not contain such information. The empirical evidence confirms our predictions for profit and loss firms. An important implication of our findings is that understanding the role of the R&D expense line item in valuation across firms and within firms, across time depends on whether the linear information dynamics assumption of the residual-income model is applicable for the sample of firms under investigation.

1. Introduction

In this study, we investigate the role of R&D expense in a residual-income based valuation framework across levels of profitability. Currently, R&D expenditures are fully expensed under generally accepted accounting principles.[1] Additionally, firms investing in R&D activity are required to disclose the amount of the R&D expenditure for the period. Darrough and Ye (2007) provide evidence that R&D

* Corresponding author. Tel.: +1 972 883 6396; fax: +1 972 883 6811.
E-mail addresses: laurelf@utdallas.edu (L. Franzen), sradhakr@utdallas.edu (S. Radhakrishnan).

[1] Under current US accounting standards (SFAS No. 2), research and development expenditures are expensed as incurred. An exception to the current period expensing of research and development expenditures is in the computer software industry. Under SFAS No. 86, software firms may capitalize software development costs after establishing the technological feasibility of the software.

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expenditures have a positive valuation multiplier for loss firms. We examine whether the positive valuation multiplier on R&D for loss firms extends to profit firms.[2]

We use a simple residual-income based valuation model similar to Ohlson (1995) to derive the relation between stock price and R&D expense, earnings (before R&D expense) and book value of equity for R&D firms with profits and losses.[3] In the residual-income valuation framework, the linear information dynamics is assumed to derive the valuation multipliers. The linear information dynamics assumption defines expected future abnormal earnings as a linear function of current abnormal earnings. However in valuing R&D firms, this assumption may not be satisfied across levels of profitability. For profit firms, current earnings are likely to provide information on potential future earnings from R&D activity and therefore, expected abnormal earnings are more likely to be a linear function of current abnormal earnings.[4] Thus, for profit firms, the linear information dynamics assumption is likely to be satisfied. However, for loss firms, current earnings are not fully informative on the potential future profitability from R&D activity. This suggests that expected abnormal earnings for loss firms are not a linear function of the current year's negative earnings.[5] That is, for loss firms, the linear information dynamics assumption is not likely to be satisfied. This is consistent with the findings in prior research that loss firms investing in research and development activity are not distressed as a result of the reported loss, and R&D activity in such firms is positively associated with value (Joos and Plesko, 2005; Darrough and Ye, 2007; Franzen et al., 2007).

Our analytical insights highlight the information that is needed for the valuation of R&D firms under two scenarios: (1) when the linear information dynamics of the residual-income valuation model is more likely and (2) less likely to be satisfied. In particular, our analytical results suggest that the positive valuation multiplier on R&D expense observed for loss firms does not extend to profit firms. For profit firms, the valuation multiplier on both earnings (before R&D expense) and R&D expense are a function of the discount rate and the growth in R&D investment. Because the information in R&D expense is already contained in earnings, the valuation multipliers on earnings (before R&D expense) and R&D expense are of opposite signs, i.e. positive and negative, respectively. This suggests that caution should be exercised when one wishes to make conclusions on the value relevance of R&D activity based on the negative association of R&D expense and stock value alone. In contrast, for loss firms, the valuation multiplier on R&D expense is a function of the discount rate, growth in R&D investment and the productivity of the R&D investment. Information on the productivity of R&D investment is not fully contained in earnings and therefore, the valuation multiplier on R&D expense is positive.[6]

We empirically examine these analytical insights. We find that, on average, R&D expenses are positively (negatively) associated with stock prices for loss (profit) firms as expected. Also, for profit firms, the magnitude of the coefficient estimate on R&D expense is smaller than the coefficient estimate on earnings before R&D.

We also examine some implications of the analytical insights for the empirical specification of the valuation model. We estimate a benchmark valuation model where firm value is specified as a function of earnings and book value of equity. Consistent with prior empirical research on loss firms (Darrough and Ye, 2007), R&D expense provides value relevant information. Therefore, for loss firms, we predict and find that the explanatory power of a valuation model that disaggregates R&D spending from earnings is higher than that of the benchmark model. For profit firms, given that the information on R&D productivity is already contained in earnings, we predict and find little improvement in the explanatory power from the benchmark to the disaggregated valuation model.

The analytical insights are derived in a setting where earnings are driven solely by R&D investment. However, since earnings are not only generated by R&D activity, but also other activities that create

[2] We define profits and losses based on the sign of earnings before extraordinary items.

[3] In our study, we consider only firms with positive R&D spending. Hereafter, R&D firms with profits and R&D firms with losses are referred to as profit firms and loss firms, respectively.

[4] In the analytical model, we refer to the information on potential future earnings from R&D activity as R&D productivity.

[5] This presumes that, on average, R&D expenditures yield positive net present value. Also, for profit firms, current earnings need not provide perfect and complete information on future earnings potential due to R&D activity, but relative to loss firms, their earnings are more informative.

[6] Shortridge (2004) shows that R&D expenditure has a positive coefficient for large firms and a negative coefficient for small firms. Our analytical insight and empirical evidence provides a rationale for such findings.

unrecognized intangible assets such as marketing, advertising and employee training, we consider firms where R&D is likely to be the most significant activity. Thus, we partition firms into high, medium and low R&D to assets, i.e. R&D intensity. For profit firms (loss firms), across all levels of R&D spending, we find that the estimated coefficient on R&D expense is significantly negative (positive) as expected. Relative to the benchmark valuation model, we find that disaggregating earnings increases the explanatory power of the model by roughly 45% for high R&D intensity, loss firms.

Finally, we provide evidence on how the value relevance of earnings and R&D expense changes for firms that transition from a loss to a profit. We find that the coefficient estimate on R&D expense is significantly positive in the loss years but insignificantly different from zero in the first year of profit. As firms transition to a reported profit, earnings are positively valued, but R&D expense is not. When we investigate the second year of profits, so that the first year of profit is not purely transitory, we find that the coefficient estimate on R&D expense becomes negative, but is not statistically significant. However, given that these firms are only a few years out from reporting losses, these results are in line with a firm that is maturing, but does not yet have all information about R&D productivity contained in earnings.

Our findings on the role of R&D expense in valuation across profit and loss firms have several important implications. First, investment in R&D activity has been increasing over time, leading to a potentially larger role for this investment activity in valuation (Darrough and Ye, 2007; Chan et al., 2001; Lev and Zarowin, 1999). Our results suggest that the role of the R&D expense line item in valuation across firms and within firms, across time depends on whether the linear information dynamics assumption of the residual-income model is applicable for the sample of firms under investigation.

Second, our results have implications for managers' voluntary disclosures related to R&D activity. Our findings highlight the role of information on R&D productivity in valuation and identify settings in which R&D related disclosures may be important.[7] For loss firms, we show that the valuation multiplier on R&D expense is a function of R&D productivity. And, in fact, empirical evidence on disclosure of innovation activities suggests that firms with reported losses disclose more information (Gu and Li, 2003). For profit firms, our findings suggest that if the linear information dynamics assumption is *not* satisfied because earnings does not provide sufficient information on the expected productivity of R&D spending, disclosure of the expected productivity of current R&D spending relative to the productivity of past R&D spending may be useful for valuation.

The rest of the paper is organized as follows: in Section 2, we develop our hypotheses. The empirical results are presented in Section 3, and in Section 4, we provide some concluding remarks.

2. Development of hypotheses

We examine the role of R&D expenditures which are an important value-relevant expense item that provides information on future earnings. We choose R&D expenditures as the component of earnings because a number of studies show that R&D expenditures are related to future operating performance (Sougiannis, 1994; Lev and Sougiannis, 1996; Lev and Zarowin, 1999). Chambers et al. (2002) show that, on average, investors consider R&D as an asset.[8] While other components embedded in earnings such as advertising expenditures may also be related to future earnings, evidence on such a relationship is weak/mixed.[9]

We focus on the partition of profit and loss firms because this partition is common in empirical research following evidence in Hayn (1995) that negative earnings are of lower value relevance than positive earnings. Also, prior research has focused on the valuation of R&D for loss firms with less evidence on how R&D is valued for profit firms. We know from prior research that loss firms investing

[7] Under current GAAP, the only required disclosure related to R&D activity is the total amount charged to R&D expense for the period is in the income statement. No additional disclosures about the nature or productivity of R&D activity are required.

[8] Some studies show that stock prices are inefficient with respect to R&D expenditures. Specifically, the market undervalues R&D expenditures (Lev and Sougiannis, 1996; Chan et al., 2001). Other studies show that the future abnormal returns could be due to unmeasured risk factors associated with R&D expenditures (Chambers et al., 2002).

[9] Advertising expenditures are shown to generate intangible assets with very short useful lives (Rayvenscraft and Scherer, 1982; Bublitz and Ettredge, 1989).

in research and development activity are not distressed as a result of the reported loss (Joos and Plesko, 2005; Darrough and Ye, 2007; Franzen et al., 2007).[10] This suggests that expected future abnormal earnings for loss firms investing in R&D are not a linear function of the current year's negative earnings.[11] On the other hand, profitable firms investing in R&D activity are more likely to have information about R&D productivity contained in earnings and therefore, expected abnormal earnings are more likely to be a linear function of current abnormal earnings. Therefore, using the residual-income valuation framework which relies on the linear information dynamics assumption, we examine the profit and loss partitions as settings where the linear information dynamics assumption is and is not likely to be satisfied, respectively. In particular, by analyzing a simple model with linear information dynamics similar to Ohlson (1995), we gain empirical insights into the value relevance of R&D expenditures for profit and loss firms.

2.1. Valuation of R&D expenditures for profit and loss firms

The value of a firm in terms of its book value of equity and earnings components, i.e. earnings before R&D expenditures and R&D expenditures, with the clean surplus and linear information dynamics assumptions can be expressed as:[12]

$$P_t + d_t = \beta_1 b_{t-1} + \beta_2 x_t + \beta_3 y_t, \qquad \text{(VAL)}$$

$\beta_1 = R(1-\theta)/(R-\theta)$ and $\beta_2 = -\beta_3 = R/(R-\theta)$ for profit firms, and $\beta_1 = R(1-\theta)/(R-\theta)$ and $\beta_2 = R/(R-\theta)$ and $\beta_3 = [R/(R-\theta)][\sum_{i=0}^{k-t}\{\delta_{t+i+1}/R^i\} - 1]$ for loss firms, where P_t is the stock price at time t, d_t is the dividend during the period $(t-1)$ to t, b_t is the book value of equity at time t, x_t is earnings from R&D activities before expensing of R&D expenditures from period $(t-1)$ to t, y_t is the R&D expenditure during the period $(t-1)$ to t. θ is the growth of the R&D expenditures and book value of equity. The benefit from R&D expenditure of y_t accrues over k periods, i.e. from t to $(t+k)$. Thus, the total benefit x_t in period t arises from R&D activity in periods $t, (t-1), \ldots, (t-k)$, with δ_j as the productivity parameter of R&D spending j-periods after the R&D spending. Thus, δ_1 refers to the contribution of R&D spending to earnings before R&D in the year of R&D spending, δ_2 refers to the contribution of R&D spending to earnings before R&D in the year after the R&D spending, and so on. Thus, δ_j is the benefit/productivity of R&D expenditure in period j after R&D investment, and k is the number of periods that the R&D expenditure provides benefits. R is the discount rate. We refer to β_1, β_2, β_3, as pricing multipliers.

We sketch the intuition behind the valuation expression (VAL). To do this, we outline (a) when the firm is likely to report profits and losses, (b) how the linear information dynamics assumption, i.e. the linear process of growth in earnings is satisfied for profit firms, (c) how the linear information dynamics assumption is not likely to be satisfied for loss firms, and (d) how the former three observations lead to the valuation expression (VAL). First, we identify when firms are likely to report profits and losses. Firms are likely to report losses in their initial years. In particular, we assume that $e_t = x_t - y_t$ for $t < k$ is negative because the recent past R&D spending has not as yet contributed the full potential benefit. To illustrate this, consider $k = 3$, which implies that the R&D spending of y_1 in the first period provides benefits, x_t in periods 1, 2, and 3 of $\delta_1 y_1$, $\delta_2 y_1$ and $\delta_3 y_1$, respectively. In the first period, if $\delta_1 < 1$, then e_1 is negative. In the second period having invested $y_2 = \theta y_1$ in R&D, the corresponding benefits, i.e. earnings before R&D is $x_2 = \delta_2 y_1 + \delta_1 y_2$ and earnings is $e_2 = \delta_2 y_1 + \delta_1 y_2 - y_2 = y_1[\delta_2 - (1-\delta_1)\theta]$, which is negative if $(1-\delta_1)\theta > \delta_2$. In words, the benefit from prior period R&D spending is not sufficient to offset the amount of R&D spending in the second period. On the other hand, we assume that for $t \geqslant k$, earnings e_t is positive. In the example with $k = 3$, in $t = 3$ the investment in R&D in the third period is $y_3 = \theta y_2 = \theta^2 y_1$, the corresponding earnings before R&D is $x_3 = \delta_3 y_1 + \delta_2 y_2 + \delta_1 y_3$ and earnings

[10] Prior research documents an increase in the frequency of reported losses over time (Hayn, 1995; Collins et al., 1997, 1999). This increase in reported losses extends over periods of economic growth suggesting that reported losses are less likely to reflect financial distress (also see Franzen, 2002).

[11] If current year's earnings are negative, then it follows by definition that the current year's abnormal earnings is also negative.

[12] The assumptions characterizing the loss and profit firms and the derivation of the valuation expression are in Appendix.

is $e_3 = \delta_3 y_1 + \delta_2 y_2 + \delta_1 y_3 - y_3 = y_1[\delta_3 + \delta_2\theta - (1-\delta_1)\theta^2]$, which is positive if $\delta_3 + \delta_2\theta > (1-\delta_1)\theta^2$: this assumption ensures that the firm is viable in the long-run.

Second, we demonstrate how for profit firms the future earnings can be expressed as growth times the current earnings, i.e. the linear information dynamics assumption is likely satisfied. Continuing with the example with $k = 3$ for $t \geqslant k$, the earnings before R&D, x_t contains the contribution of R&D spending from the current period and two prior periods, t, $(t-1)$ and $(t-2)$. For example, in $t = 4$, the R&D investment is $y_4 = \theta y_3 = \theta^3 y_1$, and the corresponding earnings before R&D is $x_4 = \delta_3 y_2 + \delta_2 y_3 + \delta_1 y_4 = \theta x_3$ and earnings is $e_4 = \delta_3 y_2 + \delta_2 y_3 + \delta_1 y_4 - y_4 = \theta y_1[\delta_3 + \delta_2\theta - (1-\delta_1)\theta^2] = \theta e_3$. Thus for $t \geqslant k$, both earnings before R&D and earnings can be represented by the following growth process: $x_t = \theta x_{t-1}$, $e_t = \theta e_{t-1}$. The residual-income valuation framework considers such an assumption for the growth in earnings process, which is called linear information dynamics.

Third, we illustrate how for loss firms future earnings cannot be expressed as growth times the current earnings, i.e. the linear information dynamics assumption is not likely to be satisfied. In the example with $k = 3$ for $t < k$, consider the valuation expression at $t = 1$. Here, if we can express x_2 as a linear function of x_1 alone, then similar to the profit setting discussed above, we will be able to express future earnings as a linear function of current earnings. The earnings before R&D for $t = 2$ is given by $x_2 = \delta_2 y_1 + \delta_1 y_2 = \theta x_1 + \delta_2 y_1$. The earnings before R&D in period 1, x_1 does not contain information on δ_2. The earnings process cannot be expressed as growth times the current earnings, i.e. $x_t \neq \theta x_{t-1}$. Thus, when firms make losses it is more likely that the current earnings are not informative about future earnings because they do not contain all the information on the productivity parameters of R&D investment. In essence, when $t < k$, the assumption of the growth in earnings process is different, resulting in a different valuation expression.

Putting the above observations together, earnings in profit firms are more value relevant than R&D expenditures because they contain information on the productivity/realizations of past R&D expenditures. However, for loss firms the benefits from R&D have not been completely realized and thus, earnings are not informative; however, R&D expenditures are likely to be informative of the future productivity directly. Alternatively, earnings are more likely to be a sufficient statistic for profit firms than loss firms in the sense that it contains the R&D productivity information.

The residual-income framework above assumes a reporting regime requiring immediate expensing of R&D expenditures. However, the intuition behind the differential value-relevance of R&D activity across profit and loss firms can also be gleaned starting from the following general framework.[13] Let g_t denote the stock of intangible assets and y_t^* denote the R&D amortization. The theoretical valuation identity represented in terms of total (tangible and intangible) assets and the corresponding earnings with pricing multipliers a_0 and a_1, respectively is given by:

$$P_t = a_0(b_t + g_t) + a_1(e_t + y_t - y_t^*).$$

Thus, the valuation identity denotes value as a function of the stock of economic assets and economic earnings.[14] Rewriting the above identity, we have

$$P_t = a_0 b_t + a_1 x_t - a_1 y_t^* + a_0 g_t$$

However, when the reporting regime requires immediate expensing of R&D expenditures, such as under current US GAAP, the stock of intangible assets, g_t and the amortization, y_t^* are not observable. Therefore, for the empirical research design, we estimate the following expression:

$$P_t = \alpha_0 b_t + \alpha_1 x_t + \alpha_2 y_t$$

That is, in our empirical estimation the stock of intangible assets and the corresponding R&D amortization are omitted variables. For profit firms, the earnings before R&D expenditures is likely to be more strongly correlated with the omitted variable, stock of intangible assets and thus x_t contains information relevant for valuing the intangible assets, g_t. It follows that the pricing multiplier on

[13] We thank the reviewer for highlighting this intuition.

[14] In reporting regimes where a choice between capitalizing and expensing R&D is allowed such as for firms traded on the Australian exchange (Ahmed and Falk (2006)) and firms following IFRS 38, this framework can be extended to examine the value relevance of capitalization versus expensing.

x_t is likely to be positive and significant for profit firms. The R&D expenditures are likely to be highly correlated with the economic R&D amortization, and as such, for profit firms the pricing multiplier on R&D expenditures is likely to be negative. For loss firms, the earnings before R&D, x_t is not likely to be informative on the intangible assets (see the discussion above), and as such, the pricing multiplier is not likely to be significant. However, since R&D expenditures are likely to be informative about the intangible assets, for loss firms the pricing multiplier is likely to be positive and significant.

We summarize the above insights in the following observation.

2.1.1. Observation

For profit firms, earnings is a sufficient statistic in the sense that it contains value-relevant information on R&D productivity, while for loss firms earnings is not likely to be a sufficient statistic on R&D productivity and thus, components of earnings such as research and development expenditures are value-relevant. Specifically, the valuation multiplier on R&D expenditure is negative for profit firms and positive for loss firms.

With this insight we provide the empirical specification and testable hypotheses.

2.2. Empirical specification, proxies and hypotheses

We state the valuation expression in an empirically testable form:

$$P_{it} + d_{it} = \beta_0 + \beta_1 BV_{it-1} + \beta_2 EBRD_{it} + \beta_3 RD_{it} + error, \quad (1a)$$

$$P_{it} + d_{it} = \beta_0 + \beta_{1A} BV_{it-1} + \beta_{2A} E_{it} + error, \quad (1b)$$

P_{it} is price per share 3 months after the fiscal year end for firm i in year t where quarterly price was obtained from the Compustat quarterly database. d_{it} is dividends per share for firm i in year t. RD_{it} is research and development expense for firm i in year t. E_{it} is the earnings before extraordinary items available for common shareholders. $EBRD_{it}$ is earnings before R&D expense (E_{it} plus RD_{it}). BV_{it-1} is book value of equity for firm i at the end of year $t-1$. The independent variables are scaled by common shares outstanding.[15] All data, with the exception of quarterly price data, were obtained from the Compustat annual database. Eq. (1b) is the benchmark model, a specification considered in prior research on profit and loss firms (Collins et al. (1999)). Eq. (1a) is the augmented specification that disaggregates earnings into earnings before R&D expense and R&D expense.

We extend the insight from valuation expression (VAL) for the cross-sectional research design in Eqs. (1a) and (1b). For loss firms, the linear information dynamics assumption is not likely to be satisfied and thus, we expect R&D expense will have a positive coefficient. Because R&D expense contains information not contained in earnings, we expect that disaggregating R&D expense from earnings will improve the explanatory power of the model. For profit firms, the linear information dynamics assumption is more likely to be satisfied and thus, we expect R&D expense to have a negative coefficient with little improvement in explanatory power when R&D expense is disaggregated from earnings.

However, we note that differences in the analytical setting relative to the empirical setting may lead to observed results that differ from our expectations. For example, in the empirical setting, there are many more activities such as marketing, advertising and employee training that are similar to R&D spending and are contained in earnings. For loss firms, this could result in a coefficient on earnings before R&D that is positive or negative depending on whether any more value-relevant components other than R&D are contained in earnings.

Also, in the empirical setting, the linear information dynamics assumption may not be satisfied for profit firms, because profit for some firms may be a poor proxy for establishing whether the assumption is satisfied. Thus, R&D expense may contain information about future earnings that is not

[15] We also scaled all variables by prior period price (P_{it-1}) and obtained similar results.

contained in current earnings even when the firm is profitable.[16] This could lead to the pricing multiplier on R&D expense being negative but lower in magnitude than the positive pricing multiplier on earnings before R&D.[17]

We summarize the empirical expectations in the following hypotheses.

2.2.1. Hypotheses

H1: For loss firms, the coefficient on R&D expense is positive, i.e. $\beta_3 > 0$ and the adjusted R^2 of Eq. (1a) is higher than the adjusted R^2 of Eq. (1b).
H2: For profit firms, the coefficient on R&D expense is negative or zero, i.e. $\beta_3 \leqslant 0$ and the adjusted R^2 of Eq. (1a) is similar to the adjusted R^2 of Eq. (1b).

We proceed with the empirical analysis.

3. Sample and empirical analysis

3.1. Sample selection

The sample includes all firm-years with positive R&D expense between 1982 and 2002 for which data on all variables are available from Compustat. Similar to Collins et al. (1999), we delete firm-years with negative book value of equity, cumulative adjustment factors less than 0.1, and with common shares outstanding less than 10,000. All variables are winsorized at the top and bottom 1% of the distribution. To minimize the influence of outliers, we delete observations with Cook's D greater than 2 (see Belsley et al., 1980). The final sample consists of 47,167 positive R&D firm-years of which 18,636 are firm-years with negative earnings and 28,531 with positive earnings.

3.2. Descriptive statistics

Table 1, Panel A provides the descriptive statistics for profit and loss firms. Various size measures such as book value of equity, market value of equity and total assets indicate that loss firms are smaller in size than profit firms. Additionally, loss firms are younger than profit firms. Loss firms have a mean (median) age of 10 (7) years, while profit firms have a mean (median) age of 17 (13) years.[18] Loss firms have a mean (median) R&D expense to total assets (RDTA) of 0.20 (0.11) while profit firms have a mean (median) RDTA of 0.06 (0.04). This suggests that loss firms are relatively more R&D intensive, and the R&D growth rate for loss firms suggests that some loss firms have very high R&D growth. Loss firms have a mean (median) R&D growth [$\text{CHRD} = (\text{RD}_{it} - \text{RD}_{it-1})/\text{RD}_{it-1}$] of 63% (7%) while profit firms have a mean (median) R&D growth of 28% (12%). The mean (median) market to book ratio of loss firms of 8.54 (2.21) indicates that loss firms are not financially distressed, on average. Overall, the descriptive evidence on various characteristics of age, size and growth profile reflect life cycle differences across profit and loss firms.

In Table 1, Panel B, we provide the correlation among the variables for profit and loss firms separately. For loss firms, earnings before R&D expense is not highly correlated with R&D expense (corre-

[16] To see this, consider two generations of R&D expense with differing productivities. When the first generation R&D outlays satisfy the linear information dynamics, the second generation may still have a few years to go before satisfying the linear information dynamics assumptions. This is more likely to occur when there are break through/blockbuster R&D discoveries/products. We examine this considering only firms with large enough profits and firms with profits for the last three years. The results are qualitatively similar to those reported, suggesting that the linear information dynamics is satisfied, on average, for profit firms.

[17] In the analytical setting, the pricing multipliers on earnings before R&D and R&D expense for profit firms are equal but of opposite signs. To the extent that in the empirical setting, not all profit firms have full information about R&D productivity contained in earnings before R&D, the coefficient on R&D expense may be lower in magnitude than the coefficient on earnings before R&D.

[18] Age is the number of years that Compustat has covered the firm. The maximum age is 53 and the minimum age is 2.

Table 1
Descriptive statistics.

Variable	Mean			Median		
	Loss	Profit	Difference t-statistic	Loss	Profit	Difference Z-statistic
Panel A: descriptive statistics						
P_t	7.72	23.15	−86.08	3.88	16.13	−112.09
BV_{t-1}	261.95	852.55	−19.27	14.86	58.42	−68.88
E_t	−58.06	141.10	−31.53	−5.17	8.01	−186.26
$EBRD_t$	−29.04	227.24	−34.71	−1.25	15.23	−157.72
RD_t	29.02	86.14	−18.43	2.85	5.14	−32.42
REV_t	452.00	2339.14	−32.20	15.73	142.56	−102.07
$RDMV_t$	0.19	0.05	33.01	0.08	0.03	73.62
$RDTA_t$	0.20	0.06	32.82	0.11	0.04	79.19
$CHRD_t$	0.63	0.28	3.98	0.07	0.12	−15.15
MB_t	8.54	3.24	9.37	2.21	2.07	6.86
TA_t	664.58	2667.17	−21.86	26.07	128.12	−79.95
MV_t	472.52	2917.52	−28.11	34.95	161.93	−75.94
AGE_t	10.20	16.98	−66.92	7.00	13.00	−59.12

Variable	Loss				Profit			
	BV_{t-1}	E_t	$EBRD_t$	RD_t	BV_{t-1}	E_t	$EBRD_t$	RD_t
Panel B: Pearson correlations								
P_t	0.10327	−0.05156	0.01668	0.19357	0.32939	0.31914	0.34760	0.30504
BV_{t-1}		−0.55993	−0.45493	0.36597		0.80895	0.82381	0.64340
E_t			0.93749	−0.31233			0.93701	0.61096
$EBRD_t$				0.03781				0.84900

Notes to Table 1

1. In Panel A, the sample contains 47,167 firm-year observations with non-negative book value of equity and positive R&D expenditures. Sample sizes used for ratio calculations are reduced by deleting observations in which the variable in the denominator is zero.
2. Earnings (E) greater than or equal to zero are classified as Profit and negative earnings are classified as Loss. Earnings are measured as earnings before extraordinary items.
3. There are 28,531 firm-year observations for the Profit firms and 18,636 firm-year observations for the loss firms.
4. All of the Pearson correlations are statistically significant with p-values of less than .0001, with the exception of the correlation between P_t and $EBRD_t$ which has a p-value of .0263 for loss firms.

Variable definitions
P_t = price per share of the firm three months after the fiscal year end (Compustat quarterly data item 14).
BV_{t-1} = book value of equity at the beginning of time t (Compustat annual data item 60).
E_t = earnings before extraordinary items available for common shareholders (Compustat annual data item 237).
$EBRD_t$ = earnings before R&D expenditures, i.e. EBRD = E + RD.
RD_t = R&D expense (Compustat annual data item 46).
REV_t = Sales revenue (Compustat annual data item 12).
MV_t = market value of equity, computed as P_t multiplied by the number of shares outstanding (Compustat annual data item 25).
TA_t = total assets (Compustat annual data item 6).
$RDMV_t$ = RD divided by MV.
$RDTA_t$ = RD divided by TA.
$CHRD_t$ = change in R&D expenditures, i.e. CHRD = $[RD_t - RD_{t-1}]/RD_{t-1}$.
MB_t = market-to-book ratio, computed as the market value of equity divided by end of fiscal year book value of equity, i.e. MB = MV_{it}/BV_{it}.
AGE_t = the number of years as of year t that Compustat has been covering the firm. The minimum age is 2 years and the maximum age is 53.

lation of 4%); and for profit firms, earnings before R&D expense is highly correlated with R&D expense (correlation of 85%). This suggests that the linear information dynamics is likely to be satisfied for profit firms because information about R&D productivity is already contained in earnings. If R&D expense and earnings before R&D expenditures are linearly related for profit firms, then in statistical tests we may observe a pricing multiplier on R&D that is statistically insignificant due to multi-collinearity problems.

3.3. Value-relevance of R&D for loss firms

3.3.1. Benchmark model

We begin the empirical analysis by establishing a benchmark for our disaggregated model. In particular, for firms with R&D spending, we estimate the empirical specification of Collins et al.'s (1999), which is a version of Eq. (1b). It is given by the following model.

3.4. Model CPX

$$P_{it} + d_{it} = \beta_{0AL} + \beta_{0AD}D_{it} + \beta_{1AL}BV_{it-1} + \beta_{1AD}BV_{it-1}D_{it} + \beta_{2AL}E_{it} + \beta_{2AD}E_{it}D_{it} + \text{error},$$

where D_{it} is a dummy variable that is one if E_{it} is non-negative or zero otherwise, and all the variables are defined as in Eq. (1b).

Table 2 contains the results of estimating Model CPX annually. The mean coefficient on earnings for loss firms is 0.10 ($\beta_{2AL} = 0.10$) and is not statistically significant. In comparison, the mean coefficient on earnings for loss firms in Collins et al. (1999) is 0.16 and is marginally statistically significant. This difference could be due to our focus on a subset of loss firms that are engaged in R&D activity. Also, our sample includes the late '90s, a period characterized by an increase in R&D activity. We find, in the late 1990's, the coefficients on earnings of loss firms are statistically insignificant. Similar to Collins et al. (1999), we find a statistically significant large positive mean coefficient on earnings ($\beta_{2AL} + \beta_{2AD} = 9.11$) for profit firms. The coefficient on book value of equity for loss firms ($\beta_{1AL} = 0.88$) is statistically greater than that for profit firms (($\beta_{1AL} + \beta_{1AD} = 0.45$). In contrast, Collins et al. (1999) find that the coefficients on book value of equity are not different across profit and loss firms. This difference in the value-relevance of book value of equity across profit and loss firms in the R&D firms' sample considered here suggests that a portion of the value-relevance of book value of equity could be due to its correlation with R&D expenditures. The average explanatory power, the adjusted R^2, of Model CPX is 65%. The average adjusted R^2 in the pre-1994 time period is about 75% and drops to about 45% in the late 1990s. This could be a due to the following characteristics of the late 1990s: stock market exuberance, presence of more firms with losses, and increased R&D activity. Overall, the results are qualitatively similar to that of Collins et al. (1999) even though our sample includes only R&D firms.

3.4.1. Test of pricing multipliers on RD and EBRD for profit and loss firms

To test hypotheses H1 and H2 we augment the empirical specification in Model CPX by disaggregating earnings into earnings before R&D expense and R&D expense. It is given by the following model.

3.5. Model RD

$$P_{it} + d_{it} = \beta_{0L} + \beta_{0D}D_{it} + \beta_{1L}BV_{it-1} + \beta_{1D}BV_{it-1}D_{it} + \beta_{2L}EBRD_{it} + \beta_{2D}EBRD_{it}D_{it} + \beta_{3L}RD_{it} + \beta_{3D}RD_{it}D_{it} + \text{error},$$

where all the variables are as defined in Eq. (1a) and Model CPX.[19] We examine Model RD so that the results can be compared with Model CPX. While Model RD allows us to test the coefficient estimates on RD and EBRD across profits and loss firms, it is not conducive for the explanatory power tests, which we perform subsequently by estimating Eqs. (1a) and (1b).

Table 3 contains the results of estimating Model RD annually. The mean coefficient estimate on R&D expense for loss firms is 3.11 ($\beta_{3L} = 3.11$) and the mean coefficient estimate on R&D expense for profit firms is −4.47 ($\beta_{3L} + \beta_{3D} = -4.47$), thus providing support for hypotheses H1 and H2.

[19] R&D expense includes in-process R&D write-offs. In-process R&D write-offs by definition are a capitalized value of prior years R&D activity of the acquired company. Thus, R&D expense would be "noisy" for some of the firms. However, we do not expect this to systematically bias the coefficients. Also, R&D expense is before tax while earnings are after tax. Hence, by simply backing out R&D expense from earnings we do not account for the tax consequences of R&D. For testing hypothesis H1 and H2, this should not systematically bias our results.

Table 2
Equity valuation without disaggregating earnings.

Year	BV_{t-1}			E_t			N/Adj. R^2
	Loss β_{1AL}	Profit $\beta_{1AL}+\beta_{1AD}$	Diff. β_{1AD}	Loss β_{2AL}	Profit $\beta_{2AL}+\beta_{2AD}$	Diff. β_{2AD}	
1982	0.67	0.16	−0.51	1.14	7.73	6.59	1593
	(14.62)	(2.83)	(−6.87)	(3.88)	(15.60)	(11.42)	.6332
1983	0.79	0.39	−0.40	0.52	6.87	6.36	1753
	(11.64)	(6.89)	(−4.57)	(2.04)	(15.14)	(12.23)	0.7263
1984	0.66	0.33	−0.32	0.57	7.30	6.73	1829
	(10.82)	(7.04)	(−4.20)	(3.04)	(20.18)	(16.52)	0.8045
1985	1.06	0.48	−0.57	0.51	9.01	8.51	1792
	(15.55)	(7.53)	(−6.16)	(1.66)	(19.20)	(15.19)	0.7989
1986	1.00	0.64	−0.36	−0.09	9.66	9.75	1861
	(7.92)	(8.69)	(−2.44)	(−0.13)	(17.00)	(10..84)	0.7869
1987	0.68	0.63	−0.05	0.12	7.61	7.49	1900
	(7.76)	(9.10)	(−0.42)	(0.32)	(15.57)	(12.20)	0.7899
1988	1.08	0.53	−0.55	0.37	7.92	7.55	1864
	(11.56)	(6.99)	(−4.57)	(1.33)	(15.36)	(12.86)	0.8212
1989	0.88	0.56	−0.32	0.81	7.88	7.07	1781
	(13.55)	(6.09)	(−2.83)	(3.30)	(13.13)	(10.90)	0.7639
1990	0.62	0.24	−0.38	−0.31	10.48	10.79	1789
	(7.11)	(3.16)	(−3.22)	(−0.50)	(17.50)	(12.51)	0.7046
1991	0.82	0.47	−0.36	0.23	10.44	10.21	1858
	(8.27)	(6.29)	(−2.89)	(0.42)	(15.51)	(11.75)	0.6832
1992	1.03	0.57	−0.45	0.39	10.27	9.88	1983
	(12.40)	(7.08)	(−3.91)	(1.22)	(14.99)	(13.03)	0.7154
1993	1.02	0.78	−0.25	0.12	9.86	9.74	2171
	(10.34)	(9.82)	(−1.94)	(0.32)	(17.76)	(14.63)	0.7248
1994	1.01	0.62	−0.39	0.26	9.64	9.38	2294
	(6.24)	(8.22)	(−2.18)	(0.75)	(18.19)	(14.88)	0.7248
1995	1.35	0.49	−0.87	−0.03	8.97	9.00	2569
	(10.56)	(5.69)	(−5.63)	(−0.06)	(17.13)	(11.42)	0.5437
1996	0.96	0.44	−0.53	0.02	10.62	10.60	2846
	(8.93)	(4.57)	(−3.64)	(0.06)	(17.68)	(16.02)	0.6554
1997	1.56	0.52	−1.04	−0.93	10.82	11.75	3011
	(11.10)	(4.48)	(−5.72)	(−2.06)	(14.68)	(13.60)	0.5606
1998	0.99	0.27	−0.73	−0.49	10.55	11.04	2940
	(7.66)	(2.16)	(−4.07)	(−1.00)	(14.81)	(12.79)	0.3852
1999	0.10	−0.01	−0.10	−3.22	8.22	11.43	2859
	(0.72)	(−0.00)	(−0.57)	(−4.24)	(10.81)	(10.64)	0.1787
2000	0.56	0.31	−0.25	0.30	8.01	7.71	2981
	(4.95)	(3.77)	(−1.78)	(1.27)	(13.51)	(12.09)	0.3941
2001	0.93	0.65	−0.28	1.26	10.03	8.77	2970
	(13.79)	(6.33)	(−2.30)	(8.53)	(10.58)	(9.14)	0.5756
2002	0.73	0.29	−0.44	0.58	9.62	9.03	2524
	(8.94)	(3.36)	(−3.66)	(2.83)	(13.50)	(12.17)	0.6176
Mean	**0.88**	**0.45**	**−0.44**	**0.10**	**9.11**	**9.02**	
t-Stat	(13.47)	(10.75)	(−8.57)	(0.51)	(33.08)	(24.95)	0.6471

Notes to Table 2

1. Model CPX: $P_{it} + d_{it} = \beta_{0AL} + \beta_{0AD}\, D_{it} + \beta_{1AL}\, BV_{it-1} + \beta_{1AD}\, BV_{it-1}D_{it} + \beta_{2AL}\, E_{it} + \beta_{2AD}\, E_{it}\, D_{it}$ + error.
2. In top row for each year is the coefficient estimate.
3. The bottom row in parenthesis is the White's (1980) heteroscedasticity corrected *t*-statistic.
4. The row mean is the mean of the annual coefficients.
5. The *t*-statistic of the mean is the time-series *t*-statistic of the annual coefficients.
6. The sample contains 47,167 firm-year observations with non-negative book value of equity and positive R&D expenditures. There are 28,531 observations in the profit sample and 18,636 in the loss sample.

Variable definitions

P_{it} is price per share 3 months after the fiscal year end for firm *i* in year *t* was obtained from Compustat quarterly database. d_{it} is dividends per share for firm *i* in year *t*. RD_{it} is research and development expense for firm *i* in year *t*, E_{it} is the earnings before extraordinary items available for common shareholders, $EBRD_{it}$ is E_{it} plus RD_{it}, and BV_{it-1} is book value of equity per share for firm *i* at the beginning of year *t*. The independent variables are scaled by common shares outstanding. D_{it} takes on a value of one if E_{it} is greater than or equal to zero, and zero otherwise.

Table 3
Equity valuation – disaggregating earnings.

Year	BV_{t-1}			$EBRD_t$			RD_t			N/Adj. R^2
	Loss β_{1L}	Profit $\beta_{1L}+\beta_{1D}$	Diff. β_{1D}	Loss β_{2L}	Profit $\beta_{2L}+\beta_{2D}$	Diff. β_{2D}	Loss β_{3L}	Profit $\beta_{3L}+\beta_{3D}$	Diff. β_{3D}	
1982	0.55	−0.06	−0.61	1.15	7.41	6.26	2.66	−1.05	−3.71	1593
	(10.94)	(−1.06)	(−8.03)	(3.86)	(16.56)	(11.63)	(2.96)	(−1.41)	(−3.19)	0.6915
1983	0.71	0.28	−0.43	0.64	6.38	5.74	2.30	−2.42	−4.72	1753
	(12.35)	(5.10)	(−5.48)	(2.55)	(14.78)	(11.51)	(2.43)	(−3.42)	(−3.99)	0.7475
1984	0.63	0.28	−0.36	0.71	6.95	6.24	0.65	−4.62	−5.26	1829
	(9.87)	(5.56)	(−4.40)	(3.98)	(19.15)	(15.44)	(1.09)	(−7.72)	(−6.25)	0.8122
1985	0.93	0.38	−0.55	0.81	8.38	7.57	2.30	−4.68	−6.97	1792
	(14.98)	(5.98)	(−6.24)	(2.82)	(17.56)	(13.57)	(3.47)	(−5.72)	(−6.63)	0.8126
1986	0.86	0.51	−0.35	0.10	9.15	9.04	3.09	−5.52	−8.60	1861
	(6.91)	(7.02)	(−2.44)	(0.15)	(16.63)	(10.24)	(2.91)	(−6.22)	(−6.22)	0.7980
1987	0.55	0.54	−0.00	0.33	7.21	6.88	2.09	−4.58	−6.68	1900
	(5.10)	(8.16)	(−0.03)	(1.01)	(14.77)	(11.73)	(2.88)	(−5.39)	(−5.97)	0.7982
1988	0.96	0.43	−0.54	0.51	7.68	7.18	1.16	−5.04	−6.20	1864
	(10.15)	(5.95)	(−4.52)	(1.79)	(15.21)	(12.40)	(2.07)	(−6.26)	(−6.32)	0.8290
1989	0.76	0.50	−0.26	1.13	7.62	6.50	1.09	−5.75	−6.84	1781
	(10.76)	(5.38)	(−2.26)	(4.62)	(12.81)	(10.10)	(1.64)	(−6.59)	(−6.24)	0.7685
1990	0.44	0.20	−0.25	0.22	10.25	10.03	3.13	−8.77	−11.90	1789
	(5.10)	(2.55)	(−2.13)	(0.39)	(16.94)	(12.11)	(3.10)	(−9.16)	(−8.55)	0.7103
1991	0.66	0.40	−0.26	0.89	10.19	9.31	3.25	−8.42	−11.67	1858
	(7.37)	(5.39)	(−2.20)	(1.89)	(15.07)	(11.30)	(3.95)	(−9.01)	(−9.37)	0.6921
1992	0.96	0.52	−0.44	0.75	10.06	9.31	0.81	−8.65	−9.47	1983
	(10.17)	(6.42)	(−3.53)	(2.38)	(14.80)	(12.41)	(1.27)	(−9.83)	(−8.69)	0.7185
1993	0.91	0.67	−0.24	0.79	9.38	8.59	2.21	−6.37	−8.58	2171
	(9.89)	(9.01)	(−2.02)	(2.08)	(17.20)	(12.91)	(3.60)	(−7.83)	(−8.42)	0.7389
1994	0.91	0.53	−0.38	0.61	8.87	8.26	1.44	−5.29	−6.73	2294
	(4.90)	(7.35)	(−1.89)	(1.82)	(16.83)	(13.25)	(2.17)	(−6.70)	(−6.51)	0.7411
1995	0.98	0.35	−0.63	2.08	8.27	6.19	5.09	−3.52	−8.61	2568
	(6.85)	(4.25)	(−3.81)	(3.41)	(16.23)	(7.79)	(5.46)	(−4.14)	(−6.83)	0.5759
1996	0.75	0.29	−0.46	0.92	10.00	9.08	3.40	−5.48	−8.88	2846
	(8.40)	(3.10)	(−3.55)	(2.89)	(17.02)	(13.60)	(6.41)	(−6.49)	(−8.90)	0.6816
1997	1.19	0.33	−0.86	0.13	10.43	10.30	5.24	−5.65	−10.90	3011
	(7.92)	(2.82)	(−4.48)	(0.26)	(14.57)	(11.72)	(6.70)	(−5.49)	(−8.42)	0.5875
1998	0.75	0.06	−0.69	0.27	9.61	9.34	3.77	−2.52	−6.29	2940
	(4.82)	(0.49)	(−3.52)	(0.53)	(13.71)	(10.81)	(4.45)	(−2.23)	(−4.45)	0.4261
1999	−0.24	−0.35	−0.12	−1.22	6.98	8.20	10.51	3.30	−7.21	2859
	(−1.55)	(−3.14)	(−0.62)	(−1.51)	(9.61)	(7.54)	(8.44)	(2.51)	(−3.98)	0.2439
2000	0.36	0.10	−0.26	1.16	7.55	6.39	5.68	−1.56	−7.24	2981
	(3.13)	(1.23)	(−1.88)	(4.26)	(13.15)	(10.06)	(7.76)	(−1.63)	(−6.02)	0.4430
2001	0.74	0.32	−0.43	1.56	10.06	8.50	3.26	−1.32	−4.58	2970
	(11.03)	(3.37)	(−3.70)	(11.07)	(11.71)	(9.77)	(6.78)	(−1.08)	(−3.49)	0.6373
2002	0.64	0.21	−0.43	1.23	9.20	7.97	2.08	−6.16	−8.25	2524
	(8.29)	(2.39)	(−3.61)	(6.16)	(13.03)	(10.86)	(3.92)	(−5.92)	(−7.05)	0.6357
Mean	**0.71**	**0.31**	**−0.41**	**0.70**	**8.65**	**7.95**	**3.11**	**−4.47**	**−7.59**	
t-Stat	(11.07)	(6.08)	(−9.38)	(4.91)	(30.48)	(26.08)	(6.47)	(−7.18)	(−15.62)	0.6709

Notes to Table 3

1. Model RD: $P_{it} + d_{it} = \beta_{0L} + \beta_{0D}\, D_{it} + \beta_{1L}\, BV_{it-1} + \beta_{1D} BV_{it-1} D_{it} + \beta_{2L} EBRD_{it} + \beta_{2D} E_{it} D_{it} + \beta_{3L} RD_{it} + \beta_{3D} RD_{it} D_{it} +$ error
2. In top row for each year is the coefficient estimate.
3. The bottom row in parenthesis is the White's (1980) heteroscedasticity corrected *t*-statistic.
4. The row mean is the mean of the annual coefficients.
5. The *t*-statistic of the mean is the time-series *t*-statistic of the annual coefficients.
6. The sample contains 47,167 firm-year observations with non-negative book value of equity and positive R&D expenditures. There are 28,531 observations in the profit sample and 18,636 in the loss sample.

Variable definitions

P_{it} is price per share 3 months after the fiscal year end for firm *i* in year *t* was obtained from Compustat quarterly database. d_{it} is dividends per share for firm *i* in year *t*. RD_{it} is research and development expense for firm *i* in year *t*, E_{it} is the earnings before extraordinary items available for common shareholders, $EBRD_{it}$ is E_{it} plus RD_{it}, and BV_{it} is book value of equity per share for firm *i* at the end of year *t*. The independent variables are scaled by common shares outstanding. D_{it} takes on a value of one if E_{it} is greater than or equal to zero, and zero otherwise.

Table 4
Equity valuation – explanatory power of disaggregated earnings.

	Loss							Profit						
	Eq. (1a)				Eq. (1b)			Eq. (1a)				Eq. (1b)		
	BV_{t-1} β_1	$EBRD_t$ β_2	RD_t β_3	N Adj. R^2	BV_{t-1} β_{1A}	E_t β_{2A}	N Adj. R^2	BV_{t-1} β_1	$EBRD_t$ β_2	RD_t β_3	N Adj. R^2	BV_{t-1} β_{1A}	E_t β_{2A}	N Adj. R^2
Panel A: whole sample														
Mean	0.71	0.70	3.11	18634	0.88	0.10	18634	0.31	8.65	−4.48	28531	0.45	9.11	28531
t-Stat	(11.07)	(4.91)	(6.47)	0.4371	(13.47)	(0.52)	0.3863	(6.08)	(30.48)	(−7.18)	0.6338	(10.75)	(33.10)	0.6089
Panel B: high R&D intensity														
Mean	0.30	0.88	4.00	9015	0.91	−0.22	9015	−0.16	12.12	−8.13	4863	0.46	12.84	4863
t-Stat	(2.91)	(3.47)	(6.47)	0.3218	(10.49)	(−0.97)	0.2226	(−0.93)	(16.62)	(−8.62)	.5676	(3.62)	(16.36)	0.5528
Panel C: medium R&D intensity														
Mean	0.45	0.77	5.77	6106	1.01	0.42	6106	0.24	9.03	−4.86	12768	0.55	9.78	12768
t-Stat	(2.52)	(3.90)	(4.26)	0.5136	(12.91)	(1.57)	0.4598	(2.78)	(23.34)	(−6.81)	0.6485	(10.09)	(21.33)	0.6367
Panel D: low R&D intensity														
Mean	0.69	0.31	5.24	10631	0.82	0.21	10631	0.42	7.83	−4.47	3513	0.51	7.97	3513
t-Stat	(13.30)	(1.33)	(3.66)	0.4967	(12.57)	(0.86)	0.4703	(11.84)	(25.81)	(−5.74)	0.6443	(14.09)	(26.47)	0.6376

Notes to Table 4

1. Eq. (1a): $P_{it} + d_{it} = \beta_0 + \beta_1\ BV_{it-1} + \beta_2\ EBRD_{it} + \beta_3\ RD_{it}$ + error.
2. Eq. (1b): $P_{it} + d_{it} = \beta_0 + \beta_{1A}\ BV_{it-1} + \beta_{2A}\ E_{it}$ + error.
3. The row mean is the mean of the annual coefficients.
4. The *t*-statistic of the mean is the time-series *t*-statistic of the annual coefficients.
5. A firm is classified as PROFIT if E_{it} is greater than or equal to zero and LOSS if E_{it} is negative.
6. High (low) R&D intensity are firms in the top (bottom) 30% of the RD/TA sorted each year and the remaining 40% constitute the medium R&D intensity.
7. The sample contains 47,167 firm-year observations with non-negative book value of equity and positive R&D expenditures. There are 28,531 observations in the profit sample and 18,636 in the loss sample.

Variable definitions

P_{it} is price per share 3 months after the fiscal year end for firm *i* in year *t* was obtained from Compustat quarterly database. d_{it} is dividends per share for firm *i* in year *t*. RD_{it} is research and development expense for firm *i* in year *t*, E_{it} is the earnings before extraordinary items available for common shareholders, $EBRD_{it}$ is E_{it} plus RD_{it}, and BV_{it} is book value of equity per share for firm *i* at the end of year *t*. The independent variables are scaled by common shares outstanding.

The mean coefficient estimate on earnings before R&D expense for loss firms is positive and statistically significant ($\beta_{2L} = 0.70$) and the mean coefficient estimate on earnings before R&D expense for profit firms is positive and statistically significant ($\beta_{2L} + \beta_{2D} = 8.65$). In comparison, estimates of Model CPX show a positive but statistically insignificant mean coefficient on earnings of 0.10 ($\beta_{2AL} = 0.10$, see Table 2) for loss firms. Without the disaggregation of earnings, the coefficient on R&D expense is not allowed to differ from the coefficient on earnings and as a result, the coefficient on earnings for loss firms is statistically insignificant. For profit firms, as expected, the results from the disaggregated model (Model RD) are qualitatively similar to those obtained by estimating Model CPX.

The adjusted R^2 of Model RD is 67%, whereas the adjusted R^2 of Model CPX is 65%. This represents an improvement of roughly 3% (=(67−65)/65) in the explanatory power of Model RD. The improvement in explanatory power is slightly more in later years than in earlier years.

In unreported analysis, we also estimate Model RD without EBRD. Comparing the results from estimating these specifications of the valuation model (Model RD compared to Model RD without EBRD), we can gain insights into whether EBRD contains information on R&D activity as suggested by the residual-income valuation model or whether R&D activity is less productive for profit firms when compared to that of loss firms. In estimating Model RD without EBRD, we find that, on average, the coefficient on R&D expense for loss and profit firms is positive and statistically significant: 3.51 ($t = 7.74$) and 5.90 ($t = 12.88$), respectively. The coefficient on R&D expense for profit firms is larger than that for loss firms suggesting that the results discussed in Table 2 are likely due to earnings before R&D containing information on R&D productivity for profit firms.

3.5.1. Estimating Eqs. (1a) and (1b)

Hypotheses H1 and H2 predict differential improvement in explanatory power of disaggregating earnings across profit and loss firms. Model CPX is not conducive for testing the differential improvement in explanatory power. Therefore, we examine the difference in explanatory power of Eqs. (1a) and (1b) for the profit and loss firms. We expect that disaggregating R&D expense from earnings will improve the explanatory power for loss firms, but not for profit firms.

Panel A of Table 4 presents the mean of the annual estimates of Eqs. (1a) and (1b) separately for profit and loss firms. For loss firms the average adjusted R^2 is 44% when earnings is disaggregated (Eq. (1a)), whereas the average adjusted R^2 is 39% when earnings is not disaggregated (Eq. (1b)), representing an increase of approximately 5%. In contrast for profit firms, the average adjusted R^2s are 63% and 61% from the disaggregated earnings model (Eq. (1a)) and aggregated earnings model (Eq. (1b)), respectively. This shows that the incremental explanatory power of the disaggregated earnings model is more for loss firms than profit firms.

3.5.2. R&D intensity and value-relevance of R&D across profit and loss firms

We examine the incremental explanatory power across Eqs. (1a) and (1b) by partitioning the profit and loss samples based on the level of the R&D intensity of the firm. The analytical insights and corresponding hypotheses are derived in a setting where earnings are driven solely by R&D investment. However, since profits are not only generated by R&D activity, but also other activities that create unrecognized intangible assets such as marketing, advertising and employee training, we consider firms where R&D is likely to be the most significant activity. Thus, we partition firms into high, medium and low R&D to assets, i.e. R&D intensity. This serves as a check on the robustness of the linear information dynamics assumption and allows us to gain insights into the characteristics of firms where the empirical specification of Eq. (1a) would be more appropriate than Eq. (1b). We classify firms that are in the top (bottom) 30% of R&D expense to total assets each year as the high (low) R&D intensity firms and the remaining 40% are the medium R&D intensity firms. Panels B, C and D of Table 4, present the results of estimating Eqs. (1a) and (1b) separately for profit and loss firms across the R&D intensity levels. For high R&D intensity loss firms (Panel B of Table 4), disaggregating earnings leads to a 10% increase in the explanatory power. Specifically, for high R&D intensity loss firms, this represents a 45% (=(0.3218 − .2226)/0.2226 = 0.45) improvement in the explanatory power of the model when earnings is disaggregated. Consistent with H1 and H2, the mean coefficient estimate on R&D expense is significantly positive (negative) for loss (profit) firms across levels of R&D intensity.

Table 5

Equity valuation of firms that transition from loss to profit.

	$Loss_{t-2}$				$Loss_{t-1}$				$Profit_t$			
	BV_{t-1} β_1	$EBRD_t$ β_2	RD_t β_3	N Adj. R^2	BV_{t-1} β_1	$EBRD_t$ β_2	RD_t β_3	N Adj. R^2	BV_{t-1} β_1	$EBRD_t$ β_2	RD_t β_3	N Adj. R^2
Panel A: Firms with positive R&D expense and a pattern of reported earnings of a profit following two consecutive losses.												
Coef.	0.64	0.43	1.90	1487	0.73	1.48	2.70	1487	0.71	3.78	0.83	1487
t-Stat	(11.74)	(1.52)	(4.16)	0.50	(12.01)	(5.38)	(4.81)	0.40	(7.66)	(4.71)	(0.69)	0.40

	$Loss_{t-3}$				$Loss_{t-2}$				$Profit_{t-1}$				$Profit_t$			
	BV_{t-1} β_1	$EBRD_t$ β_2	RD_t β_3	N Adj. R^2	BV_{t-1} β_1	$EBRD_t$ β_2	RD_t β_3	N Adj. R^2	BV_{t-1} β_1	$EBRD_t$ β_2	RD_t β_3	N Adj. R^2	BV_{t-1} β_1	$EBRD_t$ β_2	RD_t β_3	N Adj. R^2
Panel B: firms with positive R&D expense and a pattern of reported earnings of 2 years of profits following two consecutive losses.																
Coef.	0.73	0.54	1.34	781	0.80	1.35	2.17	781	0.63	6.33	−2.15	781	0.53	5.68	−1.60	781
t-Stat	(10.88)	(1.32)	(2.41)	0.62	(11.26)	(3.75)	(3.45)	0.52	(5.80)	(6.16)	(−1.30)	0.48	(5.01)	(6.41)	(−1.23)	0.50

Notes to Table 5

1. Eq. (1a): $P_{it} + d_{it} = \beta_0 + \beta_1 BV_{it-1} + \beta_2 EBRD_{it} + \beta_3 RD_{it}$ + error.
2. In top row 'Coef.' is the coefficient estimate.
3. The bottom row '*t*-stat' in parenthesis is the White's (1980) heteroscedasticity corrected *t*-statistic.
4. A firm is classified as profit if E_{it} is greater than or equal to zero and loss if E_{it} is negative.

Variable definitions

P_{it} is price per share 3 months after the fiscal year end for firm *i* in year *t* was obtained from Compustat quarterly database. d_{it} is dividends per share for firm *i* in year *t*. RD_{it} is research and development expense for firm *i* in year *t*, E_{it} is the earnings before extraordinary items available for common shareholders, $EBRD_{it}$ is E_{it} plus RD_{it}, and BV_{it} is book value of equity per share for firm *i* at the end of year *t*. The independent variables are scaled by common shares outstanding.

3.5.3. Transition from loss to profit

In Table 5, we report the results of estimating Eq. (1b) for firms that transition from losses to profits. The results are reported for a constant sample of firms that have (1) positive R&D spending and (2) exhibit a particular pattern of earnings over consecutive years. We report the results for each year of the pattern. In Panel A, the required pattern of earnings is two consecutive years of losses followed by one year of profit. Consistent with hypothesis H1, the coefficient estimates on R&D expense are significantly positive when the firm reports losses (1.90 and 2.70 in $t-2$ and $t-1$ respectively). In the profit year following the two consecutive losses, the coefficient estimate on R&D expense is insignificantly different from zero (0.83 with a t-stat of 0.69). While this does not support hypothesis H2, that is, we do not find a statistically significant negative coefficient on R&D expense, but it is not positive and statistically significant, and thus H2 cannot be rejected. The coefficient estimate on earnings is increasing from year $t-2$ to year t (0.43, 1.48 and 3.78 with corresponding t-statistics of 1.52, 5.38 and 4.71 for years $t-2$, $t-1$ and t, respectively). This indicates that as earnings contains more information about the expected benefits to R&D spending, the R&D expense is less value relevant. In Panel B, we extend the pattern of earnings to include an additional year of profits, so that the profit is not purely transitory. The results are qualitatively similar to those reported in Panel A of Table 5.

4. Conclusions

The residual-income valuation framework highlights the factors that can affect the role of R&D expense in valuation across firms and within firms, across time. The insights that we derive show that caution should be exercised for profit firms when conclusions on the value relevance of R&D activity are drawn from the association of R&D expense and stock value alone. Consistent with the analytical insight from the residual-income valuation framework, we find that R&D expense is positively (negatively) associated with stock prices for loss (profit) firms. The explanatory power of disaggregating earnings for high R&D intensity loss firms results in a 45 percent improvement in adjusted R^2.

The results suggest several avenues for future research. While we highlight the role of information on R&D productivity in valuation across profit and loss firms, it is an open empirical question as to whether or how R&D related disclosures affect valuation. Anecdotal evidence suggests that R&D firms that transition from losses to profits become sensitive to amounts reported as R&D expense and the impact of such investment on bottom line earnings.[20] An explanation for this may be the changes in the valuation of earnings and R&D expense across profit and loss firms that we highlight in our model. Future research may provide further evidence on whether the market fixates on bottom-line earnings for profitable, innovative R&D firms and if so, whether additional disclosures mitigate the problem.

Appendix A. Appendix: R&D valuation in profit and loss firms

Consider one firm that starts operations at time $t = 0$ and generates earnings in period t denoted by e_t. Period t starts from time $j = (t-1)$ to $j = t$. To keep the model simple and generate insights into profit and loss firms, we do not assume any uncertainty. During each period the firm invests y_t in R&D activity. The benefit from R&D expenditure of y_t accrues over k periods, i.e., from t to $(t+k)$. Thus, the total benefit x_t in period t arises from R&D activity in periods t, $(t-1),\ldots,(t-k)$, and is given by $x_t = \Sigma_{m=1,k}\delta_m y_{(t-m+1)} I_m$ where $I_m = 1$ for $(t-m+1) > 0$, or $I_m = 0$ if $(t-m+1) \leqslant 0$, and δ_k is the productivity parameter of R&D spending k-periods after the R&D spending: δ_1 refers to the contribution of R&D spending to earnings before R&D in the year of R&D spending, δ_2 refers to the contribution of R&D spending to earnings before R&D in the year after the R&D spending, and so on. Following the conservative accounting convention of writing-off R&D expenditure, the earnings is given by $e_t = x_t - y_t$. The firm's book value of equity at time t is given by b_t. The firm invests $y_t = \theta y_{t-1}$ in R&D activity and maintains book value of equity at time t of $b_t = \theta b_{t-1}$ to sustain the growth. Also, the first period starts from

[20] For instance, an article in Forbes entitled, "Putting a Spin on R&D" (Moukheiber, 1999) highlights this transition for Alza Corp., a pharmaceutical firm. Alza Corp reported large R&D expenses on its income statement for many years in which the firm had reported losses, but when Alza began reporting profits, the firm sought ways to keep this same R&D spending off of the income statement.

$t = 0$ to $t = 1$. The stock variables b_t exists at $t = 0$, but the flow variables occur in period 1 and are registered in x_1 and y_1. The firm's cost of capital is R which is assumed to be greater than the growth rate, i.e., $R > \theta$. The abnormal earnings in period t is denoted $a_t = e_t - (R-1)b_{t-1}$.

We assume that e_t for $t < k$ is negative because the benefit from prior period R&D spending is not sufficient to offset the initial period's net benefit of R&D spending (see the text for an illustration). We assume that e_t is positive for $t \geqslant k$, because the contribution of benefit from all prior periods' R&D spending has occurred, and consequently steady state is achieved: if this assumption is not satisfied then it would imply that R&D spending is not a viable investment.

We first derive Eq. (VAL) for profit firms, i.e. for $t \geqslant k$. For $t \geqslant k$, we first show that the firm is profitable and the linear information dynamics is satisfied, i.e. the abnormal earnings in a period can be expressed as the growth rate times the abnormal earnings of the previous period.

For $t \geqslant k$

$$\begin{aligned} a_t &= e_t - (R-1)b_{t-1} \\ &= x_t - y_t - (R-1)b_{t-1} \\ &= [\sum_{m=1,k} \delta_m y_{(t-m+1)}] - y_t - (R-1)b_{t-1} \\ &= [y_{(t-k+1)} \sum_{m=1,k} \delta_m \theta^{(k-m)}] - \theta^{(k-1)} y_{(t-k+1)} - (R-1)b_{t-1} \\ &= [\{\Delta - \theta^{(k-1)}\}] y_{(t-k+1)} - (R-1)b_{t-1} \\ &= [\{\Delta - \theta^{(k-1)}\}] \theta y_{(t-k)} - (R-1)\theta b_{t-2} \\ &= \theta a_{t-1} \end{aligned}$$

Given that the linear information dynamics assumption is satisfied, we introduce the other assumptions as in Ohlson (1995) to derive (VAL) for profit firms. The clean surplus relation is given by

$$b_t = b_{t-1} + e_t - d_t \qquad \text{(CS)}$$

Starting with the dividend discount model, the valuation for $t \geqslant k$ is given by

$$P_t = \sum_{j=(t+1)}^{\infty} d_j / R^{j-t} \qquad \text{(PVED)}$$

Using the linear information dynamics assumption given by $a_t = \theta a_{t-1}$ for $t \geqslant k$, (CS) in (PVED) similar to Ohlson (1995) we obtain

$$P_t = b_t + \alpha a_t$$

where $\alpha = \theta/(R-\theta)$. Rewriting the above using the clean surplus relation (i.e. Eq. (CS)) to substitute for dividends, d_t the definition of abnormal earnings, (i.e. $a_t = e_t - (R-1)b_{t-1}$) and the definition of earnings (i.e. $e_t = x_t - y_t$), we get Eq. (VAL) with $\beta_1 = R(1-\theta)/(R-\theta)$ and $\beta_2 = -\beta_3 = R/(R-\theta)$ for $t \geqslant k$.

Note that the valuation expression is over determined in the sense that we can set the pricing multiplier on R&D activity to zero and correspondingly compensate the loadings on earnings and book value. We choose this solution to emphasize the intuition that bottom-line earnings ($e_t = x_t - y_t$) is sufficient without backing out R&D expenditure when the firm makes profits.

For $t < k$

Note that for $t < k$, $a_t \neq \theta a_{t-1}$ and as such, we cannot use the linear information dynamics directly. In other words, we cannot use the same algebraic derivation as we did for $t \geqslant k$. For $t < k$, we note the following $x_{t+1} = \theta x_t + \delta_{t+1} y_t$, $x_{t+2} = \theta x_{t+1} + \delta_{t+2} y_t$, and so on. Also, y_t and b_t are assumed to grow at the rate θ. We use this relationship in the valuation derivation

$$\begin{aligned} P_t &= b_t + R^{-1}[e_{t+1} - (R-1)b_t] + R^{-2}[e_{t+2} - (R-1)\theta b_t] + R^{-3}[e_{t+3} - (R-1)\theta^2 b_{t+2}] + \cdots \\ &= b_t + R^{-1}[\theta x_t - \theta y_t + \delta_{t+1} y_t - (R-1)b_t] + R^{-2}[\theta x_{t+1} - \theta y_{t+1} + \delta_{t+2} y_t - (R-1)\theta b_t] \\ &\quad + R^{-3}[\theta x_{t+2} - \theta y_{t+2} + \delta_{t+3} y_t - (R-1)\theta^2 b_t] + \cdots \end{aligned}$$

Substituting for x_{t+1}, x_{t+2}, and so on, we get

$$P_t = b_t + R^{-1}[\theta x_t - \theta y_t + \delta_{t+1} y_t - (R-1)b_t] + R^{-2}[\theta^2 x_t - \theta^2 y_t + \theta\delta_{t+1} y_t + \delta_{t+2} y_t - (R-1)\theta b_t] + R^{-3}[\theta^3 x_t - \theta^3 y_t + \theta^2 \delta_{t+1} y_t + \theta\delta_{t+2} y_t + \delta_{t+3} y_t - (R-1)\theta^2 b_{t+2}] + \cdots$$

Collecting terms and using the infinite sum of geometric series we get

$$P_t = [(1-\theta)/(R-\theta)]b_t + [\theta/(R-\theta)]x_t + [\theta/(R-\theta)]\left[\left\{\sum_{i=1}^{k-t} \delta_{t+i}/R^{(i-1)}\theta\right\} - 1\right]y_t$$

Using (CS) and following Collins et al. (1999) we get the Eq. (VAL) for loss firms.

Here again, the solution is over-determined. However, R&D activity has an independent pricing multiplier based on the productivity of R&D. This is related to R&D activity being a positive net present value product.

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