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R&D Capital Replication

Assumptions

- Portfolio reconstitution occurred once annually every April 1.
- Shifting annual financial information 90 days into the future handled lookahead bias.
- Firms with negative or missing R&D expenditure values were replaced with 0.
- Weights in value-weighted portfolios were determined by using lagged market value of equity.
- Portfolio results reflect excess returns.

Methodology

To determine if a firm's R&D expenditure was related to stock returns, various back-tests were performed on quintile-sorted portfolios of R&D firms and Non R&D firms over various time periods. Portfolios were created with equally-weighted returns, value-weighted returns, and value-weighted returns with the top 1000 firms removed to determine if this effect was positive and statistically significant for both CAPM and Fama-French 3-Factor alphas. The results are replicated below.

Results

1. Portfolio Returns (Equally-Weighted)

Time	Low	2	3	4	High	NonR&D
1981.07 - 2012.12	0.244	0.593	0.869	1.120	1.770	0.706
1981.07 - 1999.12	0.242	0.598	0.866	1.122	1.723	0.569
2000.01 - 2012.12	0.248	0.581	0.873	1.114	1.837	0.901

Figure 1: Equally-weighted portfolio returns (1981 - 2012)

2. Long-Short Portfolio (Equally-Weighted)

a. CAPM alpha:
   i. 1.47% per month (t-statistic 5.867)
b. Fama-French 3-factor alpha:
   i. 1.44% per month (t-statistic 6.417)
c. Sharpe ratio:
   i. 1.089 (annual)

3. Portfolio Returns (Value-Weighted)

Time	Low	2	3	4	High	NonR&D
1981.07 - 2012.12	0.439	0.607	0.665	0.887	0.967	0.551
1981.07 - 1999.12	0.675	0.994	1.056	1.082	1.193	0.767
2000.01 - 2012.12	0.101	0.055	0.110	0.620	0.646	0.244

Figure 2: Value-weighted portfolio returns (1981 - 2012)

Long-Short Portfolio (Value-Weighted)

a. CAPM alpha:
   i. 0.33% per month (t-statistic 1.325)
b. Fama-French 3-factor alpha:
   i. 0.10% per month (t-statistic 0.469)
c. Sharpe ratio:
   i. 0.364 (annual)

4. Portfolio Returns without Top 1000 (Value-Weighted)

Time	Low	2	3	4	High	NonRD
1981.07 - 2012.12	0.317	0.537	0.741	0.872	1.291	0.580
1981.07 - 1999.12	0.407	0.605	0.854	1.016	1.277	0.496
2000.01 - 2012.12	0.148	0.444	0.581	0.670	1.308	0.702

Figure 3: Value-weighted portfolio returns (1981 - 2012) without Top 1000

Long-Short Portfolio (Value-Weighted)

a. CAPM alpha:
   i. 0.86% per month (t-statistic 3.821)
b. Fama-French 3-factor alpha:
   i. 0.80% per month (t-statistic 3.717)
c. Sharpe ratio:
   i. 0.763 (annual)

5. Repeat Steps 1-4 extending through December 2021

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1. Portfolio Returns (Equally-Weighted)

Time	Low	2	3	4	High	NonRD
1981.07 - 2021.12	0.394	0.715	1.034	1.189	1.723	0.761
1981.07 - 1999.12	0.242	0.598	0.866	1.122	1.723	0.569
2000.01 - 2012.12	0.248	0.581	0.873	1.114	1.837	0.901
2013.01 - 2021.12	0.917	1.145	1.609	1.428	1.560	0.954

Figure 4: Equal-weighted portfolio returns (1981 - 2021)

2. Long-Short Portfolio (Equally-Weighted)

a. CAPM alpha:
   i. 1.24% per month (t-statistic 5.577)
b. Fama-French 3-factor alpha:
   i. 1.27% per month (t-statistic 6.426)
c. Sharpe ratio:
   i. 0.946 (annual)

3. Portfolio Returns (Value-Weighted)

Time	Low	2	3	4	High	NonRD
1981.07 - 2021.12	0.553	0.826	0.858	1.058	1.127	0.631
1981.07 - 1999.12	0.675	0.994	1.056	1.082	1.193	0.767
2000.01 - 2012.12	0.101	0.055	0.110	0.620	0.646	0.244
2013.01 - 2021.12	0.952	1.593	1.535	1.659	1.689	0.909

Figure 5: Value-weighted portfolio returns (1981 - 2021)

Long-Short Portfolio (Value-Weighted)

a. CAPM alpha:
   i. 0.31% per month (t-statistic 1.465)
b. Fama-French 3-factor alpha:
   i. 0.21% per month (t-statistic 1.158)
c. Sharpe ratio:
   i. 0.405 (annual)

4. Portfolio Returns without Top 1000 (Value-Weighted)

Time	Low	2	3	4	High	NonRD
1981.07 - 2021.12	0.484	0.703	0.891	1.069	1.451	0.615
1981.07 - 1999.12	0.407	0.605	0.854	1.016	1.277	0.496
2000.01 - 2012.12	0.148	0.444	0.581	0.670	1.308	0.702
2013.01 - 2021.12	1.076	1.288	1.414	1.759	2.011	0.735

Figure 6: Value-weighted portfolio returns (1981 - 2021) without Top 1000

Long-Short Portfolio (Value-Weighted)

a. CAPM alpha:
    i. 0.82% per month (t-statistic 4.014)
b. Fama-French 3-factor alpha:
    i. 0.82% per month (t-statistic 4.208)
c. Sharpe ratio:
    i. 0.743 (annual)

Conclusion

In summation, within the original time period stretching from 1981 - 2012 as well as the extended time period through December 2021, the equally-weighted portfolios as well as the value-weighted portfolios after the top 1000 firms (as measured by their market value of equity) generated statistically significant and positive CAPM alphas and Fama-French 3-factor alphas. In the value-weighted portfolios, the alphas were positive, but statistically insignificant at the 5% level. In most time periods in the return tables, the portfolio returns monotonically increased from Low to High R&D, and exhibited fairly similar values in terms of magnitude when compared to the measures provided in the class slides.

These results suggest that after controlling for size by removing the top 1000 firms in both time periods, there is a statistically significant effect of R&D and these excess returns are driven mainly by small stocks.