R&D expenses, R&D capitalization, the book-to-price ratio and the cross-section of returns*

Martin M. Kapons†
m.m.kapons@tilburguniversity.edu
Tilburg School of Economics and Management
Tilburg University

September 18, 2020

*I am indebted to many helpful comments by Peter Easton and Harm Schütt. I also thank Mustafa Ahci, Stephan Hollander, Philip Joos, Robin Litjens, Christoph Sextroh, Jake Zureich, and seminar participants at Tilburg University for helpful feedback. Main parts of this paper have been written during my research visit at the University of Notre Dame and I thank the colleagues at the University of Notre Dame for their hospitality; I also gratefully acknowledge the funding for this research visit by the Center for Accounting Research and Education (CARE).

†Tilburg School of Economics and Management, Tilburg University, 5000LE Tilburg, The Netherlands.

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Abstract

I study whether capitalized R&D is more informative about future realized returns than R&D expenditures. A book-to-price ratio that is adjusted for capitalized R&D has a more significant association with future returns than the unadjusted book-to-price ratio. However, the predictive ability of the unadjusted B/P ratio and the R&D-to-price ratio combined is higher than that of the R&D capitalization adjusted B/P ratio. Also, capitalized-R&D-to-price and expensed-R&D-to-price are equally informative about future realized returns when evaluated as separate variables. This holds for firms with a long (short) history of R&D spending and when varying the useful life of capitalized R&D across time within R&D intensive industries. But in a sub-sample of firms with no current R&D expenditures but positive capitalized R&D, capitalized R&D has no statistically significant association with future returns.

Keywords: R&D capitalization; unconditional conservatism; intangibles; book-to-price

JEL Classification: G12, G14, M41

1 Introduction

There is widespread consensus that research and development (R&D) activities are on average positively associated with future benefits. Irrespective of this consensus, there is an ongoing debate regarding expensing versus capitalizing intangible investments. While it has been shown that a capitalized R&D asset is associated with future returns and that R&D expenses scaled by price are associated with future realized returns, there is no study that compares which of the variables is more informative. This can be helpful in further understanding how R&D is priced. It can also inform the debate of expensing versus capitalizing R&D by showing which variable, a capitalized R&D asset or R&D expenditures, is more informative about future realized returns in the current regime of R&D expensing under U.S. GAAP. Therefore, I study whether capitalizing R&D is more informative about future realized returns than using R&D expenditures as a variable to predict returns.

The motivation to construct a capitalized R&D asset is based on the observation that past R&D expenditures have explanatory power for current earnings and equity market value (Sougiannis, 1994; Lev and Sougiannis, 1996). For example, R&D expenditures of the past seven years have explanatory power for current earnings (Sougiannis, 1994). Further, it has been shown that capitalized R&D expenditures scaled by price (CapRD/P) are positively associated with future returns (for example Lev and Sougiannis, 1996, 1999; Chambers, Jennings and Thompson, 2002; Lev, Nissim and Thomas, 2007).

In addition, the practice of expensing R&D might distort the positive association between the book-to-price ratio and future realized returns. It is well-documented that the book-to-price (B/P) ratio is positively associated with subsequently realized returns (Rosenberg, Reid and Lanstein, 1985; Fama and French, 1992).[1] Given that R&D is expensed intangible

[1]And researchers have provided mispricing explanations for the B/P effect (Lakonishok, Shleifer and Vishny,

investments and therefore not recorded on the balance sheet, the book-to-price ratio of a firm that has high R&D spending may be low, despite experiencing higher returns if payoffs from its uncertain R&D investments are realized. Lev and Srivastava (2020) show that for the entire cross-section of firms (those with and those without R&D expenditures), a B/P ratio adjusted for capitalization of intangibles is more informative about future realized returns than the unadjusted B/P ratio.

Yet, the capitalization of R&D expenditures might not be necessary to account for intangible investments. One could instead use R&D expenses as recorded on the income statement to assess a firm's risk and growth associated with R&D. Conceptually, this is already embedded in the R&D expensing requirement of U.S. GAAP; it serves the valuation role of accounting in that it captures investments with uncertain future benefits in the income statement rather than on the balance sheet: In the absence of unconditional conservatism (the absence of direct expensing) for intangible investment, R&D would be recorded on the balance sheet as an asset and the income statement would act as a means to resolve the uncertainty towards R&D ex post - via asset write-downs. By expensing R&D, investors are able to form an ex ante expectation of the future benefits of uncertain intangible investment via the income statement (Barker and Penman, 2020).

Also, empirically, Chan, Lakonishok and Sougiannis (2001) find that R&D expenses scaled by price (RD/P) are positively associated with future realized returns. In addition, Penman and Reggiani (2013, 2018) and Penman, Reggiani, Richardson and Tuna (2018) argue and show that the book-to-price ratio should be used conditional on a firm's earnings-to-price ratio (E/P), as a lower E/P indicates expensed intangible investment. Given E/P, B/P reflects risky growth. Further, current R&D expenses might be a more timely measure

1994; La Porta, 1996), as well as, risk-based explanations (Fama and French, 1995; Berk, Green and Naik, 1999).

to incorporate changes of R&D than a capitalized R&D asset that aggregates historical R&D expenditures over time. This might be important, given that the changes in R&D are also associated with future returns (Penman and Zhang, 2002). Moreover, given that R&D intensive firms may have a low B/P ratio, despite experiencing higher returns if payoffs from its uncertain R&D investments are realized, a separate variable to account for R&D may actually explain variation in future realized return that is orthogonal to that of the B/P ratio.

Given the above and no comprehensive study that compares the informativeness of capitalized R&D and of expensed R&D about future realized returns, it is an empirical question whether a capitalized R&D asset scaled by price (and a capitalization adjusted B/P ratio) is a better predictor of future realized returns, or whether R&D-to-price (in addition to book-to-price) is better at explaining future realized returns.

Consistent with the notion that intangible assets are not recorded on the balance sheet for firms that invest in R&D, the average R&D intensity is higher in firms that have a low book-to-price multiple (as found, for example, by Lev and Sougiannis, 1999, by Chan et al., 2001, by Mohanram, 2005, and by McNichols, Rajan and Reichelstein, 2014). Also, the average R&D spending has increased over time (as reported by Chan et al. (2001), Skinner (2008), Franzen et al. (2007), Srivastava (2014), and Curtis, McVay and Toynbee (2020)) and has increased disproportionately in the lowest B/P quintile compared to the average R&D intensity in the other B/P quintiles.

For the entire cross-section of firms, the capitalization of R&D expenditures improves the ability of the B/P ratio to predict returns. This is consistent with Lev & Srivastava (2020) that the capitalization of intangibles improves the returns to B/P-based portfolios. I show that the effect is concentrated in small stocks and becomes apparent after 1991. The former is consistent with findings by Loughran (1997) and Kok, Ribando and Sloan (2017) that the B/P effect in the prediction of returns is concentrated in small firms. The latter is consistent with the observation that the amount of R&D spending has increased over time.

Yet, importantly, when adding RD/P to Fama-MacBeth regressions, the combination of the predictive ability of the unadjusted B/P ratio and the R&D-to-price ratio is higher than that of the R&D capitalization adjusted B/P ratio alone. Hence, when accounting for R&D activities, I show that it is better to evaluate them separately from the book-to-price effect. R&D intensive firms have low B/P ratios, despite experiencing higher future returns if the R&D activities payoff. This feature predicts return variation that is orthogonal to that of the B/P ratio. Therefore, R&D and B/P should be evaluated as separate variables. Also, RD/P and capitalized R&D scaled by price are equally informative about future returns. To provide further evidence that R&D should be evaluated separately from B/P, I show that, in portfolio sorts, the R&D capitalization is not able to fully eliminate (push) high R&D-to-price stocks from lower (to higher) book-to-price ratio portfolios. R&D-to-price still has a significant return spread in the lowest portfolio of the capitalization adjusted B/P ratio.

For the subset of firms that have R&D expenditures, I also show that the informativeness of R&D-to-price about future realized returns is very similar to that of capitalized-R&D-to-price. This holds for firms with a long (and a short) history of R&D expenditures. Hence, the result is not driven by firms with a short history of R&D expenditures for which the capitalized R&D portion might be negligible. The result also holds when examining time-varying useful lives within R&D intensive industries: capitalized-R&D-to-price ratios based on useful lives of 3 years, 5 years, and 8 years, while all varying over time, show very similar associations with future realized returns at each point in time within each of the R&D intensive industries examined, except for one industry between 1993 and 2006. Also, RD/P has a similar association with future realized returns than any of the capitalized R&D assets scaled by price. Hence, the result is also not driven by not accounting for time-varying useful lives of capitalized R&D assets within respective industries. This is important, as one could use current R&D expenses from the income statement as a return predictor instead of creating a capitalized R&D asset based on assumed, or estimated, useful lives.

Lastly, I examine potential reasons why R&D-to-price (and capitalized-R&D-to-price) predicts returns. CapRD/P and RD/P are highly correlated due to the very construction of the capitalized R&D asset (capitalized R&D includes (parts of) current R&D expenditures). Therefore, first, I analyze the sub-sample of firms that has no current R&D expenditures but has positive capitalized R&D from past R&D expenditures. If capitalized R&D predicts returns over and above the R&D expenses variable, there should be a statistically significant association between capitalized R&D with future realized returns. I find that the association of capitalized R&D and future realized returns is not statistically significant. Hence, at least for the small sub-sample of firms with no current R&D expenditures but positive capitalized R&D, capitalized R&D has no explanatory power for future realized returns. This also implies that the information in current R&D expenses scaled by price could be driving the association with future realized returns.

Second, I examine firm characteristics around the portfolio formation date of RD/P and capitalized RD/P. I find that high (low) R&D-to-price firms have negative (positive) equity market value changes (i.e., annual returns) before the portfolio formation date. Also, high R&D-to-price firms have negative earnings growth changes before the portfolio formation date, but earnings growth reverses after the portfolio formation date. These findings are in line with the findings of Chan et al. (2001) who interpret these patterns as evidence of mispricing. I additionally find that high (low) R&D-to-price firms have a reduction (an increase) in R&D expenditure growth from the year of portfolio formation to the year after portfolio formation. This observation might be consistent with the theoretical work about the real options aspect of a firm's operations by Berk, Green and Naik (1999): drawing from (R&D) investment options is consistent with time-varying firm-specific risk. Importantly, this observation shows that R&D-to-price captures information about changes in R&D.

Also, high (low) capitalized-R&D-to-price firms have a reduction (an increase) in R&D expenditure growth in the year of portfolio formation to the year after portfolio formation. But the highest and lowest capitalized RD/P quintiles incorporate changes in R&D expenditure growth earlier. This is likely caused by the construction of the capitalized R&D variable, as it aggregates past R&D expenditures and therefore incorporates the past change in R&D. Despite this, capitalized-R&D-to-price has a similar association with future realized returns compared with R&D-to-price.

The study makes several contributions. Foremost, I show that expensed R&D-to-price and capitalized-R&D-to-price are equally good to predict future realized returns. I also provide evidence that the return predictiabiliy might be driven by current R&D expenditures rather than by capitalized R&D. Hence, when studying the returns to a capitalized R&D asset, it is important to use R&D expenses as a benchmark. Also, R&D-to-price or capitalized-R&D-to-price should be evaluated separately from the B/P ratio. The properties of R&D intensive firms embed variation that is orthogonal to that of the returns to the B/P ratio and adding a capitalized R&D asset to equity book value reduces the variation with future returns.

My results could also contribute to the debate of expensing versus capitalizing R&D expenditures. I show that, under current U.S. GAAP, R&D expenses are equally informative about future realized returns than a capitalized R&D asset. As R&D endeavors are uncertain and risky (for example Kothari, Laguerre and Leone, 2002; Penman and Reggiani, 2013, 2018; Penman et al., 2018) and the profitability of R&D investments has been decreasing in recent years (Curtis et al., 2020), it might still be important to apply unconditional conservatism to R&D investment, especially in a business environment with increasing R&D expenditures. In absence of unconditional conservatism towards intangible investment, investors might not be able to form ex ante expectations about a firm's future growth via the income statement.

I also show that R&D-to-price and capitalized-R&D-to-price capture information about changes in R&D activities. This adds to our understanding about the underlying reason why these variables are associated with future returns.

The paper proceeds as follows. Section 2 describes the sample and sample requirements, and the R&D capitalization methodology. Section 3 reports the results. Section 4 concludes.

2 Data and R&D capitalization methodology

2.1 Sample requirements and data definitions

Monthly stock returns are obtained from CRSP and annual accounting data are obtained from Compustat. The sample includes firms with ordinary common shares (share codes 10 or 11) traded on NYSE, Amex, and Nasdaq (exchange codes 1, 2, or 3). In case of delistings, returns in the delisting month include only the delisting return when the delisting happens on the last trading day of the month, but include the partial month return and the delisting return when the delisting happens before the last trading day of the month, as outlined in Beaver, McNichols and Price (2007). Missing delisting returns for performance related delistings are replaced by -30% for NYSE and Amex firms, and by -55% for Nasdaq firms (Shumway, 1997; Shumway and Warther, 1999).

Annual accounting information from Compustat is assumed to be publicly available 3 months after the fiscal year end. The sample starts in July 1974 and ends in June 2019.[2] The sample consists of firms with non-missing B/P, earnings before extraordinary items, current and lagged monthly return, current and lagged equity market value, and lagged one-year return, and excludes firms with negative equity book value, amounting to a sample of 199,151 firm-year observations to which returns are matched.[3] For the analysis that only focuses on firms that have R&D expenditures, the sample reduces to 78,551 firm-year observations to which returns are matched.

Equity book value is calculated as shareholders' equity plus balance sheet deferred taxes and balance sheet investment tax credits, minus preferred stock. Missing values of balance sheet deferred taxes and missing values of balance sheet investment tax credits are set to zero. The value of preferred stock is set to the redemption value, if non-missing, or the liquidation value, or the carrying value, in that order. Shareholders' equity is set to the value of common equity, if shareholders' equity is missing, or to total assets minus total liabilities, in that order. Missing equity book values are then filled with Davis, Fama and French (2000) equity book values, obtained from Kenneth French's website. The B/P ratio is then calculated by scaling equity book value by equity market value obtained at the end of December. All variable definitions and calculations described in this section, and additional variables used throughout the study, can be found in the description of Table 1.

[2] I start the sample in 1974 as the FASB issued the requirement to expense R&D in that year. To construct the capitalized R&D asset, up to eight lags of R&D expenditures are required. For this, I use information back until 1976.

[3] The R&D capitalization adjustment added to equity book value also transforms negative equity book value firms to positive equity book value firms. To have a clean comparison between the adjusted and the unadjusted equity book value, I exclude these firms from the analyses. This ensures that the same number of observations are examined with and without the R&D capitalization adjustment.

2.2 R&D capitalization methodology

Throughout the paper, I follow Chan et al. (2001) to capitalize past R&D expenditures. Specifically, I assume a straight-line amortization of R&D capital over a useful life of five years. This results in the following capitalization of R&D expenditures,

$$RDCapital_{i,t} = RD_{i,t} + 0.8 \times RD_{i,t-1} + 0.6 \times RD_{i,t-2} + 0.4 \times RD_{i,t-3} + 0.2 \times RD_{i,t-4}$$

where $RD_{i,t}$ are R&D expenditures for firm i at time t.

To account for tax effects of the R&D capitalization, I follow the assumptions adopted by Franzen et al. (2007). Firms with positive net income are assumed to make full use of expensed R&D for tax purposes. Therefore, a deferred tax liability (DTL) will be added to the equity book value adjustment. The total adjustment of equity book value is thus the following:

$$Adj\_BV_{i,t} = \begin{cases} BV_{i,t} + RDCapital_{i,t} - DTL_{i,t} & \text{if } EARN_{i,t} > 0 \\ BV_{i,t} + RDCapital_{i,t} & \text{otherwise} \end{cases}$$

where $DTL_{i,t} = RDCapital_{i,t} \times tax$. tax is the statutory federal tax rate plus 2 percent average state tax rate. $EARN_{i,t}$ are earnings before extraordinary items for firm i at time t. The inferences of the analyses are unchanged when using the sum of years digits method or the industry-specific coefficients reported in Lev and Sougiannis (1996), as applied in Penman and Zhang (2002), or the industry-specific coefficients reported in Li and Hall (2018), as applied in Lev and Srivastava (2020), as a R&D capitalization methodology. I further show that the results hold when accounting for time-varying useful lives of 3 years, 5 years, and 8 years within R&D intensive industries. Inferences are also unchanged when not accounting for the deferred tax liability.

2.3 Summary statistics

Table 1 Panel A reports the summary statistics of the variables. The reported values are averages of the yearly distributional statistics across the sample years. The mean B/P ratio amounts to 0.94 and the median B/P ratio amounts to 0.75. B/P ratio values greater than one start at the 75th percentile. The mean (median) of the adjusted B/P ratio amounts to 1.02 (0.80). The higher values of the adjusted B/P ratio compared to the unadjusted B/P ratio reflect the R&D capitalization adjustment. The mean capitalized R&D asset to 8 percent of price while the 95th percentile amounts to 37 percent of price. The values are highly skewed given that not all firms have R&D expenditures. This is also reflected in the other R&D variables: R&D-to-assets has a mean (median) of 0.04 (0.00) and the 95th percentile amounts to 0.20; R&D-to-price has a mean (median) of 0.03 (0.00) and the 95th percentile amounts to 0.17. Equity market value, as a proxy for firm size, is highly right-skewed. The mean equity market value amounts to USD 2,053.47 million whereas the median equity market value amounts to USD 208.38.05 million. The average monthly return in excess of the risk-free rate amounts to 0.93% and the median monthly excess return amounts to -0.05%. The mean (median) lagged monthly return amounts to 1.29 (0.26) percent and the mean (median) 12-month return skipping one month to 14.85 (6.36) percent.

Table 1 Panel B reports average annual Pearson correlations (above the diagonal) and average annual Spearman rank correlations (below the diagonal) between the variables across the sample years. The unadjusted and the capitalization adjusted B/P ratio are highly correlated (average Pearson and Spearman correlation coefficients of 0.95 and 0.96, respectively). The capitalized R&D asset (CapRD/P) and the B/P ratio have a negative Pearson (Spearman) correlation coefficient of -0.07 (-0.18). The capitalized R&D asset is positively related to the adjusted B/P ratio for the average Pearson correlation coefficient (0.34) and is negatively related to the adjusted B/P ratio for the average Spearman correlation coefficient (-0.01). This change in the sign between the average Pearson and the average Spearman correlation might be driven by the skewness of the capitalization adjustment. RD/P is highly correlated to the capitalized R&D asset (CapRD/P) with a Pearson (Spearman) correlation coefficient of 0.89 (0.97), as R&D expenditures at time t are part of the R&D capitalization adjustment.

To highlight the growing importance of R&D expenditures over time, I plot the average R&D intensity (i.e., R&D expenditures to total assets) for each year. Subfigure (a) of Figure 1 depicts the mean R&D intensity for each of the sample years. The mean R&D intensity amounts to approximately 0.01 in 1974 and increases to around 0.075 in 2019. This is consistent with the findings of, for example, Chan et al. (2001), Skinner (2008), Franzen et al. (2007), Srivastava (2014), and Curtis et al. (2020) who show that firms report higher levels of R&D expenditures over time. To highlight that firms that invest in R&D have a lower B/P ratio, I plot the average R&D intensity for each B/P quintile. Subfigure (b) reports the mean R&D intensity by B/P quintiles for each of the sample years. B/P quintiles are formed each June according to NYSE breakpoints. The figure shows that the mean R&D intensity is especially pronounced in the lowest B/P quintile (as found by Lev and Sougiannis, 1999; Chan et al., 2001; Mohanram, 2005; and McNichols et al. (2014); and consistent with the notion that R&D expenditures represent missing assets on firms' balance sheets) and the mean R&D intensity is decreasing the higher the B/P quintile. While the mean R&D intensity in the lowest (second lowest) B/P quintile amounts to 0.025 (0.015) in 1974, the mean R&D intensity in the lowest (second lowest) B/P quintile amounts to 0.16 (0.090) in 2019. In subfigure (c) I depict the share of R&D firms for each of the sample years. The number of firms that report R&D expenditures is stable, amounting to 40 percent of the sample in 1974 and amounting to around 45 percent of the sample in 2019.

3 Results

3.1 Fama-MacBeth regressions

In this sub-section, by running Fama and MacBeth (1973) regressions, I compare the ability of the B/P ratio and of the R&D capitalization adjusted B/P ratio to predict subsequent monthly average returns. I also examine whether (Cap)RD/P combined with B/P is better at predicting returns than the adjusted B/P ratio. The results show that the B/P ratio that adds capitalized R&D expenditures to equity book value is a stronger predictor of future returns than the unadjusted B/P ratio. This is consistent with the conjecture that growth expectations from intangible investment that are not incorporated in the B/P ratio are important when evaluating the returns to the B/P ratio. I also show that the improved predictive ability due to the R&D capitalization adjustment is concentrated in small stocks. However, the combination of RD/P and B/P are better at predicting future realized returns than the R&D capitalization adjusted B/P ratio does. This is consistent with the notion that R&D intensive firms have lower B/P ratios, and if the R&D activities payoff in the future and the firms earn higher returns, this creates return variation that is orthogonal to that of the B/P ratio. I also show that RD/P and capitalized-R&D-to-price have a similar association with future realized returns.

3.1.1 Comparing the adjusted and unadjusted B/P ratio and RD/P as a separate variable

Table 2 reports the results of the monthly Fama and Macbeth (1973) regressions to compare the ability of the B/P ratio to the ability of the R&D capitalization adjusted B/P ratio to predict returns. All explanatory variables are transformed by taking the natural logarithm (except for the return variables). Also, for the Fama-MacBeth-regressions, for each month, all explanatory variables are winsorized at the extreme percentiles. All regressions control for equity market value (size), lagged monthly return, and past annual return skipping one month. All regression slopes are multiplied by 100.[4][5]

Column (1) of Panel A reports the baseline regression including the unadjusted B/P ratio for the entire sample. The B/P coefficient is statistically significant (coefficient of 0.32 and t-value of 4.86). Column (2) replaces the B/P ratio with the R&D capitalization adjusted B/P ratio. The coefficient amounts to 0.43 and the t-value amounts to 7.28. Hence, the adjusted B/P ratio is a stronger predictor of future monthly realized returns than the B/P ratio, on average.

In column (3) I include R&D expenditures scaled by price in the Fama-MacBeth regressions. For the firms that do not have R&D expenditures, I include a dummy variable which takes the value one for firms that do not have R&D expenditures and that takes the value zero otherwise (labelled dy_RD/P). The coefficient of RD/P (the RD/P = 0 dummy) amounts to 0.33 (-1.37) and is highly significant with a t-value of 7.79 (-5.96). Column (4)

[4]The results in this section are robust to controlling for retained-earnings-to-price (RE/P). This is important as Ball, Gerakos, Linnainmaa and Nikolaev (2020) show that RE/P subsumes the B/P ratio in predicting returns. I find that, RE/P subsumes the B/P effect in large firms, as reported in Ball et al. (2020), but B/P subsumes RE/P in small firms.

[5]The results in this section are also robust to additionally controlling for operating profitability and for investment (Fama and French (2015)).

reports the results when adding B/P to the regression that also includes RD/P. B/P is still a significant predictor of future realized returns (coefficient of 0.35 and t-value of 5.74). Hence, B/P increases in significance compared to column (1). The coefficient and t-value of RD/P (the RD/P = 0 dummy) amount to a coefficient of 0.26 (-1.28) and a t-value of 5.76 (-5.56).

As the average slope coefficients of the Fama-MacBeth regressions can be interpreted as average monthly returns on long-short strategies that are trading on the variation that is orthogonal to the variation of other regressors, the results imply that an investor might be better off using B/P and RD/P in combination rather than using a B/P ratio that capitalizes R&D expenditures alone: the average slope coefficients of the B/P ratio and the RD/P ratio amount to 0.35 and 0.26 in column (4) with a t-value of 5.74 and 5.76, respectively, and the average slope coefficient of the R&D capitalization adjusted B/P ratio amounts to 0.43 in column (2) with a t-value of 7.28. This is consistent with the notion that R&D intensive firms might have a low B/P ratio, despite earning higher returns if payoffs from its uncertain R&D investments are realized and a separate variable to account for R&D provides variation with future realized return that is orthogonal to that of the B/P ratio.

I further test the ability of the R&D capitalization scaled by price as a separate variable to predict returns. In column (5) I include capitalized-R&D-to-price in addition to book-to-price. The slope coefficient of capitalized-R&D-to-price amounts to 0.21 and a t-value of 5.66. This is comparable to, but slightly smaller than, the coefficient of RD/P (coefficient of 0.26 with a t-value of 5.76) in column (4).

Table 2 Panel B shows the regression results for the sample of large firms (all-but-microcaps) which excludes firms that have an equity market capitalization that is lower than the 20th percentile of the NYSE equity market capitalization distribution. This exclusion criterion is applied for monthly distributions. Column (1) and column (2) show that the coefficient of the B/P ratio (the adjusted B/P ratio) is significant with a coefficient of 0.18 and a t-value of 2.43 (a coefficient of 0.22 and a t-value of 3.14). This result is not as strong as for the entire sample, but is consistent with prior studies that the B/P effect is less strong in large firms. The capitalization adjusted B/P ratio is still a better predictor than the unadjusted B/P ratio. Yet, when adding RD/P, the unadjusted B/P ratio has a coefficient of 0.18 (t-value of 2.64) and RD/P is still a positive and significant predictor of future realized returns: the RD/P coefficient (t-value) amounts to 0.19 (4.22). The same holds when adding capitalized-R&D-to-price. The CapRD/P coefficient amounts to 0.14 with a t-value of 3.95.

Table 2 Panel C shows the regression results for the sample of small firms (microcaps) which only considers firms that have an equity market capitalization that is lower than the 20th percentile of the NYSE equity market capitalization distribution. This inclusion criterion is applied for monthly distributions. Column (1) and column (2) show that the coefficient of the B/P ratio (the adjusted B/P ratio) is highly significant with a coefficient of 0.37 and a t-value of 5.36 (a coefficient of 0.53 and a t-value of 8.84). This result shows that the B/P effect is much stronger in small stocks (consistent with, for example, Loughran, 1997, and Kok et al., 2017) and the R&D capitalization adjusted B/P ratio predicts returns stronger than the unadjusted B/P ratio. However, as shown in column (4) the unadjusted B/P ratio (RD/P ratio) has a coefficient of 0.42 and a t-value of 6.57 (coefficient of 0.29 with a t-value of 5.48). Also, column (5) shows that the CapRD/P coefficient amounts to 0.25 with a t-value of 5.58. That is, also in the small sample, an investor might be better off using B/P and (Cap)RD/P in combination rather than using a B/P ratio that capitalizes R&D expenditures.

In sum, the adjusted B/P ratio predicts monthly returns stronger than the unadjusted

B/P ratio does. This holds when controlling for size, lagged monthly return, and past annual return skipping one month. This is consistent with the conjecture that growth expectations from intangible investment that are not incorporated in the B/P ratio are important when evaluating the returns to the B/P ratio. The effect of the R&D capitalization adjustment is concentrated in small stocks. However, RD/P is still a positive and statistically significant predictor when controlling for B/P, and the B/P ratio in conjunction with the RD/P ratio are better to predict future realized returns than using the R&D capitalization adjusted B/P ratio alone. Comparing the RD/P ratio and the capitalized-R&D-to-price as separate predictors shows that they have very similar informativeness about future realized returns.

3.2 Analysis of the Fama-MacBeth regression slopes over time

In this sub-section, I analyze the Fama-MacBeth regression slopes across the sample years. This is motivated by the observations that average R&D spending increased over time, as reported in Figure 1 and documented by prior literature. I show that the association of the unadjusted B/P ratio with future returns decreases after 1991 and that the R&D capitalization adjustment added to the book-to-price ratio helps to alleviate the decreasing ability of the book-to-price to predict returns. While the R&D capitalization adjustment helps to alleviate the decrease in return predictability of the B/P ratio after 1991, the RD/P ratio significantly predicts future realized returns throughout the sample period.

3.2.1 Regression slopes of the adjusted and unadjusted B/P ratio over time

To investigate the Fama-MacBeth regressions slopes over time, I plot 10-year moving averages and associated t-values of the regression slopes of the B/P ratio and the adjusted B/P ratio in Figure 2, as done by, for example, Ball, Gerakos, Linnainmaa and Nikolaev (2016).[6] Subfigures (a) and (b) depict the 10-year rolling averages and associated t-values for all firms. The regression slope of the unadjusted B/P ratio increases from the period of 1984 to 1990 from 0.4 to about 0.8 and declines thereafter to about 0.2 in 2019, having a negative spike in 2000 and a positive spike in 2010. The 10-year moving average of the adjusted B/P ratio is persistently higher than that of the unadjusted B/P ratio after 1991. The gap is specifically pronounced from 2000 to 2010. Yet, the adjusted B/P ratio regression slope also has a declining trend, especially after 2010 (declining from 0.65 to 0.2). The associated t-value of the adjusted B/P ratio is persistently higher than that of the unadjusted B/P ratio; the difference is most pronounced in the period between 2000 and 2010. The t-values of both ratios increase from about 2.5 in 1984 to 7 in 1991. While the t-value of the unadjusted B/P ratio drops to 1.5 in 2000 and fluctuates around 2 until 2010 (with a spike to 3 in 2010), the t-value of the adjusted B/P ratio drops only to 4.5 in 2000 and decreases to 4 in 2010. The t-value of the unadjusted B/P ratio drops to 1 in recent years and the t-value of the adjusted B/P ratio drops to 2 in recent years.

Subfigures (c) and (d) depict the 10-year rolling averages and associated t-values for the subset of all-but-microcap firms. The difference of the 10-year moving average regression slopes between the B/P ratio and the R&D capitalization adjusted B/P ratio is far less pronounced in this subsample. Notable differences can only be observed between 2002 and 2010. In general, the regression slopes decrease from 0.4 in 1984 to about zero in 2019, with a spike between 2002 and 2010 (and have negative values for some of the recent years). The associated t-values follow the same pattern: there are no notable differences between the t-values of the B/P ratio and the adjusted B/P ratio. In general, the t-values fluctuate

[6]These are the regression slopes from columns (1) and (2) of Table 2.

around 2 and become insignificant after 2010 (after which they fluctuate around zero).

Subfigures (e) and (f) depict the 10-year rolling averages and associated t-values for the subset of microcap firms. The 10-year moving average regression slope differences between the unadjusted B/P ratio and the adjusted B/P ratio observed in all firms (subfigures (a) and (b)) are mostly driven by firms in this subsample. Both slope coefficients increase from around 0.4 in 1984 to 0.8 in 1991. The difference of the regression slopes widens since 1991, peaking in the period from 2000 to 2010. While the slope coefficient of the adjusted B/P ratio increases to 0.9 in 2004 and decreases to 0.3 in 2019, the slope coefficient of the unadjusted B/P ratio drops to 0.25 in 2000 and fluctuates thereafter around the same value. Both slope coefficients have a positive spike in 2010. Also, the difference in associated t-values between the unadjusted B/P ratio and the adjusted B/P ratio is much higher in the small stock samples. Both t-values increase from a value of 2 in 1984 to a value of 8 in 1991. While the t-value of the unadjusted B/P ratio drops to 1.5 in 2000 and fluctuates around 2 until 2010 (with a spike to 4 in 2010), the t-value of the adjusted B/P ratio drops only to 6 in 2000 and decreases to 5 in 2010. After 2010 the t-value of the unadjusted B/P ratio fluctuates between 2 and 3 and the t-value of the adjusted B/P ratio fluctuates around 3 and 6. Hence, the investigation of Fama-MacBeth regression slopes over time shows that the R&D capitalization adjustment of the book-to-price ratio helps to alleviate the decreasing ability of the book-to-price to predict returns after the year 1991.

3.2.2 Regression slopes of B/P in combination with RD/P over time

Lastly, I also depict in Figure 2 the 10-year rolling average slope coefficients and associated t-values for the regression that includes B/P and RD/P (column (4) in Table 2). The rolling average regression slopes and t-values of B/P from this regression are labelled "comb_BP" and the rolling average regression slopes and t-values of RD/P from this regression are labelled "comb_RDP". The figure shows that the average slopes and t-values of B/P when adding RD/P to the regression closely mimic the average slopes and t-values of the B/P ratio regression that does not add RD/P as an additional variable.

For large firms, the average slope coefficients for RD/P fluctuate between 0 and 0.1 from 1984 to 1995. After that, the average slope coefficients increase up to 0.5 between 2001 and 2004 and decline to 0.2 in 2010. Thereafter the average slope coefficients fluctuate between 0.1 and 0.2 again. The associated t-values are only statistically significant after 1998, increasing from around 2 in 1998 to around 5 in 2001, and decreasing after that to around 2 in 2010. From 2010 to 2019, the average t-values fluctuate around 2.

For small firms, the average slope coefficients for RD/P increase from 0.2 in 1984 to 0.4 in 1999. In 2000 the average slope coefficient spikes from 0.4 to 0.6 and decreases in 2010 from 0.6 to 0.3, after which it stays at around 0.3. The associated t-values are statistically significant throughout the sample period, fluctuating between 2 and 4. Hence, especially in the small stocks sample, the RD/P ratio consistently predicts future realized returns throughout the sample. This is important, as the different predictive ability between the unadjusted B/P ratio and the adjusted B/P ratio only becomes apparent after 1991.

3.3 The mechanism that improves the predictive ability of the B/P ratio

This subsection examines the mechanism why the capitalization of R&D expenditures improves the returns to the B/P ratio. Consistent with prior findings that firms that invest in intangibles have higher returns, I find that, for each B/P portfolio, firms that have a high R&D-to-price ratio have higher returns than those firms that have no R&D expenditures.

The R&D capitalization adjustment pushes firms that have a high R&D-to-price ratio from low B/P portfolios to higher B/P portfolios, thereby increasing the average monthly excess return spread between the lowest and highest B/P portfolio. However, not all firms in the lowest B/P portfolio that have a high R&D-to-price ratio are pushed to higher B/P portfolios via the R&D capitalization adjustment. This exemplifies the point that one might be better off to use the (Cap)RD/P ratio in conjunction with the B/P ratio to predict future realized returns.

I examine how firms that have high current R&D expenditures are sorted into different book-to-price portfolios and how the sorts change when the equity book value is adjusted for R&D capitalization. That is, I sort firms independently into quintiles of B/P and tertiles of RD/P and into quintiles of adjusted B/P and tertiles of RD/P at the end of each June according to NYSE breakpoints.[7] Portfolios are held for one year. Observations that delist during the portfolio holding period are invested in the value-weighted market index until the end of the portfolio holding period. Monthly excess returns are monthly returns in excess of the one month treasury bill rate.

Table 3 reports the average monthly equal-weighted excess returns, the average monthly value-weighted excess returns, and the time-series average of the number of observations for the portfolios sorted on the (adjusted) B/P ratio and sorted on RD/P. Panel A reports the results for the unadjusted B/P ratio. The equal-weighted return spreads between high and low RD/P for each B/P quintile are all statistically significant (return spreads of 0.56, 0.57, 0.54, 0.49, and 0.58 percent with a t-value of 3.23, 3.51, 3.36, 3.32, and 3.80, respectively from the lowest to the highest B/P quintile). Also, the value-weighted return spreads between high and low RD/P for each B/P quintile are statistically significant for the two highest B/P

[7] As there are firms that do not have R&D expenditures, I sort all firms that do not report R&D expenditures in the lowest RD/P portfolio and do a median sort on RD/P for firms that have R&D expenditures.

quintiles (return spreads of 0.24, 0.13, 0.03, 0.36, and 0.35 percent with a t-value of 1.76, 0.92, 0.24, 2.19, and 1.95, respectively from the lowest to the highest B/P quintile).

Panel B of Table 3 reports results for the sorts on the adjusted B/P ratio and on RD/P. While the equal-weighted return spreads between high and low RD/P for each B/P quintile are all high and significant (return spreads of 0.42, 0.38, 0.39, 0.45, and 0.59 percent with a t-value of 2.69, 2.30, 2.48, 2.83, and 3.57, respectively from the lowest to the highest B/P quintile), only the value-weighted return spread between high and low RD/P for the lowest B/P quintile is marginally statistically significant (return spread of 0.27 with a t-value of 1.88). Also, the average equal-weighted (value-weighted) return of the lowest B/P quintile decreases from 0.57 percent (0.61 percent) in Panel A to 0.50 percent (0.59 percent) in Panel B and the average equal-weighted (value-weighted) return of the highest B/P portfolio increases from 1.25 percent (0.86 percent) in Panel A to 1.32 percent (0.93 percent) in Panel B when adjusting the book-to-price ratio.

Those results of the capitalization adjustment are also reflected by the number of firms in the high RD/P portfolio in the lowest B/P quintile: the average number of portfolio observations for the highest RD/P portfolio within the lowest B/P quintile decreases from 325 (in Panel A) to 191 (in Panel B) when adjusting equity book value for R&D capitalization. Also, the average number of portfolio observations for the highest RD/P portfolio within the highest B/P quintile increases from 188 (in Panel A) to 310 (in Panel B) when adjusting for R&D capitalization.[8]

[8]Further inspection of the transfer of high RD/P firms across B/P quintiles shows that for the lowest B/P portfolio, about 60 percent of high RD/P observations remain in the lowest adjusted B/P portfolio, about 27 percent are allocated to the second lowest adjusted B/P portfolio, 7 percent are allocated to the third adjusted B/P portfolio, 4 percent are allocated to the fourth adjusted B/P portfolio, and the remainder is allocated to the highest adjusted B/P portfolio. 24 percent of the high RD/P observations of highest adjusted B/P portfolio are transferred from the fourth B/P portfolio; 62 percent of high RD/P observations of the highest B/P portfolio remain in the highest B/P portfolio.

To highlight the effect of adjusting the B/P ratio by capitalizing R&D expenditures, I show the percentage of observations that fall into the high RD/P portfolio in each (adjusted) B/P quintile over time. Figure 3 depicts these percentages for the unadjusted B/P ratio quintiles (Subfigure (a)), for the adjusted B/P ratio quintiles (Subfigure (b)), for the adjusted B/P ratio quintiles when only the past three years of R&D expenditures are capitalized (Subfigure (c)), and for the adjusted B/P ratio quintiles when the past eight years of R&D expenditures are capitalized (Subfigure (d)). Subfigure (a) shows while all B/P quintiles contained a comparable percentage of high RD/P firms from the late 1980s to the mid 1990s (a percentage of about 20 percent), the percentage of high RD/P firms became more dispersed after the mid 1990s. Importantly, in this period, the lowest B/P quintile contained the highest percentage of high RD/P observations, and the highest B/P quintile contained the lowest percentage of high RD/P firms.

With the capitalization adjustment of the past five years of R&D expenditures (Subfigure (b)), the lowest adjusted B/P quintile has noticeably less high RD/P firms across the sample than the other adjusted B/P quintiles. Also, with the adjustment, the highest adjusted B/P quintile has a higher percentage of high RD/P firms and contains the highest percentage of high RD/P firms in many years. This pattern is less strong for the adjusted B/P quintiles based on a capitalization of the past three years of R&D expenditures (Subfigure (c)), and the pattern is stronger for the adjusted B/P quintiles based on a capitalization of the past eight years of R&D expenditures (Subfigure (d)). This is consistent with R&D capitalization pushing high RD/P firms from lower B/P quintiles to higher B/P quintiles, but shows that the R&D capitalization is not able to fully eliminate high RD/P firms from low B/P portfolios.

In sum, the R&D capitalization adjusted B/P ratio provides higher average equal-weighted and value-weighted excess returns compared to the unadjusted B/P ratio, as the capitalization adjustment reduces the number of high RD/P observations in the lowest B/P portfolio and increases the number of high RD/P observations in the highest B/P portfolio. However, the capitalization adjustment does not fully eliminate high RD/P firms in the lowest B/P portfolio. This is exemplifies the point to use (Cap)RD/P ratio as a separate predictor for future realized returns. The next sections compare the ability of the R&D-to-price variable and the capitalized-R&D-to-price variable to predict future returns.

3.4 Additional comparisons of RD/P and capitalized-R&D-to-price

In this subsection I further examine whether capitalized-R&D-to-price exhibits different variation than R&D-to-price by looking at different subsamples of firms. Hence, here, I only focus on firms that have R&D expenditures. I first examine whether firms with a short history of R&D spending for which capitalizing past R&D expenditures might not have a big impact are responsible for the similar predictive ability of RD/P and capitalized-R&D-to-price. Therefore, I split RD/P and capitalized-R&D-to-price into firms that report R&D expenditures for more than 5 years in a row and firms that report R&D expenditures for less than 5 years in a row. If R&D capitalization is more informative about future returns than R&D expenses, we would expect a higher predictive ability of the capitalized R&D asset for firms that have a long history of R&D expenditures compared with the predictive ability of R&D expenses for these firms. Yet, I find that for firms with a long history of R&D expenditures and for firms with a short history of R&D expenditures the predictive ability of capitalized-R&D-to-price is similar to the predictive ability of RD/P.

In Table 4 I run monthly Fama-MacBeth regressions, controlling for B/P, size, lagged monthly return and lagged annual return skipping one month, as in Table 2. RD/P and capitalized-R&D-to-price have similar informativeness about future realized returns. Column (1) in Table 4 reports the results for RD/P. The slope coefficient amounts to 0.26 and a t-value of 5.51. Column (2) reports the results for capitalized-R&D-to-price. The slope coefficient amounts to 0.25 and a t-value of 5.54. Column (3) adds a dummy variable for firms that report R&D expenditures for less than 5 years in a row (labelled dy_U5) and the interaction term between RD/P and the dummy variable. Hence, the main effect of RD/P captures the variation of firms that report R&D expenditures for more than 5 years in a row. The RD/P coefficient amounts to 0.19 with a t-value of 3.80. Column (4) repeats this procedure for capitalized-R&D-to-price. The CapRD/P coefficient amounts to 0.18 with a t-value of 3.59. Hence, for firms that have a long history of R&D expenditures, the predictive ability of R&D expenses is similar to that of the capitalized R&D asset.

In column (5) I analyze the sub-sample of firms that has no current R&D expenditures but has positive capitalized R&D from past R&D expenditures. This reduces the sample to 4,622 firm-year observations to which returns are matched. If capitalized R&D predicts returns over and above the R&D expenses variable, there should be a statistically significant association between capitalized R&D with future realized returns. I find that the association of capitalized R&D and future realized returns is not statistically significant. The coefficient of CapRD/P amounts to 0.03 with a t-value of 0.56. That implies, at least for the small sub-sample of firms with no current R&D expenditures but positive capitalized R&D, capitalized R&D has no explanatory power for future realized returns. This also implies that current R&D expenses scaled by price could be driving the association with future realized returns.

I also examine whether the finding might be driven by industry-specific and time-varying useful lives of R&D activities. This is motivated by the findings that useful lives of R&D activities are varying across industries (Lev and Sougiannis, 1996; Lev, Nissim and Thomas,

2007) and that useful lives can be varying over time (Li and Hall, 2018). I therefore estimate Fama-MacBeth regressions within a respective R&D intensive industry and examine the informativeness of capitalized-R&D-to-price for useful lives of 3 years, 5 years, and 8 years over time. If the useful live of R&D varies over time within a respective R&D intensive industry, we would expect differences in associations with future realized returns for the respective useful lives across the sample years. However, the regressions within each industry do not show differences in associations with future realized returns for the respective useful lives across the sample years. In fact, capitalized-R&D-to-price for the useful lives of 3 years, 5 years, and 8 years, although time-varying, show similar associations with future realized returns at each point in time and RD/P has a similar association with future realized returns.

Figure 4 reports the ten-year rolling average Fama-MacBeth slope coefficients estimated within the five 2-digit SIC industries that report the most observations with R&D expenditures. The industries are "Chemical and Allied Products" (2-digit SIC = 28), "Industrial Machinery and Equipment" (2-digit SIC = 35), "Electronic and Other Electric Equipment" (2-digit SIC = 36), "Instruments and Related Products" (2-digit SIC = 38), and "Business Services" (2-digit SIC = 73). The figure reports average slope coefficients of RD/P estimated within each industry with controls as specified in column (1) of Table 4 and average slope coefficients of capitalized-R&D-to-price with useful lives of 3 years, 5 years, and 8 years, estimated within each industry with similar controls. Hence, if a different useful life of the R&D asset is differentially associated with future realized returns at different points in time, the ten-year rolling average slope coefficients would pick up this pattern.

Yet, the figure shows that the informativeness of the capitalized-R&D-to-price coefficient for different useful lives is very similar. Except for "Instruments and Related Products", the average RD/P coefficient is higher or similar to the average coefficient of the capitalized

R&D assets for different useful lives. For "Instruments and Related Products", the average RD/P coefficient is lower than that of the capitalized R&D assets for the years between 1993 to 2006. For all other periods the coefficients are similar. Also, except for "Instruments and Related Products", when the regression slopes for different capitalized R&D assets are differing, the lower the useful life, the higher the average slope coefficient. That implies that the higher the useful life, the lower the association with future realized returns. For "Instruments and Related Products", this pattern is reversed for the period between 1993 and 2006 (the same period for which the RD/P slope coefficient is lower than of the capitalized R&D asset).

Figure 5 reports the associated t-values for each industry. For all industries and all different useful lives, including RD/P, the average t-values are comparable, except for "Instruments and Related Products", where the t-values of the capitalized R&D assets are slightly higher in the period between 1993 and 2006.

In sum, capitalized-R&D-to-price based on useful lives of 3 years, 5 years, and 8 years, while all varying over time, show very similar association with future realized returns at each point in time within each of the R&D intensive industries examined, except for one industry between 1993 and 2006. And except for this industry between 1993 and 2006, RD/P has a very similar association with future realized returns compared with capitalized-R&D-to-price.

3.5 Examining the reason why RD/P and capitalized-R&D-to-price predict returns

In this last section I examine potential reasons why R&D-to-price (and capitalized-R&D-to-price) predicts returns. I find that high (low) R&D-to-price firms have negative (positive) equity market value changes (i.e., annual returns) before the portfolio formation date. Also, high R&D-to-price firms have negative earnings growth changes before the portfolio formation date, but earnings growth reverses on and after the portfolio formation date. These findings are in line with Chan et al. (2001) who interpret these patterns as evidence of mispricing. I additionally find that high (low) R&D-to-price firms have a reduction (an increase) in R&D expenditure growth in the year of portfolio formation to the year after portfolio formation. This observation might be consistent with the theoretical work about the real options aspect of a firm's operations by Berk, Green and Naik (1999) that drawing from (R&D) investment options is consistent with time-varying firm-specific risk. Also, high (low) capitalized-R&D-to-price firms have a reduction (an increase) in R&D expenditure growth in the year of portfolio formation to the year after portfolio formation, yet that reduction is recognized earlier, presumably due to the incorporation of past R&D expenditure in the capitalized-R&D-to-price variable.

In Figure 6 I report firm characteristics around the portfolio formation date of RD/P and capitalized RD/P. That is, I form (capitalized) RD/P quintiles in each June according to NYSE breakpoints. I then calculate the time-series average of the annual median firm characteristics across the sample years for 2 years before the portfolio formation until 2 years after the portfolio formation.

Subfigure (a) reports the average median earnings growth for the respective RD/P quintiles. Firms in the highest R&D-to-price quintile have negative earnings growth changes before the portfolio formation date, but earnings growth reverses on and after the portfolio formation date. That is, median earnings growth changes from negative growth to positive growth. Firms in the lowest R&D-to-price quintiles experience a decrease in earnings growth on the portfolio formation date to the year after the portfolio formation date, but the median earnings growth remains positive. Subfigure (c) reports the average median equity market value growth for the respective RD/P quintiles. High (low) R&D-to-price firms switch from negative (positive) to positive (negative) equity market value changes (i.e. annual returns) from before to on and after the portfolio formation date. These results are in line with the findings of Chan et al. (2001). The authors argue that the observation of high (low) RD/P firms experiencing negative (positive) returns before the portfolio formation date is consistent with underpricing (overpricing).

Subfigure (e) reports average median R&D expenditure growth for the respective RD/P quintiles. The highest RD/P quintile experiences declining but positive R&D expenditure growth in the year before portfolio formation. In the portfolio formation year, the R&D expenditure growth further declines (to year t+1). The lowest RD/P quintile experiences increases in the year of portfolio formation (to year t+1). This might be interpreted as evidence that firms in the lowest RD/P quintile draw from their (R&D) investment options whereas high RD/P firms have fewer R&D investment opportunities. Drawing from investment options reduces systematic risk of firm's future cash flows (Berk, Green and Naik, 1999; Anderson and Garcia-Feijoo, 2006). However, more investigation might be necessary to substantiate such risk-based explanation.

Importantly, subfigure (f) reports the average median R&D expenditure growth for the respective CapRD/P quintiles.[9] Here, compared to the average median R&D growth of the highest and lowest RD/P quintiles, the highest and lowest capitalized RD/P quintiles incorporate the changes in R&D expenditure growth earlier. This might be caused by the construction of the capitalized R&D variable, as it incorporates past R&D expenditures and therefore incorporates the past change in R&D expenditures. Other than this difference, the

[9]Subfigures (b) and subfigure (d) report the average median earnings growth and equity market value growth, respectively, for capitalized RD/P quintiles and the patterns closely mimic those of the RD/P quintiles.

R&D growth magnitudes after the portfolio formation date are comparable to those of the RD/P quintiles. Despite this, capitalized-R&D-to-price has a similar association with future realized returns compared with R&D-to-price.

4 Conclusion

In this paper, I study whether capitalizing R&D is more informative about future realized returns than using R&D expenditures. This is especially relevant for recent years, as the number of firms that invest in research and development has increased over time and therefore a larger amount of intangible investment is not recognized on firms' balance sheets.

I find that a book-to-price ratio that is adjusted for capitalized R&D predicts returns significantly stronger than the unadjusted book-to-price ratio. This is consistent with the conjecture that growth expectations from intangible investment that are not incorporated in the B/P ratio are important when evaluating the returns to the B/P ratio. The effect is concentrated in small stocks and after 1990.

However, the predictive ability of the unadjusted B/P ratio and the (capitalized-)R&D-to-price ratio combined is higher than that of the R&D capitalization adjusted B/P ratio. Capitalized-R&D-to-price and expensed-R&D-to-price are equally informative about future realized returns when evaluated as separate variables. This holds for firms with a long (short) history of R&D spending and when varying the useful life of capitalized R&D across time within R&D intensive industries. Although there is little within industry variation of capitalized-R&D-to-price for different useful lives, I cannot rule out that firm-specific useful lives within for R&D within industries might be more informative about future returns than current R&D expenditures scaled by price. This might be interesting to examine in a future study.

Also, The information in R&D-to-price could be driving the association with future realized returns. In the subset of firms with no current R&D expenditures but positive capitalized R&D, the association of capitalized-R&D-to-price and future realized returns is not significant. I further show that high (low) R&D-to-price firms have a reduction (an increase) in R&D expenditure growth in the year of portfolio formation. Hence, this observation shows that R&D-to-price captures information about changes in R&D. This observation might be consistent with the theoretical work about the real options aspect of a firm's operations by Berk, Green and Naik (1999) that drawing from (R&D) investment options is consistent with time-varying firm-specific risk.

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Tables and figures

Table 1: Descriptive Statistics, 1974 - 2019

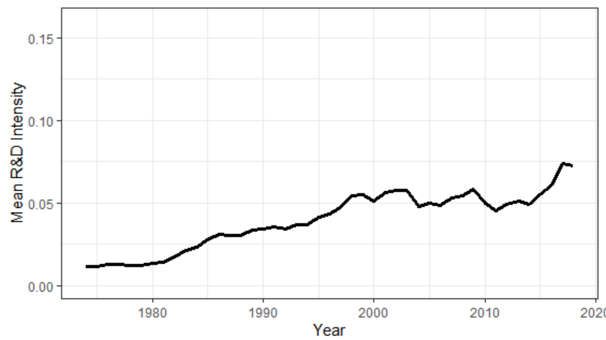
Panel A: Summary Statistics

	Mean	s.d.	p5	p10	p25	p50	p75	p90	p95
B/P	0.94	0.96	0.15	0.23	0.43	0.75	1.18	1.76	2.30
adj. B/P	1.02	1.02	0.18	0.27	0.47	0.80	1.26	1.90	2.50
CapRD/P	0.08	0.27	0.00	0.00	0.00	0.00	0.05	0.19	0.37
SIZE [$M]	2,053.47	9,502.66	9.05	16.19	49.99	208.38	879.15	3,337.91	7,947.34
R&D intensity	0.04	0.11	0.00	0.00	0.00	0.00	0.03	0.12	0.20
RD/P	0.03	0.10	0.00	0.00	0.00	0.00	0.03	0.10	0.17
exc. ret [%]	0.93	17.15	-21.11	-14.84	-6.58	-0.05	6.70	16.35	25.04
$ret_{1,1}$ [%]	1.29	17.17	-20.78	-14.17	-6.28	0.26	7.10	16.78	25.52
$ret_{12,2}$ [%]	14.85	64.45	-55.53	-41.90	-18.24	6.36	33.98	72.18	108.84

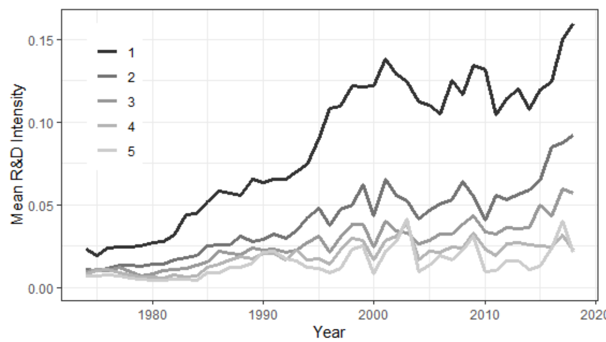
Panel B: Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) B/P		0.95	0.06	-0.07	-0.16	0.05	0.12	0.12	0.01
(2) adj. B/P	0.96		0.34	-0.07	-0.02	0.29	0.01	0.01	0.01
(3) CapRD/P	-0.18	-0.01		-0.03	0.46	0.89	0.01	0.01	0.01
(4) SIZE	-0.28	-0.34	-0.07		-0.02	-0.03	-0.00	-0.00	-0.00
(5) R&D intensity	-0.29	-0.12	0.95	-0.03		0.57	0.00	0.00	-0.01
(6) RD/P	-0.19	-0.02	0.97	-0.05	0.98		0.01	0.01	0.00
(7) exc. ret [%]	0.02	0.01	-0.01	0.05	-0.01	-0.01		-0.03	-0.00
(8) $ret_{1,1}$ [%]	0.02	0.01	-0.01	0.05	-0.01	-0.01	-0.02		-0.01
(9) $ret_{12,2}$ [%]	0.04	0.02	-0.04	0.09	-0.04	-0.03	0.03	0.01	

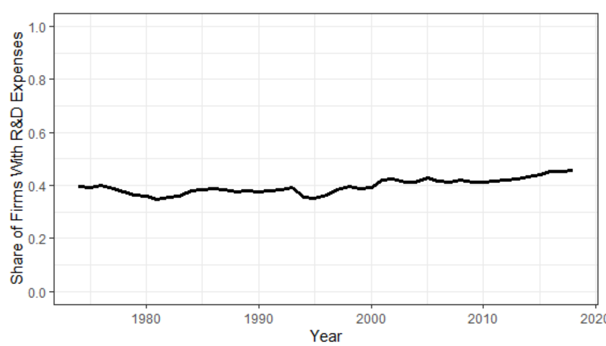
N = 199,151 firm-year observations. The sample spans from 1974 to 2019. Panel A reports the distributions of the variables employed in the analyses. The descriptive statistics are time-series averages of the respective annual statistic. B/P (book-to-price ratio) is equity book value scaled by December t-1 equity market value. Equity book value is calculated as shareholders' equity plus balance sheet deferred taxes and balance sheet investment tax credits, minus preferred stock. Missing values of balance sheet deferred taxes (Compustat: txdb) and missing values of balance sheet investment tax credits (Compustat: itcb) are set to zero. The value of preferred stock is set to the redemption value (Compustat: pstkr), if non-missing, or the liquidation value (Compustat: pstkl), or the carrying value (Compustat: pstk), in that order. Shareholders' equity (Compustat: seq) is set to the value of common equity (Compustat: ceq + pstk), if shareholders' equity is missing, or to total assets minus total liabilities (Compustat: at - lt), in that order. Missing equity book values are then filled by Davis, Fama and French (2000) equity book values, obtained from Kenneth French's website. Adj. B/P (adjusted book-to-price ratio) is the B/P ratio including capitalized R&D expenses of the last 5 years using the straight line method, as outlined in Section 2. CapRD/P is the capitalized R&D asset. SIZE is equity market value from December of year t-1. R&D intensity is R&D expenses scaled by total assets. RD/P (R&D-to-price) is R&D expenses scaled by December t-1 equity market value. RE/P (Retained-earnings-to-price) is retained earnings (Compustat: re - acominc) scaled by December t-1 equity market value. Exc. ret (excess returns) are monthly returns minus the one month treasury bill rate. $ret_{1,1}$ is the prior month's return. $ret_{12,2}$ is the year's return excluding the last month. For analysis of firm characteristics around the portfolio formation date of (CapRD/P), I construct the following growth variables. Earnings growth (EG) at date t is calculated as $(E_{t+1} - E_t)/|E_t|$, where E is earnings before extraordinary items and tax-adjusted special items ($(ib - (1 - tax) \times spi)$). MVE growth (MVEG) at date t is calculated as $(MVE_{t+1} - MVE_t)/|MVE_t|$, where MVE is equity market value from December at time t-1. R&D expenditure growth (RDG) at date t is calculated as $(RD_{t+1} - RD_t)/|RD_t|$. Panel B reports the time-series averages of Pearson correlations (upper diagonal) and Spearman rank correlations (lower diagonal).



(a) Mean R&D intensity for each sample year



(b) Mean R&D intensity by B/P quintile for each sample year



(c) Share of R&D firms for each sample year

Figure 1: R&D statistics across years

Figure 1 depicts the average R&D intensity (R&D-to-total-assets) across years from 1974 to 2019. (a) depicts the average R&D intensity for each sample year. (b) depicts the average R&D intensity across years by B/P quintile. Quintiles are formed at the end of each June according to NYSE breakpoints. (c) depicts for each sample year the share of firms that reports R&D expenditures.

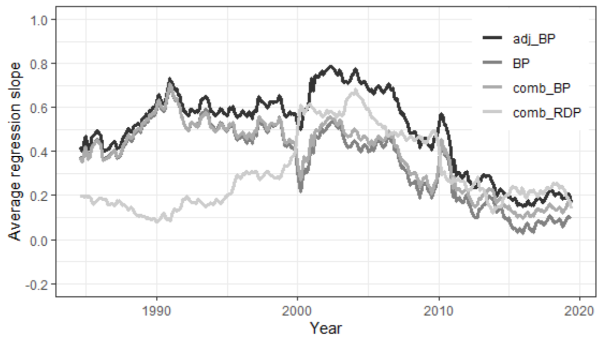
Table 2: Fama-MacBeth Regressions

Panel A: All Firms	(1)	(2)	(3)	(4)	(5)
Log(B/P)	0.32			0.35	0.35
	(4.86)			(5.74)	(5.89)
Log(adj. B/P)		0.43			
		(7.28)			
Log(RD/P)			0.33	0.26	
			(7.79)	(5.76)	
Log(CapRD/P)					0.21
					(5.66)
dy_RD/P			-1.37	-1.28	-1.02
			(-5.96)	(-5.56)	(-5.45)
Log(MVE)	-0.07	-0.05	-0.07	-0.04	-0.04
	(-1.88)	(-1.38)	(-2.17)	(-1.22)	(-1.20)
$r_{1,1}$	-4.92	-4.88	-4.87	-5.10	-5.09
	(-11.42)	(-11.18)	(-11.36)	(-12.16)	(-12.17)
$r_{12,2}$	0.43	0.42	0.46	0.42	0.42
	(2.43)	(2.39)	(2.63)	(2.44)	(2.42)
Adj. R^2	3.0%	2.9%	3.0%	3.5%	3.5%

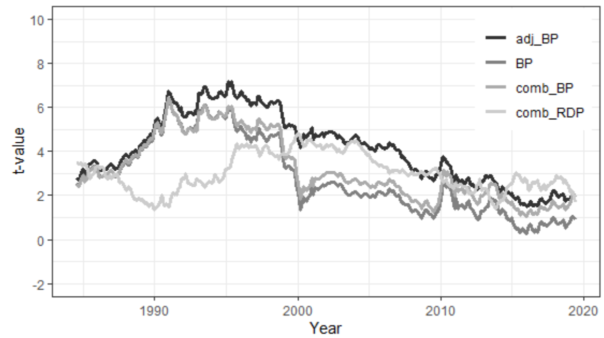
Panel B: All-but-microcaps	(1)	(2)	(3)	(4)	(5)
Log(B/P)	0.18			0.18	0.19
	(2.43)			(2.64)	(2.73)
Log(adj. B/P)		0.22			
		(3.14)			
Log(RD/P)			0.24	0.19	
			(5.58)	(4.22)	
Log(CapRD/P)					0.14
					(3.95)
dy_RD/P			-1.03	-0.91	-0.67
			(-4.59)	(-3.95)	(-3.72)
Log(MVE)	-0.04	-0.04	-0.04	-0.03	-0.04
	(-1.05)	(-0.96)	(-1.08)	(-0.81)	(-1.22)
$r_{1,1}$	-3.19	-3.16	-3.06	-3.36	-3.36
	(-6.59)	(-6.47)	(-6.28)	(-7.12)	(-7.10)
$r_{12,2}$	0.56	0.55	0.57	0.56	0.56
	(2.35)	(2.32)	(2.45)	(2.40)	(2.40)
Adj. R^2	5.3%	5.2%	5.3%	6.2%	6.1%

Panel C: Microcaps	(1)	(2)	(3)	(4)	(5)
Log(B/P)	0.37			0.42	0.42
	(5.36)			(6.57)	(6.86)
Log(adj. B/P)		0.53			
		(8.84)			
Log(RD/P)			0.37	0.29	
			(7.34)	(5.48)	
Log(CapRD/P)					0.25
					(5.58)
dy_RD/P			-1.48	-1.43	-1.17
			(-5.89)	(-5.72)	(-5.67)
Log(MVE)	-0.18	-0.14	-0.21	-0.14	-0.13
	(-2.92)	(-2.30)	(-3.65)	(-2.35)	(-2.23)
$r_{1,1}$	-5.45	-5.41	-5.42	-5.64	-5.63
	(-12.25)	(-11.97)	(-12.32)	(-13.02)	(-13.04)
$r_{12,2}$	0.43	0.43	0.47	0.42	0.42
	(2.68)	(2.62)	(2.96)	(2.69)	(2.66)
Adj. R^2	2.5%	2.3%	2.5%	2.9%	2.9%

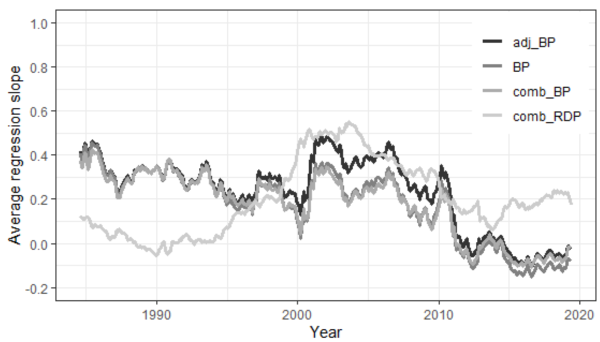
Table 2 reports Fama & MacBeth (1973) regressions that predict monthly returns; regressions are estimated monthly from July 1974 to June 2019. All independent variables are winsorized at the 1st and 99th percentile. Regression slopes are multiplied by 100. Panel A reports results for all sample firms. Panel B reports results for all-but-microcaps firms: these are all firms that have equity market values above or equal to the 20th percentile of the distribution of the NYSE equity market capitalization. Panel C reports results for microcaps: these are firms that have equity market values below the 20th percentile of the distribution of the NYSE equity market capitalization. t-values are reported in parentheses. Variable definitions can be found in Table 1.



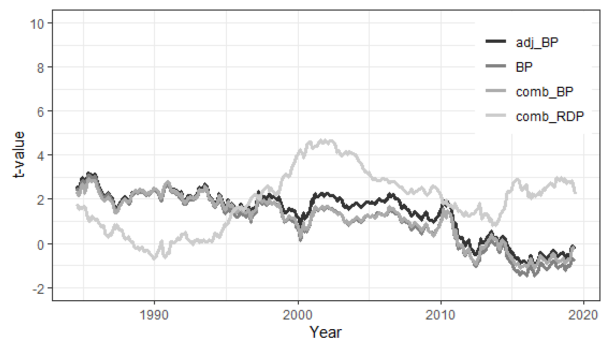
(a) regression slope - all firms



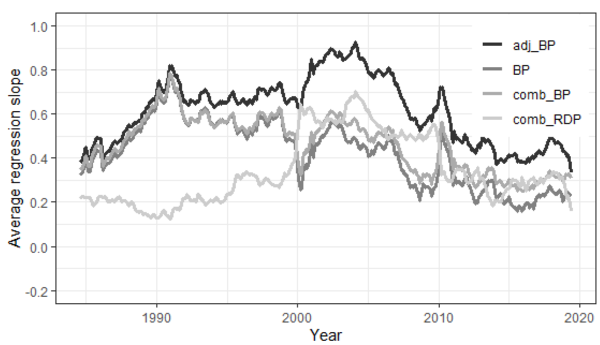
(b) t-values - all firms



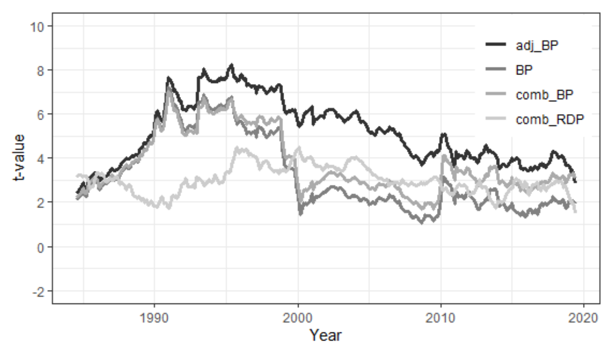
(c) regression slope - all-but-microcaps



(d) t-values - all-but-microcaps



(e) regression slope - microcaps



(f) t-values - microcaps

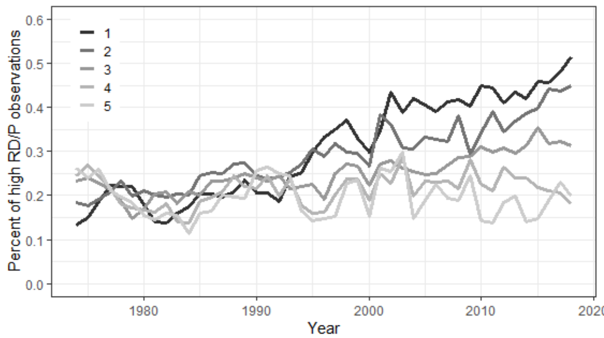
Figure 2: Rolling 10-year average regression slopes and t-values

Figure 2 depicts rolling ten-year averages of Fama-MacBeth regression slopes and the corresponding t-values for the B/P ratio (regression slope of column 1 in Table 2), the adjusted B/P ratio (regression slope of column 2 in Table 2), and the RD/P ratio (regression slope of column 3 in Table 2), respectively. The respective date indicated on the x-axis indicates the end of each 10-year period. All-but-microcaps are all firms that have equity market values above or equal to the 20th percentile of the distribution of the NYSE equity market capitalization. Microcaps are all firms that have equity market values below the 20th percentile of the distribution of the NYSE equity market capitalization.

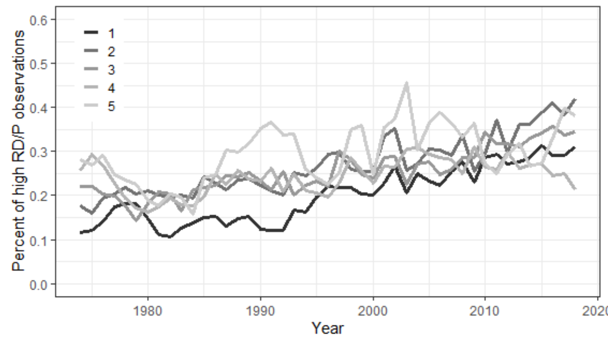
Table 3: Returns on portfolios sorted by B/P and RD/P, and adjusted B/P and RD/P

	EW					t(EW)					VW					t(VW)					nobs			
		RD/P tertiles					RD/P tertiles					RD/P tertiles					RD/P tertiles					RD/P tertiles		
		Low	2	High	H-L		Low	2	High	H-L		Low	2	High	H-L		Low	2	High	H-L		Low	2	High
Panel A: Portfolios sorted on B/P and RD/P																								
B/P Low	0.57	0.41	0.44	0.97	0.56	2.06	1.67	1.60	2.85	3.23	0.61	0.58	0.54	0.82	0.24	2.85	2.65	2.41	3.53	1.76	1,103	483	295	325
2	0.92	0.74	0.81	1.31	0.57	3.81	3.39	3.47	4.20	3.51	0.77	0.75	0.80	0.88	0.13	3.87	3.68	3.83	3.68	0.92	773	418	132	223
3	0.99	0.84	0.91	1.38	0.54	4.42	4.07	3.95	4.63	3.36	0.76	0.81	0.66	0.84	0.03	3.92	4.03	3.22	3.44	0.24	749	474	90	185
4	1.09	0.96	1.12	1.45	0.49	5.07	4.77	4.52	5.14	3.32	0.78	0.77	0.66	1.13	0.36	3.82	3.77	2.87	4.26	2.19	789	552	68	169
B/P High	1.25	1.12	1.11	1.70	0.58	5.16	4.78	4.01	5.63	3.80	0.86	0.88	0.73	1.23	0.35	4.04	4.05	2.59	4.37	1.95	952	715	49	188
Panel B: Portfolios sorted on adjusted B/P and RD/P																								
Adj. B/P Low	0.50	0.43	0.42	0.85	0.42	1.90	1.77	1.52	2.65	2.69	0.59	0.57	0.53	0.84	0.27	2.78	2.65	2.36	3.60	1.88	1,008	523	294	191
2	0.86	0.74	0.85	1.12	0.38	3.60	3.39	3.53	3.59	2.30	0.76	0.73	0.81	0.83	0.10	3.84	3.59	3.94	3.54	0.67	769	432	134	203
3	0.97	0.87	0.90	1.27	0.39	4.34	4.25	3.86	4.26	2.48	0.82	0.84	0.68	1.02	0.18	4.18	4.14	3.23	4.14	1.27	752	473	89	190
4	1.10	0.97	1.15	1.42	0.45	5.03	4.83	4.61	4.84	2.83	0.76	0.78	0.67	0.90	0.12	3.70	3.86	2.90	3.45	0.73	802	539	67	196
Adj. B/P High	1.32	1.12	1.11	1.71	0.59	6.31	4.74	3.96	5.37	3.57	0.93	0.88	0.70	1.21	0.33	4.15	4.04	2.43	4.19	1.71	1,032	674	48	310

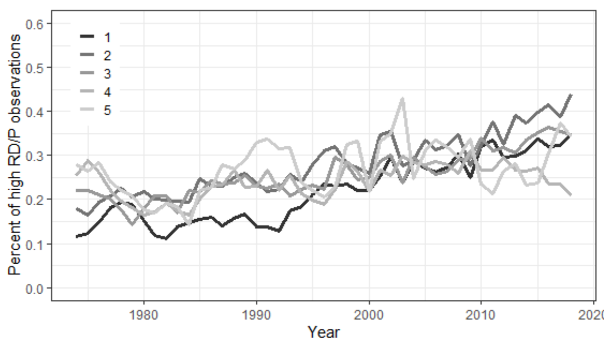
Table 3 reports average equal-weighted excess returns (EW) and value-weighted excess returns (VW) for portfolios sorted independently on the B/P ratio and the RD/P ratio, and independently on the adjusted B/P ratio and the RD/P ratio. Excess returns are monthly returns in excess of the one month treasury bill rate. t(·) represents the t-values of the respective returns. At the end of each June stocks are sorted into the portfolios according to NYSE breakpoints. Portfolios are held for one year. Observations that delist during the year are invested in the value-weighted market index until the end of the portfolio formation period. nobs is the time-series average of the number of observations per portfolio. As not all firms report R&D expenditures, the lowest RD/P portfolio comprises all firms that do not report R&D expenditures; the second RD/P tertile represents the firms below the RD/P median at the end of each June; the third RD/P tertile represents the firms above the RD/P median at the end of each June.



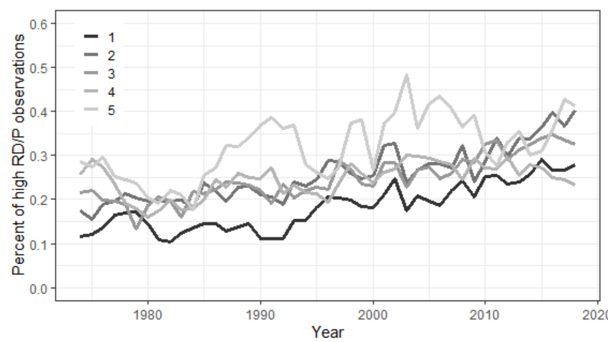
(a) Percentage of high RD/P observations in respective B/P quintile over time



(b) Percentage of high RD/P observations in respective adjusted B/P quintile over time



(c) Percentage of high RD/P observations in respective adjusted B/P quintile over time with a 3 year R&D expense capitalization



(d) Percentage of high RD/P observations in respective adjusted B/P quintile over time with a 8 year R&D expense capitalization

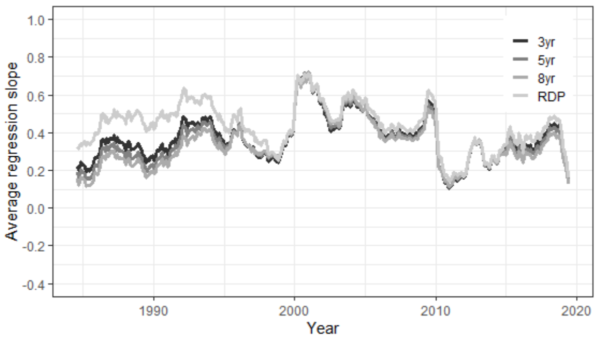
Figure 3: Percentage of high RD/P tertile observations by B/P quintile

Figure 3 depicts the percentage of observations in each B/P quintile and each adjusted B/P quintile that fall into the highest RD/P tertile (independent sort) for each sample year. (a) depicts the percentage of high RD/P tertile observations in each B/P quintile. (b) depicts the percentage of high RD/P tertile observations in each adjusted B/P quintile. The B/P ratio is adjusted for the capitalization of the past 5 years of R&D expenditures. (c) depicts the percentage of high RD/P tertile observations in each adjusted B/P quintile. The B/P ratio is adjusted for the capitalization of the past 3 years of R&D expenditures. (d) depicts the percentage of high RD/P tertile observations in each adjusted B/P quintile. The B/P ratio is adjusted for the capitalization of the past 8 years of R&D expenditures. Quintiles and tertiles are independently formed at the end of each June according to NYSE breakpoints. As not all firms report R&D expenditures, the lowest RD/P portfolio comprises all firms that do not report R&D expenditures; the second RD/P tertile represents the firms below the RD/P median at the end of each June; the third RD/P tertile represents the firms above the RD/P median at the end of each June.

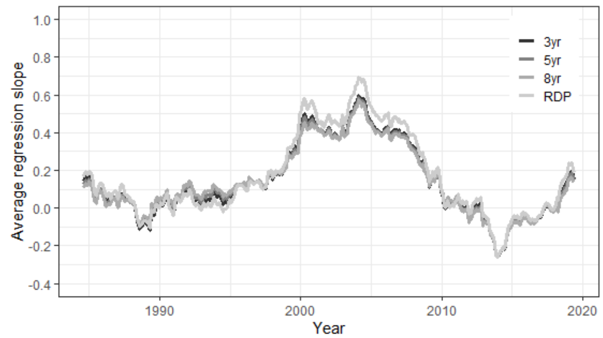
Table 4: Fama-MacBeth Regressions for firms that have R&D expenditures

	(1)	(2)	(3)	(4)	(5)
Log(RD/P)	0.26		0.19		
	(5.51)		(3.80)		
Log(CapRD/P)		0.25		0.18	0.03
		(5.54)		(3.59)	(0.56)
Log(dy_U5)			0.53	0.45	
			(3.11)	(3.03)	
Log(RD/P_U5)			0.18		
			(4.15)		
Log(CapRD/P_U5)				0.15	
				(3.78)	
Log(B/P)	0.35	0.35	0.34	0.34	0.49
	(4.60)	(4.52)	(4.63)	(4.74)	(3.17)
Log(MVE)	-0.05	-0.04	-0.05	-0.04	-0.08
	(-1.14)	(-0.98)	(-1.29)	(-1.06)	(-1.09)
$r_{1,1}$	-5.82	-5.81	-5.89	-5.90	-6.89
	(-13.47)	(-13.49)	(-13.72)	(-13.80)	(-5.16)
$r_{12,2}$	0.16	0.15	0.15	0.15	-0.35
	(0.94)	(0.89)	(0.92)	(0.88)	(-0.85)
Adj. R^2	3.4%	3.4%	3.6%	3.6%	6.4%

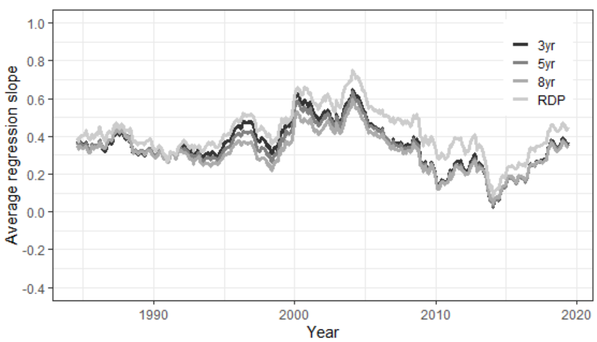
Table 4 reports Fama & MacBeth (1973) regressions that predict monthly returns for firms that have current R&D expenditures (N = 78,551); column (5) reports Fama & MacBeth (1973) regressions that predict monthly returns for firms that do not have current R&D expenditures, but have a positive capitalized R&D asset (N = 4,622); regressions are estimated monthly from December 1974 to June 2019. All independent variables are winsorized at the 1st and 99th percentile. Regression slopes are multiplied by 100. t-values are reported in parentheses. Variable definitions can be found in Table 1.



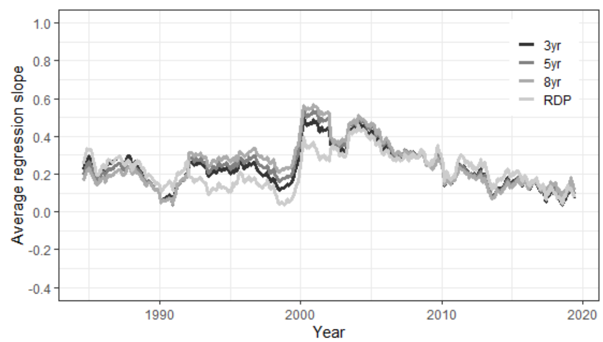
(a) Chemical and Allied Products (SIC = 28)



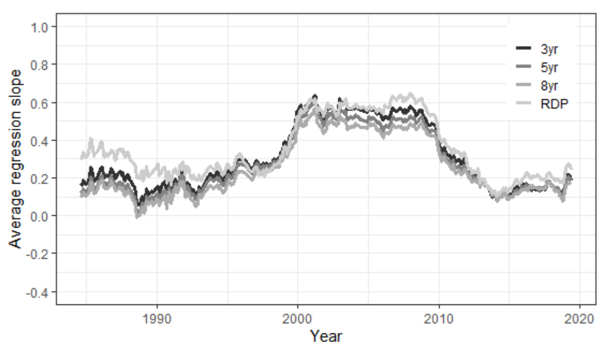
(b) Industrial and Machinery Equipment (SIC = 35)



(c) Electronic and Other Electric Equipment (SIC = 36)



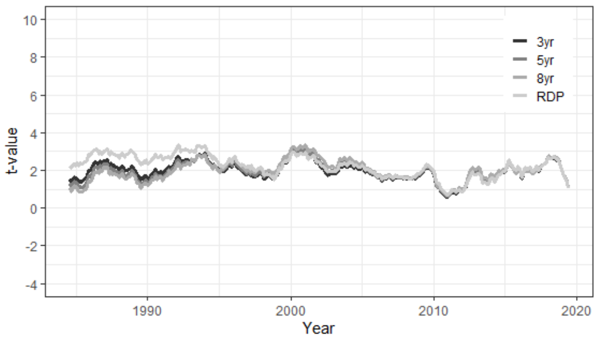
(d) Instruments and Related Products (SIC = 38)



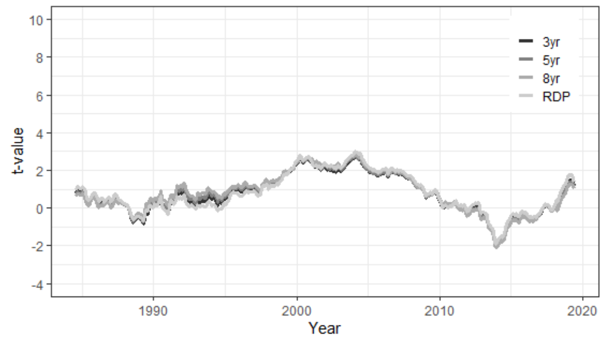
(e) Business Services (SIC = 73)

Figure 4: Rolling 10-year average regression slopes within R&D intensive industries

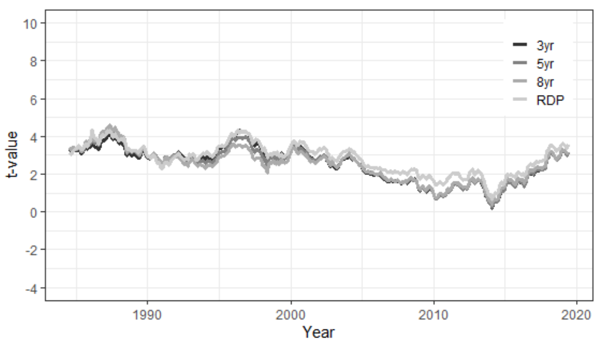
Figure 4 depicts rolling ten-year averages of Fama-MacBeth regression slopes for the RD/P ratio estimated within the respective industry and using size, B/P, lagged monthly returns and lagged annual returns skipping one month as controls. The Figure also shows rolling ten-year averages of Fama-MacBeth regression slopes for the CapRD/P ratio for a useful life of 3 years, 5 years, and 8 years, respectively, estimated within the respective industry and using size, B/P, lagged monthly returns and lagged annual returns skipping one month as controls. The respective date indicated on the x-axis indicates the end of each 10-year period.



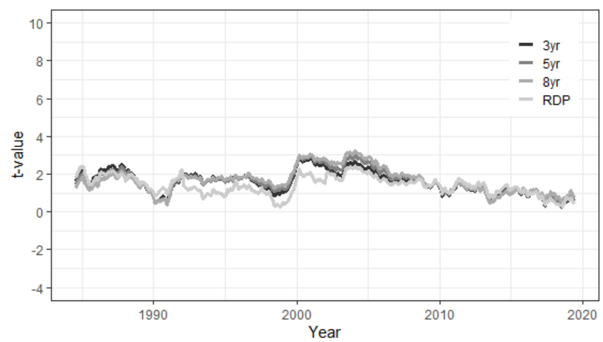
(a) Chemical and Allied Products (SIC = 28)



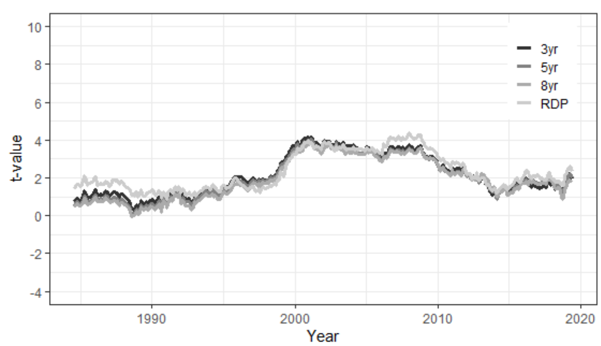
(b) Industrial and Machinery Equipment (SIC = 35)



(c) Electronic and Other Electric Equipment (SIC = 36)



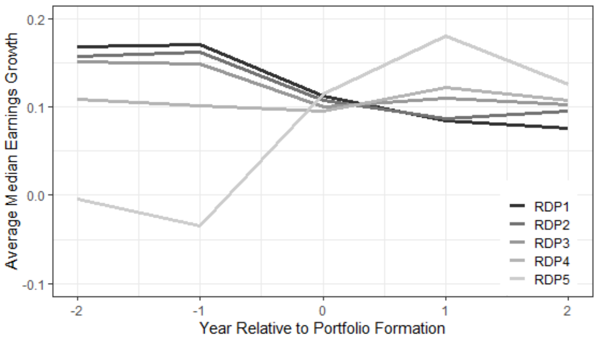
(d) Instruments and Related Products (SIC = 38)



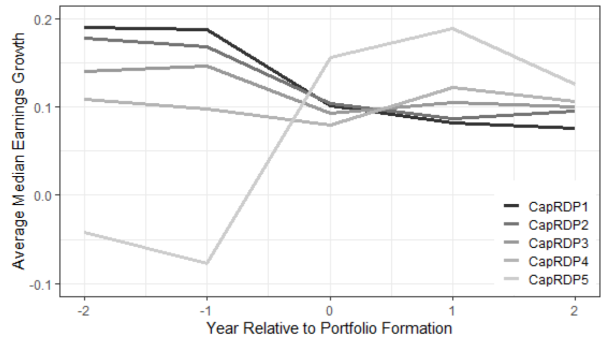
(e) Business Services (SIC = 73)

Figure 5: T-values obtained from rolling 10-year average regression slopes within R&D intensive industries

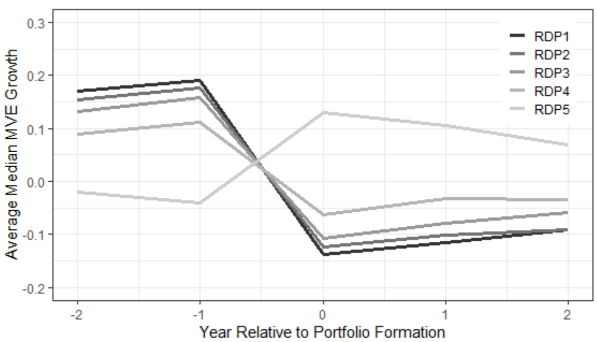
Figure 5 depicts t-values obtained from rolling ten-year averages of Fama-MacBeth regression slopes for the RD/P ratio estimated within the respective industry and using size, B/P, lagged monthly returns and lagged annual returns skipping one month as controls. The Figure also shows t-values obtained from rolling ten-year averages of Fama-MacBeth regression slopes for the CapRD/P ratio for a useful life of 3 years, 5 years, and 8 years, respectively, estimated within the respective industry and using size, B/P, lagged monthly returns and lagged annual returns skipping one month as controls. The respective date indicated on the x-axis indicates the end of each 10-year period.



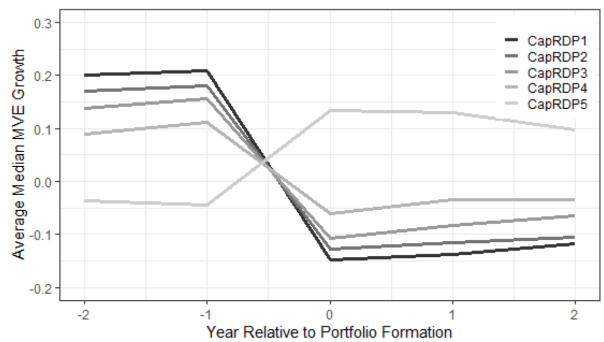
(a) Earnings growth by RDP quintiles



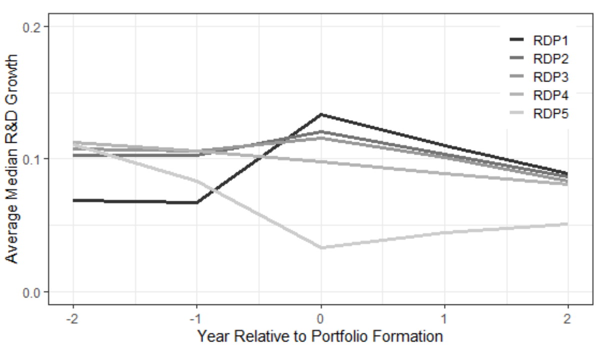
(b) Earnings growth by capitalized RDP quintiles



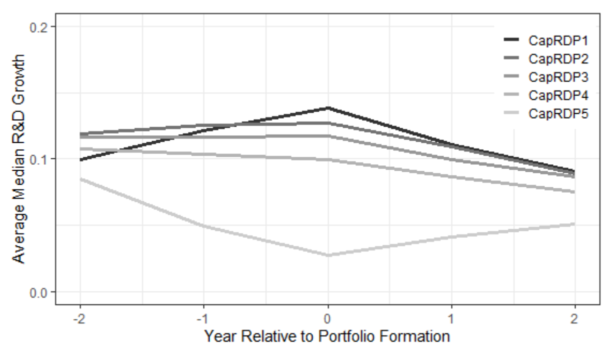
(c) MVE growth by RDP quintiles



(d) MVE growth by capitalized RDP quintiles



(e) R&D expenditure growth by RDP quintiles



(f) R&D expenditure growth by capitalized RDP quintiles

Figure 6: Firm characteristics around portfolio formation date

Figure 6 depicts firm characteristics around the portfolio formation date of RD/P and capitalized RD/P. At the end of each June stocks are sorted into quintiles according to NYSE breakpoints. For each year, the median firm characteristic is calculated and the average across the sample years is calculated. Earnings growth (EG) at date t is calculated as $(E_{t+1} - E_t)/|E_t|$, where E is earnings before extraordinary items and tax-adjusted special items. MVE growth (MVEG) at date t is calculated as $(MVE_{t+1} - MVE_t)/|MVE_t|$, where MVE is equity market value from December at time t-1. R&D expenditure growth (RDG) at date t is calculated as $(RD_{t+1} - RD_t)/|RD_t|$.