Cost of Capital for Pharmaceutical, Biotechnology, and Medical Device Firms

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Abstract

This study provides new estimates of systematic risk and the cost of equity capital for the pharmaceutical, biotechnology, and medical device sectors using data for firms with publicly-traded stock on U.S. exchanges during 2001-2005 and 2006-2008. Two frameworks are employed for estimating firms' risk and the cost of equity capital: (1) the capital asset pricing model, and (2) the Fama-French three-factor model. Evidence is provided of the relationship between risk, cost of equity, and the intensity of firms' R&D expenditures. Controlling for firms' principal sector (pharmaceutical, biotechnology, or device), R&D intensity, as measured by the ratio of R&D expense to total revenues, is positively related to market betas and thus the estimated cost of equity capital. Estimates of the Fama-French model imply a size-related risk premium in the cost of equity for small firms in each sector. Controlling for R&D intensity, average market betas differ significantly across sectors during the periods analyzed. Large biotech firms on average had large, negative, and significant book-to-market betas during 2001-2005, significantly lowering their estimated cost of equity capital, but the negative book-to-market betas and lower estimated cost of equity for large biotechs disappeared during 2006-2008.

I. Introduction

The investment, financing, and risk management decisions of pharmaceutical, biotechnology, and medical device firms are fundamentally important to the development and availability of innovative treatments to enhance health outcomes and the quality of life. Economically efficient investment, including research and development, requires undertaking projects with positive "net present value," i.e., projects for which the discounted value of expected net cash flows is positive, where the discount rate reflects investors' opportunity cost of capital. The cost of capital therefore has significant effects on investment decisions. It also affects the minimum product prices that are required to make basic research and particular R&D projects economically attractive.

Given long research and development cycles and relatively low scientific success rates for individual projects, the effects of the cost of capital on investment decisions can be particularly large for the pharmaceutical, biotechnology, and medical device sectors. Because firms in these sectors are primarily financed by equity (common equity issues and retained earnings), as opposed to debt, the relevant cost of capital for investment decisions is dominated by the cost of equity capital (see, e.g., Myers and Shyam-Sunder, 1996). Estimates of the cost of equity capital and understanding factors that influence the cost of equity are thus highly relevant to project development and policy issues, including drug and device pricing, and measurement of the average cost of developing a new drug or device (e.g., Dimasi, Hansen, and Grabowski, 2003; DiMasi and Grabowski, 2007; Vernon, Golec, and DiMasi, 2009).

This study provides new estimates of systematic risk and the cost of equity capital for the pharmaceutical, biotechnology, and medical device sectors using data for firms with publicly traded stock on U.S. exchanges (including foreign owned-firms) during 2001-2005 and 2006-2008. Two frameworks are employed for estimating firms' risk and the cost of equity capital:

(1) the capital asset pricing model (CAPM), and (2) the empirically-driven three risk-factor model of Fama and French (F-F, 1992, 1993).

The CAPM is widely used by corporations, investment banks, and portfolio managers in valuation and capital budgeting. It is based on the simple notion that investors who are able to diversify at low cost will only demand compensation for bearing non-diversifiable risk. The CAPM posits that the risk premium required by investors for holding a particular security will depend on the sensitivity of the security's return to returns on the market portfolio of risky assets, as measured by the security's "beta." Beta is a measure of a security's market risk that cannot be diversified away by combining it with other securities in a portfolio.

The CAPM assumes a single, market risk factor. The F-F model was developed in response to evidence that, controlling for market beta, historical mean returns for small firms' stock were higher than for large firms and historical mean returns for stocks with high ratios of book-to-market equity ("value" stocks) were higher than those for stocks with low book-to-market equity ("growth" or "glamour" stocks). The F-F model posits that two non-diversifiable risk factors affect the required return on a security in addition to its market risk: (1) a risk factor related to firms' market capitalization (the size factor), and (2) a risk factor related to a firms' ratios of book value of equity capital to the market value of equity capital (the book-to-market factor). A firm's cost of equity capital depends on its market, size, and book-to-market betas and the risk premia associated with each risk factor. While the F-F model is less widely used in valuation and capital budgeting than the CAPM, it is often used in comparison with the CAPM. In addition, many investment analysts employ cost of equity capital estimates that incorporate a size factor if not both the size and book-to-market factors.

This study's empirical analysis focuses on possible differences in risk and the associated cost of equity capital across the pharmaceutical, biotechnology, and device sectors and between large and small firms within each sector. It also provides evidence of the relationship between firms' risk, cost of equity capital, and the intensity of research and development expenditures (R&D), as measured by the ratio of R&D to total revenues ("sales"). Prior work (see below) has emphasized that while technical uncertainty associated with success or failure during product development and approval is likely diversifiable, expected future R&D expenditures for a given project create a form of leverage analogous to operating and financial leverage. That leverage, which declines as the project moves through development, increases the project's systematic risk that arises from correlation between the project's projected commercial value conditional on success and underlying risk factors priced by investors, such as market risk.

There are four principal findings from the empirical analysis. First, R&D intensity is positively related to market betas and thus the estimated cost of equity capital, after controlling for firms' principal sector of operations (pharmaceutical, biotechnology, or device). Second, the choice of model matters. The CAPM and F-F models can produce materially different estimates of the cost of equity capital. In particular, the results for the F-F model imply a size-related risk premium in the cost of equity capital for smaller firms in each sector. Third, controlling for R&D intensity, average market betas can differ significantly across sectors. Biotech firms had significantly higher market betas than pharmaceutical firms during 2001-2005. Device firms had significantly higher betas than pharmaceutical firms during 2006-2008. Fourth, the time period matters, as implied by the preceding results and by a large negative and significant average book-to-market beta for large biotech firms during 2001-2005, which significantly lowered the estimated cost of capital during that period, but which did not persist during 2006-2008.

Section II briefly reviews prior work and discusses the likely relation between the cost of equity capital and R&D intensity. Section III outlines the CAPM and F-F models and their empirical implementation. The data and samples are discussed in Section IV. Section V presents beta and cost of equity capital estimates for equally-weighted portfolios formed by sector and by sector and firm size. Section VI presents results concerning the relationship between individual firm betas and R&D intensity. Section VII concludes.

II. Prior Work

Enormous theoretical and empirical literatures consider the cost of capital in general and the cost of equity capital in particular. Much of this research addresses the CAPM and the F-F models, including their ability to explain cross-sectional stock returns (see, e.g., F-F, 1992, 1993, 2006). While much of this work castes doubt on its empirical veracity, the CAPM remains the most widely used method in practice for estimating the cost of capital.

The question of whether size and book-to-market factors in returns are persistent and related to underlying priced risk factors has been extensively debated, including whether historical size-related return premia compensate for risk related to illiquidity or financial distress (see van Dijk, 2007), and whether historical book-to-market related return premia compensate for risk related to earnings volatility or financial distress.

Studies that have employed the CAPM or F-F model to estimate the cost of equity capital for pharmaceutical and/or biotechnology firms are summarized in Table 1.[1] Grabowski and Vernon (1990) and DiMasi, Hansen, and Grabowski (DHG, 1991) utilize a real cost of capital estimate of 9 percent assuming an average CAPM beta of one based on beta estimates using data from the 1970s to the mid-1980s. The Office of Technology Assessment (1993) reports an average pharmaceutical firm beta of 0.90 based on annual estimates for 20-25 firms during 1975-1987.

[1] Also see Cockburn and Lerner (2009), citing high betas for early state ventures. A variety of studies have used the CAPM or F-F based models in event studies of abnormal returns for pharmaceutical and biotechnology stocks (see, e.g., Bastin and Hubner, 2006; Golec, Hegde, and Vernon, 2005; McNamara and Baden-Fuller, 2007)

Myers and Shyam-Sunder (1996) provide CAPM-based cost of capital estimates for large pharmaceutical firms as of 1980, 1985, and 1990. They report mean CAPM betas of 0.98, 0.70, and 1.04 for the 1975-1979, 1981-1985, and 1985-1989 periods, respectively. They also report an average beta of 1.54 using 1984-1988 data for seven small pharmaceutical and biotechnology firms.

Myers and Howe (1997) report an average CAPM beta of 1.05 for 13 large pharmaceutical firms using data for 1989-1993 and an average beta of 1.43 using annual data on weekly returns during 1986-1992 for 39 biotechnology firms with traded stock throughout the period. DHG (2003) use the Myers and Shyam-Sunder, Myers and Howe, and updated beta estimates to estimate the cost of capital and resulting opportunity costs for drugs in development.

Golec and Vernon (2007) use the Fama-French model to estimate cost of capital for samples of pharmaceutical and biotechnology firms using 1982-2005 data. The average market betas are 0.92 for pharmaceuticals and 1.06 for biotechnology firms. The F-F size betas are large and significant for both samples, especially for biotechs, increasing the estimated cost of capital. The book-to-market factor betas are close to zero and insignificant for both sectors. Vernon, Golec, and DiMasi (2009) compare cost of capital estimates obtained using the CAPM and F-F models for pharmaceutical firms with 3-10 years of returns data ending in 1980 and 1986. The F-F cost of capital estimates are 300-600 basis points greater using the F-F model due to large estimated size betas.

Myers and Shyam-Sunder explain why, given the implicit leverage associated with R&D, systematic risk will likely increase with R&D intensity and be greater for early stage projects compared with more mature projects. Myers and Howe provide a detailed explanation of how the quasi-fixed nature of planned R&D expenditures produces a form of leverage analogous to operating leverage associated with fixed operating costs and financial leverage associated with debt finance. They explain how variation in expected R&D over the life of a project will cause R&D leverage and systematic risk to decline as a drug moves through the development process, giving risk to what they term the "risk-return staircase" in drug development.

Myers and Shyam-Sunder and Myers and Howe also note that a positive relationship between R&D intensity and risk is implied by option pricing models. Berk, Breen, and Naik (2004) develop a dynamic model of multistage investment to illustrate how risk associated with ultimate cash flows in R&D intensive ventures has a systematic component even though technical risk about advancement of a project is diversifiable. They view risky, R&D ventures as compound options with systematic uncertainty. They explain how an R&D intensive project can be viewed as a series of compound options on the underlying cash flows of the project, with the strike price equivalent to the expected future investment in R&D. The risk premium on the project decreases if the project advances and, as a result, becomes more "in the money." When a development stage is completed successfully, expected future investment drops, thus reducing the strike price and systematic risk of the project.

Myers and Shyam-Sunder conjecture that the higher mean beta they report for small biotech and pharmaceutical companies than for large pharmaceutical companies is consistent with high R&D being associated with high systematic risk. In an analysis of the potential effects of the Clinton Administation's proposed Health Security Act of 1993 on pharmaceutical / biotechnology firms' stock prices and R&D spending, Golec, Hegde, and Vernon (2005) use the CAPM to estimate abnormal stock returns and report higher average CAPM betas (estimated with data during 1992-1993) for firms with higher average ratios of R&D to assets during 1989-1991.[2]

[2] Also see Ellison and Mullins (2001). In related research, studies of the relationship between R&D intensity and equity values have considered whether stock prices accurately reflect intangible assets associated with R&D. Chan, Lakonishok, and Sougiannis (2001), for example, analyze the relation between historical stock returns and firms' R&D. Eberhart, Maxwell, and Siddique (2004) provide evidence of

III. The CAPM and Fama-French Models

The CAPM and F-F models are expected-return beta representations of linear factor pricing models.[3] The basic formulation of such models is:

$$E(R_j) = \gamma + \beta_{j1}\lambda_1 + \beta_{j2}\lambda_2 + \ldots + \beta_{jK}\lambda_K, \qquad j = 1, 2, \ldots, N \tag{1}$$

where $E(R_j)$ is the expected return on asset j, γ is the riskless rate of interest (or, if no riskless rate exists, the expected return on a zero-beta asset or portfolio), λ_k ($k = 1, 2, \ldots, K$) is the expected risk premium for the k^{th} risk factor, and β_{jk} ($j = 1, 2, \ldots, N; k = 1, 2, \ldots, K$) is the sensitivity of asset j's return to the k^{th} risk factor.

The k underlying risk factors proxy for changes in the marginal utility of consumption and represent sources of risk that cannot be eliminated via portfolio diversification. Equation (1) portrays the fundamental principle that assets with greater risk sensitivities must provide investors with higher expected returns; i.e., when they tend to provide greater (smaller) payoffs when consumption is high (low) and the marginal utility of consumption is low (high).

The single risk factor in the CAPM is the return on the market portfolio of risky assets. With a riskless interest rate, R_F, each asset's expected return is:

$$E(R_j)_{CAPM} = R_F + \beta_j E(R_M - R_F), \qquad j = 1, 2, \ldots, N \tag{2}$$

where β_j is the asset's market ("CAPM") beta, $E(R_M - R_F)$ is the expected excess return on the market portfolio (the "market risk premium"). $E(R_j)_{CAPM}$ is the required expected return

positive abnormal stock returns for firms with unexpected increases in R&D. Lev and Sougiannis (1999) consider a possible relationship between R&D and the book-to-market phenomenon in stock returns. Other studies consider possible valuation effects of the accounting treatment of R&D. See, for example, Lev, Sarath, and Sougiannis (2004), and, for specific application to the pharmaceutical and/or biotechnology sectors, Joos (2002, empirical analysis of relations between pharmaceutical firms' book-to-market ratios and R&D), Healy, Myers, and Howe (2002, simulation analysis of relations between accounting treatment of R&D and pharmaceutical firm economic value), Hand (2004, empirical analysis of relation between market equity value and R&D measures in biotechnology), and Clem, Cowan, and Jeffrey (2004, examination of stock price reactions to proposed changes in accounting treatment of purchased in-process R&D for R&D intensive firms).

[3] See, for example, Cochrane (2001), Ch. 5.

(opportunity cost of equity capital) for stock j given its risk, $\beta_{j.}$ If β_j varies across assets in relation to some variable, x_j, the cost of capital will vary according to:

$$\frac{\partial E(R_j)_{CAPM}}{\partial x_j} = E(R_M - R_F)\frac{\partial \beta_j}{\partial x_j}.$$

The F-F model posits three risk factors: (1) the excess return on the market portfolio, (2) the excess return on a portfolio of "small" stocks versus "big" stocks, and (3) the excess return on a portfolio of stocks with "high" ratios of book equity to market equity (book-to-market ratios) and versus stocks with "low" book-to-market ratios. The expected return for asset *j* is:

$$E(R_j)_{FF} = R_F + \beta_{j,MKT\text{-}RF}\, E(R_M - R_F) + \beta_{j,SMB}\, E(R_S - R_B) + \beta_{j,HML}\, E(R_H - R_L), \qquad (3)$$

where $\beta_{j,MKT\text{-}RF}$ is the asset's excess market return beta (analogous to its CAPM beta), and R_S, R_B, R_H, and R_L are returns on the relevant portfolios of small, big, high book-to-market, and low book-to-market stocks, respectively (see F-F, 1993). If the F-F betas vary in relation to some variable, x_j, the cost of capital will likewise vary according to:

$$\frac{\partial E(R_j)_{FF}}{\partial x_j} = E(R_M - R_F)\frac{\partial \beta_{j,MKT-RF}}{\partial x_j} + E(R_S - R_B)\frac{\partial \beta_{j,SMB}}{\partial x_j} + E(R_H - R_L)\frac{\partial \beta_{j,HML}}{\partial x_j}.$$

Given equation (2), an estimate of a security's or portfolio's CAPM beta can be obtained using least squares to estimate the following model with returns data for a given period:

$$R_{jt} - R_{Ft} = \alpha_{j,CAPM} + \beta_{j,CAPM}(R_{Mt} - R_{Ft}) + \varepsilon_{jt} \;. \qquad (4)$$

Similarly, given equation (3), estimates of F-F betas can be obtained by estimating:

$$R_{jt} - R_{Ft} = \alpha_{j,FF} + \beta_{j,MKT-RF}(R_{Mt} - R_{Ft}) + \beta_{j,SMB}(R_{St} - R_{Bt}) + \beta_{j,HML}(R_{Ht} - R_{Lt}) + \varepsilon_{jt}\,. \qquad (5)$$

Given beta estimates from (4) and (5), cost of equity capital estimates can be generated as a function of assumed values for the risk free interest rate and market, size factor, and book-to-market factor risk premia. If, for example, the assumed risk free rate is 5% and the assumed market, size factor, and book-to-market factor risk premia are 7%, 3%, and 4%, respectively, cost of equity capital estimates would be obtained as:

$$\hat{k}_{j,CAPM} = 0.05 + 0.07\hat{\beta}_{j,CAPM}$$

and

$$\hat{k}_{j,FF} = 0.05 + 0.07\hat{\beta}_{j,MKT-RF} + 0.03\hat{\beta}_{j,SML} + 0.04\hat{\beta}_{j,HML}\,.$$

Assumed risk premia typically are based on historical mean excess returns for the relevant factor portfolios.

IV. Data and Samples

This study estimates CAPM and F-F betas using monthly returns data for two time periods: 2001-2005 (60 monthly returns) and 2006-2008 (36 monthly returns). The 2001-2005 period follows the dot.com boom and bust and predates the subprime mortgage / financial crisis that began in 2006 and accelerated during 2007-2008. The 2006-2008 period thus encompasses the crisis.

The following criteria were used to select sample firms in each period:

- The firm's stock was included in the S&P 1500 and identified in the *Standard & Poor's Industry Survey* at the end of the period for pharmaceutical firms, biotechnology firms, or medical device (healthcare products and supplies) firms.
- Complete monthly returns were available from CRSP for the sample period.
- The firm was included in Compustat each year during the sample period, and had non-missing data for R&D expenses.
- The firm had market capitalization of $100 million or more at the beginning of the sample period.[4]

This procedure resulted in samples of 100 and 99 firms for 2001-2005 and 2006-2008, respectively. The firms were classified as primarily pharmaceutical, biotechnology, or medical device using the classification in *Standard & Poor's Industry Surveys*.[5] Firms were then classified into large and small firm subgroups within each sector based on whether their market

[4] The minimum market capitalization criterion was designed to reduce issues associated with infrequent trading. A handful of firms that met the other criteria were excluded on this basis.
[5] Clinical research organizations and labs were excluded even if they reported some R&D expense.

capitalization was above or below the median value for the entire sample at the beginning of the sample period ($2.51 billion for 2001-2005 and $2.48 billion for 2006-2008).[6]

Monthly returns (including dividends) for each firm were obtained from CRSP available through Wharton Research Data Services (WRDS). Monthly returns in excess of the monthly Treasury bill yield ("excess returns") were calculated for each security. Monthly Treasury bill yields (the risk-free rate used) and monthly excess returns (above the Treasury bill yield) on the value-weighted portfolio of all NYSE/AMEX/NASDAQ securities, size-based, and book-to-market based portfolios were obtained from WRDS (and are also available from Kenneth French's website).

R&D expense (net of acquired in process R&D), total revenues (sales), and other financial data were obtained from the Compustat Annual Fundamentals files, also available through WRDS. The average lagged (one-year) ratio of a firm's annual R&D expense to its annual sales during the sample period was calculated as a measure of its average R&D intensity. A few values above one were truncated at one for each sample.[7] The average lagged ratio of a firm's long-term debt to value (long-term debt plus convertible debt plus preferred stock plus market value of equity) and the average lagged ratio of the firm's book value of equity to market value of equity also were calculated for each firm in each period.

Table 2 shows sample sizes, mean monthly excess returns, and mean and median values of market capitalization, R&D / sales, long-term debt / value, and book-to-market equity for each sector and sector-size subgroup for each sample period. Consistent with the general upward trend in stock prices, the mean excess returns are positive for each category during 2001-2005, with large excess returns for small pharmaceutical and small device firms. During the 2006-

[6] Classifying size groups based on the F-F size portfolio cutoffs would have produced too few small firms for meaningful analysis.
[7] For regressions of betas on R&D / sales, qualitatively similar results were obtained using the raw values of the variable.

2008 period, when the overall market declined sharply in the latter half of 2008, the excess returns are negative for each group except small biotech and small device firms. Relatively few pharmaceutical firms had market capitalizations less than the overall sample median value during each period, whereas the device firm samples include many small firms. The giant pharmaceutical firms cause the mean values of market capitalization for the overall pharmaceutical and large pharmaceutical groups to be much greater than the medians.

During 2001-2005, the mean and median values of R&D / sales are much larger for biotechs than for pharmaceutical and medical device firms. For example, the median of R&D / sales for the overall biotech group is 33% compared with 10% for pharmaceutical firms and 7% for device firms. During 2006-2008, however, the mean and median R&D / sales for the large biotech group are much lower than in 2001-2005, and the difference in R&D intensity between large biotechs and large firms in the other sectors narrows considerably.

The mean and median values of book-to-market equity are roughly similar across groups and time periods. The mean and median values of long-term debt / value are low, just exceeding 10 percent for the small pharmaceutical group during 2006-2008. Because many firms in these sectors hold substantial cash and marketable securities, measures of net debt (total debt less cash and marketable securities) would be even lower (and negative for some firms). As a result of the minimal use of debt finance by most firms, the weighted-average cost of debt and equity capital will be approximately equal to the cost of equity capital. As has been true in a number of previous studies, for this reason the focus in this paper is on the cost of equity capital.

V. Beta and Cost of Capital Estimates by Sector and Size

A. CAPM Betas

Table 3 shows the results of using equation (4) to estimate CAPM betas for nine equally-weighted portfolios: three sector portfolios and six sector-size portfolios. Beta estimates for equally-weighted portfolios are mathematically equivalent to the arithmetic mean of beta estimates for the securities in the portfolio. A multivariate regression model (MVRM) was used to jointly estimate the equations for the three sectors and for the six sector-size portfolios. The MVRM produces estimates identical to estimating the model for each portfolio separately, but it permits tests of equality of betas across portfolios that reflect possible correlations in disturbances across the portfolios.

For the 2001-2005 sample, the CAPM beta estimate is much larger for biotechs (1.32) than for the pharmaceutical firms (0.69) and device firms (0.66), and the differences are statistically significant at the 0.01 level. During 2006-2008, the CAPM beta estimate for the pharmaceutical portfolio is 0.61. The large biotech beta drops to 0.75 and the overall biotech beta drops to 0.97. The beta estimate for the overall device portfolio is 0.89. The biotech and device betas for 2006-2008 are significantly greater than the pharmaceutical beta at the 0.05 level but not significantly different from each other. The R-squared for the small pharmaceutical portfolio for 2006-2008, which includes only 7 firms, is only 14%. With the exception of the small pharmaceutical portfolio, the R-squareds are materially larger during 2006-2008 than during 2001-2005, especially for device firms.

The much higher biotech beta for 2001-2005 is consistent with the much higher R&D intensity for biotechs during this time period (see Table 2). The drop in biotech portfolio betas for 2006-2008 coincides with reductions in R&D intensity during this period compared with 2001-2005. The increases in the device portfolio betas during the 2006-2008 period versus 2001-2005 were not accompanied by any increase in R&D intensity.

The estimated "alphas" (intercepts) shown in Table 3 are generally positive, especially for the 2001-2005 period.[8] The values for the small device portfolio are large and statistically significant, producing a large and significant estimate for the overall device portfolio as well. Controlling for beta, small device firms therefore "outperformed" the overall stock market during this period. The estimated average risk-adjusted excess return for the small device portfolio is 1.6% per month.

B. Fama-French Betas

Table 4 shows F-F betas obtained from estimating equation (5) for the nine portfolios. The market betas are generally lower than those shown in Table 4, with the exception of the overall and large pharmaceutical betas for 2001-2005, which are larger than the CAPM beta estimates. The biotechnology market betas again are significantly larger than those for pharmaceutical and device firms during 2001-2005, and for biotechs and device firms compared with pharmaceutical firms during 2006-2008. The estimated alphas for device firms during 2001-2005 are again large and significant due to the small device firm portfolio.

The inclusion of the size and book-to-market factors in the returns equation produces relatively little increase in R-squareds over the CAPM model. However, consistent with Vernon, Golec, and DiMasi (2005) and Golec and Vernon (2007), the size factor beta estimates are positive and statistically significant for the small firm portfolios for each sector and time period, which is some cases causes the size factor beta to be positive and significant for the overall sector portfolio. Thus, smaller pharmaceutical, biotech, and device stock returns were correlated with those of other small firms during these time periods. The large pharmaceutical firm portfolio has a negative and statistically significant size beta during 2001-2005.

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[8] The estimated alpha from equation (4), sometimes called "Jensen's alpha", is a commonly measure of risk-adjusted performance for portfolios and individual securities.

The book-to-market betas are negative, large in absolute value, and significantly different from zero for the overall and large biotech portfolios during 2001-2005. This result suggests that, after controlling for overall market returns, biotech stock returns tracked those of growth stocks during this time period, when average biotech R&D intensity was high. However, the statistically significant and negative book-to-market betas for biotechs do not persist in 2006-2008, when the larger biotechs had matured with greater sales and lower R&D intensity.

C. Cost of Equity Capital Estimates

Table 5 uses the CAPM and F-F beta estimates from Tables 3 and 4 and their estimated variances and covariances to generate (nominal) cost of equity capital estimates and 95% confidence intervals for those estimates. The estimates assume a risk-free rate of 5 percent per year, which would correspond to an expected annual real return on short-term Treasuries of 2 percent plus an expected inflation rate of 3 percent.[9] Cost of equity capital estimates for a different riskless rate could be obtained by simple addition or subtraction from those shown. The assumed market risk premium is 7 percent, which is approximately equal to the average annualized monthly excess market return available from CRSP during July 1926 – June 2009 (7.1%). The expected excess return on small versus large stocks is assumed to be 3 percent, compared with an average annualized excess return on the F-F size portfolio of 2.8% during that period. The expected excess return on high book-to-market versus low book-to-market stocks is assumed to be 4%. This is 1% (100 basis points) lower than the average annualized excess return on the F-F book-to-market factor portfolio during July 1926 – June 2009, but it is more in line with the average return on that portfolio since the mid-1980s.

Given these assumptions, the point estimates of the (nominal) cost of equity capital based on the 2001-2005 CAPM betas are approximately 10% for pharmaceutical and device

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[9] Myers and Shyam-Sunder (1996) employed a projected 20-year Treasury rate less the average term premium compared with Treasury bills to proxy for the riskless rate for long-duration R&D investments.

firms and 14% for the more R&D intensive and higher beta biotechnology firms. For 2006-2008, the CAPM-based cost of equity capital estimates are approximately 9% for pharmaceuticals,11% for device firms, and 12% for biotechs. For biotechs during 2006-2008, the estimated cost of equity is 13% for the higher beta and more R&D intensive small firms compared with 10% for larger biotechs.

For the F-F model, the estimated cost of equity capital values for pharmaceutical firms are similar to those obtained from the CAPM in both time periods. During 2001-2005, the lower (higher) F-F market beta for small (large) pharmaceutical firms compared with the CAPM basically offsets the effects of the positive (negative) size beta for small (large) firms (see Table 4). A similar offset affects the estimated cost of equity for small pharmaceutical firms for 2006-2008. Due primarily to the positive size betas for small device firms, the F-F cost of equity values for device firms are about 1-2% higher than those obtained with the CAPM for 2001-2006 and 2-3% higher for 2006-2008 (in part due to positive albeit insignificant book-to-market betas).

Given the large and negative book-to-market betas for large biotechs during 2001-2005, the estimated cost of equity for large biotechs using the F-F model during that period is much lower (9.1%) than the value obtained using the CAPM (14.1%). However, the disappearance of the relationship between biotechnology firm returns and book-to-market factor returns during 2006-2008 causes the cost of equity capital estimates for large biotechs to converge for the two models (10.9% for the F-F model vs. 10.2% for the CAPM).

VI. Individual Firm Betas and R&D Intensity

Individual firm CAPM and F-F beta estimates were also obtained using equations (2) and (3) for the 2001-2005 and 2006-2008 samples. In order to provide evidence of the relationship between estimated betas, sector, R&D intensity, and firm size (market capitalization), the following cross-sectional regression model was estimated for each beta estimate and period:

$$\hat{\beta}_{j,l} = a_0 + a_1\,Biotech_j + a_2 Device_j + a_3 R\,\&\,D\,/\,Sales_j + a_4 Log\,Market\,Equity_j + e_j \qquad (6)$$

where *l* = *CAPM, MKT-RF, SML,* or *HML, Biotech* and *Device* are sector indicators, *R&D/Sales* is the firm's average ratio of R&D expense to sales for the period (again truncated at one), and *Log Market Equity* is the log of the firm's market value of equity at the beginning of the sample period. Similar results to those reported below were obtained when indicators were included for generic pharmaceutical firms, for foreign-owned (or ADR) firms, and including the average ratio of long-term debt to value. None of the additional variables were significantly related to the estimated betas. Results with similar implications also were obtained estimating models (without sector indicators) separately for each sector.

Table 6 shows bivariate correlations between the beta estimates, R&D intensity, log market equity, and long-term debt / value. As expected, R&D intensity is positively and significantly related to both CAPM and F-F market betas each period. It is negatively and significantly related to F-F book-to-market betas in 2001-2005. Again as would be expected, log market equity is negatively and significantly related to the F-F size betas.

Table 7 shows least squares estimates of equation (6) for each beta estimate and time period (with heteroskedasticity robust standard errors in parentheses). For the CAPM and F-F market betas, the estimates for the biotechnology and device indicators are consistent with the findings of the portfolio analysis, except that the coefficient for the biotech indicator is not statistically significant during 2006-2008. The CAPM and F-F market betas are positively and significantly related to R&D intensity in both periods. The coefficient on R&D intensity is 1.17 for the CAPM beta and 0.83 for the F-F market beta for 2001-2005. The coefficients are approximately one for both market beta measures for 2006-2008. Given an expected market risk premium of 7%, a coefficient for R&D intensity of one implies that, other factors held constant, the cost of equity capital would increase 0.7% (70 basis points) for every 10 percentage point increase in R&D intensity.

The F-F size betas are negatively and significantly related to log market equity for each period with estimated coefficients of -0.31 and -0.22 for 2001-2005 and 2006-2008, respectively. Using a 3% size factor premium and the -0.22 estimate, an increase in market capitalization at the beginning of 2006 from $948 million (approximately the 25th percentile value for the 2006-2008 sample) to $16.2 billion (approximately the 75th percentile) would increase the estimated cost of equity by 1.9% (190 basis points).

Consistent with the portfolio results, there is a strong, negative relationship between F-F book-to-market betas and R&D intensity during 2001-2005, but the estimated coefficient for R&D intensity is much closer to zero and insignificant for the 2006-2008 sample. The coefficient for the device indicator in the book-to-market beta equation is positive and significant for 2006-2008. Other factors held constant, the magnitude of the coefficient, along with a 4% book-to-market factor risk premium, would imply a 2.5% (250 basis) point higher cost of equity for device firms than for pharmaceutical firms. The explanation of this result (assuming that it's not spurious) is not clear. It reflects in part the negative (albeit statistically insignificant) estimated beta for pharmaceutical firms during 2006-2008 (see Table 4).

VII. Conclusions

This study provides estimates of systematic risk and the cost of equity capital for the pharmaceutical, biotechnology, and medical device sectors using data for firms with publicly traded stock on U.S. exchanges (including foreign owned-firms) during 2001-2005 and 2006-2008 using the CAPM and Fama-French three-factor model. It also provides evidence of the relationship between firms' systematic risk, cost of equity, and intensity of R&D expenditures.

There are four principal findings. First, R&D intensity, as measured by the ratio of R&D expense to sales, is positively related to market betas and thus the estimated cost of equity capital, after controlling for firms' principal sector of operations (pharmaceutical, biotechnology, or device). Second, the choice of model matters. The CAPM and F-F models can produce materially different estimates of the cost of equity capital. In particular, and consistent with other work, the F-F model results imply a size-related risk premium in the cost of equity for small firms in each sector. Third, controlling for R&D intensity, average market betas can differ significantly across sectors. Biotech firms had significantly higher market betas than pharmaceutical firms during 2001-2005. Device firms had significantly higher betas than pharmaceutical firms during 2006-2008. Fourth, the time period matters, as implied by the preceding results and by the large negative and significant book-to-market beta for large biotech firms during 2001-2005, which significantly lowered the estimated cost of capital during that period but which did not persist during 2006-2008.

These results have potentially important implications for valuation and capital budgeting of pharmaceutical, biotechnology, and device firms. They raise the possibility of obtaining better estimates of a firm's cost of equity using on the cross-sectional relationship between risk and R&D intensity. They also suggest the possible value in practice of comparing values of projects based on estimates of the cost of capital using the CAPM and F-F model, at least for small firms.

Along with theory and prior work, the study's results concerning risk and R&D intensity also highlight the question of whether a time-varying discount rate should be used to value molecules or devices in different stages of development. Although technical (scientific) risk is likely diversifiable by investors, early stage projects have greater R&D intensity and thus greater systematic risk. The return required by investors is therefore likely to be greater than for late stage projects. If a constant discount rate is used to value all expected future cash flows based on a firm's overall cost of capital, early stage projects would tend to be overvalued and late stage projects would tend to be undervalued. Additional work is needed to determine whether and how time-varying discount rates could be employed in practice.

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Table 1

Prior Studies of Pharmaceutical and Biotechnology Firms' Cost of Capital

Study	Model	Sample	Time Period	Mean Market Beta	Nominal Cost of Equity (WACC)	Real Cost of Equity (WACC)	Notes
Grabowski &Vernon (1990) & DHG (1991)	CAPM	Pharma	1970s to mid 1980s	1.0		9%	Market beta used in cost of equity calculation
Office of Technology Assessment (1993)	CAPM	20-25 pharma firms	Annual, 1975-1987	0.90	14.6% (14.0%)		6.8% risk-free rate; 8.7% risk premium
Myers and Shyam-Sunder (MS-S) (1996)	CAPM	14 pharma firms, market cap. at least $250m.	1975-1979 1981-1985 1995-1989	0.98 0.70 1.04	17.9% (17.2%) 16.7% (16.1%) 15.9% (15.9%)	10.3% (9.7%) 11.3% (10.8%) 10.9% (10.3%)	Equally-weighted industry portfolio; 8.7% risk premium
		7 small pharma & biotech	1984-1988	1.54	21.1% (19.1%)	16.1% (14.1%)	
Myers & Howe (MH) (1997)	CAPM	13 pharma firms	1989-1993	1.05	14.2% (13.7%)	11.2% (10.7%)	Equally-weighted; 8.7% risk premium
		39 biotech traded since 1986	Annual, 1986-1992	1.43			Estimated by Shyam-Sunder
DHG (2003)	CAPM	MS-S and MH; updated through 2000	1985 1990 1994 2000	0.98 0.70 1.04 n.a.	16.1% 15.1% 14.2% 15.0%	10.8% 10.6% 11.1% 11.9%	
Golec & Vernon (2007)	F-F	Pharma	1982-2005	0.92	14.5%		0.8 size beta; 0.02 B/M beta
		Biotech		1.06	16.2%		1.3 size beta; -0.10 B/M beta
Vernon, Golec & DiMasi	CAPM	Pharma firms, 3-10 years of data	Ending 1980 Ending 1986			11.0% 10.4%	
	F-F		Ending 1980			14.4%	0.66 size beta
			Ending 1986			16.6%	0.99 size beta

Table 2

Means and Medians (in brackets) of Selected Characteristics of Sample Firms

	Pharmaceutical			Biotechnology			Device		
	All	Large	Small	All	Large	Small	All	Large	Small
2001-2005									
Number of firms	31	22	9	26	17	9	44	12	32
Portfolio mean excess return	0.51%	0.13%	1.43%	0.31%	0.15%	0.61%	1.40%	0.60%	1.70%
Market equity ($bill., 12/31/00)	$40.2	$56.2	$1.0	$8.6	$12.6	$1.2	$4.6	$14.6	$0.8
	[$5.9]	[$10.2]	[$0.8]	[$3.3]	[$8.5]	[$1.1]	[$0.9]	[$8.0]	[$0.6]
R & D / sales*	0.179	0.162	0.221	0.466	0.511	0.382	0.090	0.073	0.097
	[0.104]	[0.106]	[0.086]	[0.329]	[0.327]	[0.348]	[0.072]	[0.058]	[0.077]
Long-term debt / value	0.074	0.067	0.092	0.074	0.082	0.063	0.069	0.064	0.071
	[0.041]	[0.048]	[0.041]	[0.043]	[0.064]	[0.030]	[0.034]	[0.048]	[0.032]
Book equity / market equity	0.279	0.306	0.215	0.280	0.259	0.318	0.270	0.264	0.272
	[0.218]	[0.230]	[0.187]	[0.286]	[0.283]	[0.328]	[0.224]	[0.182]	[0.256]
2006-2008									
Number of firms	28	21	7	29	14	15	42	15	27
Portfolio mean excess return	-0.58%	-0.66%	-0.36%	0.36%	-0.55%	0.42%	-0.17%	-0.51%	0.01%
Market equity ($bill., 12/31/05)	$40.8	$54.7	$1.2	$12.8	$24.5	$0.9	$4.2	$10.0	$0.9
	[$6.0]	[$37.9]	[$1.3]	[$2.6]	[$11.1]	[$0.9]	[$1.3]	[$6.9]	[$0.8]
R & D / sales*	0.154	0.153	0.156	0.307	0.156	0.447	0.088	0.082	0.092
	[0.150]	[0.152]	[0.124]	[0.194]	[0.157]	[0.321]	[0.062]	[0.062]	[0.067]
Long-term debt / value	0.096	0.088	0.118	0.082	0.077	0.087	0.065	0.063	0.066
	[0.072]	[0.071]	[0.079]	[0.056]	[0.082]	[0.047]	[0.164]	[0.055]	[0.014]
Book equity / market equity	0.308	0.275	0.405	0.273	0.290	0.256	0.294	0.240	0.324
	[0.295]	[0.215]	[0.356]	[0.238]	[0.264]	[0.185]	[0.259]	[0.206]	[0.264]

*Individual firm means truncated at one.

Table 3

CAPM Model Parameter Estimates for Equal-weighted Sector / Size-Based Portfolios using Monthly Returns

The regression equation is:

$$R_{jt} - R_{Ft} = \alpha_{j,CAPM} + \beta_{j,CAPM}(R_{Mt} - R_{Ft}) + \varepsilon_{jt}\ .$$

Large (small) firm sub-sample includes firms in the sector with market value of equity above (below) the median value for all sample firms at the beginning of the sample period. 2-tailed p-values in parentheses. Bold values significant at 0.05 level.

	2001-2005			2006-2008		
Group	$\hat{\alpha}_{j,CAPM}$	$\hat{\beta}_{j,CAPM}$	*R-sq.*	$\hat{\alpha}_{j,CAPM}$	$\hat{\beta}_{j,CAPM}$	*R-sq.*
Pharmaceutical	0.004	**0.692**	39.6%	-0.000	**0.611**	52.0%
	(0.406)	**(0.000)**		(0.952)	**(0.000)**	
Large	0.000	**0.650**	41.7%	-0.001	**0.641**	59.3%
	(0.080)	**(0.000)**		(0.862)	**(0.000)**	
Small	0.132	**0.795**	25.3%	0.001	**0.521**	14.2%
	(0.100)	**(0.000)**		(0.916)	**(0.024)**	
Biotechnology	0.001	**1.319**	46.2%	0.008	**0.971**	58.6%
	(0.867)	**(0.000)**		(0.217)	**(0.000)**	
Large	-0.000	**1.302**	41.8%	0.001	**0.752**	56.3%
	(0.987)	**(0.000)**		(0.807)	**(0.000)**	
Small	0.004	**1.350**	42.6%	0.015	**1.175**	49.5%
	(0.638)	**(0.000)**		(0.132)	**(0.000)**	
Device	**0.013**	**0.662**	52.2%	0.006	**0.889**	73.7%
	(0.001)	**(0.000)**		(0.152)	**(0.000)**	
Large	0.005	**0.606**	40.3%	0.002	**0.836**	69.4%
	(0.230)	**(0.000)**		(0.585)	**(0.000)**	
Small	**0.016**	**0.693**	42.5%	0.008	**0.919**	69.0%
	(0.001)	**(0.000)**		(0.100)	**0.000)**	

Table 4

Fama-French Model Parameter Estimates for Equal-weighted Sector / Size-Based Portfolios

The regression equation is:

$$R_{jt} - R_{Ft} = \alpha_{j,FF} + \beta_{j,MKT-RF}(R_{Mt} - R_{Ft}) + \beta_{j,SMB}(R_{St} - R_{Bt}) + \beta_{j,HML}(R_{Ht} - R_{Lt}) + \varepsilon_{jt}$$

Large (small) firm sub-sample includes firms in the sector with market value of equity above (below) the median value for all sample firms at the beginning of the sample period. 2-tailed p-values in parentheses. Bold values significant at 0.05 level.

	2001-2005					2006-2008				
Group	$\hat{\alpha}_{j,FF}$	$\hat{\beta}_{j,MKT-RF}$	$\hat{\beta}_{j,SMB}$	$\hat{\beta}_{j,HML}$	*R-sq.*	$\hat{\alpha}_{j,FF}$	$\hat{\beta}_{j,MKT-RF}$	$\hat{\beta}_{j,SMB}$	$\hat{\beta}_{j,HML}$	*R-sq.*
Pharmaceutical	0.005	**0.724**	-0.115	0.022	40.1%	-0.000	**0.583**	0.236	-0.172	53.9%
	(0.377)	**(0.000)**	(0.520)	(0.907)		(0.928)	**(0.000)**	(0.315)	(0.315)	
Large	0.003	**0.771**	**-0.440**	0.085	39.7%	-0.001	**0.643**	-0.009	-0.001	59.3%
	(0.579)	**(0.000)**	**(0.020)**	(0.660)		(0.869)	**(0.000)**	(0.966)	(0.966)	
Small	0.009	**0.608**	**0.679**	-0.132	33.4%	0.000	**0.404**	**0.970**	-0.692	26.4%
	(0.279)	**(0.004)**	**(0.015)**	(0.641)		(0.963)	**(0.078)**	**(0.050)**	(0.166)	
Biotechnology	0.005	**1.068**	0.215	**-0.620**	50.8%	0.007	**0.869**	**0.684**	-0.051	64.3%
	(0.588)	**(0.000)**	(0.452)	**(0.041)**		(0.254)	**(0.000)**	**(0.031)**	(0.872)	
Large	0.006	**1.043**	-0.020	**-0.795**	47.6%	0.001	**0.721**	0.185	0.067	57.2%
	(0.492)	**(0.000)**	(0.949)	**(0.015)**		(0.860)	**(0.000)**	(0.486)	(0.804)	
Small	0.002	**1.115**	**0.660**	-0.290	47.9%	0.013	**1.008**	**1.149**	-0.161	58.7%
	(0.872)	**(0.000)**	**(0.039)**	(0.376)		(0.147)	**(0.000)**	**(0.012)**	(0.718)	
Device	**0.009**	**0.639**	**0.387**	0.178	60.3%	0.005	**0.781**	**0.614**	0.338	84.1%
	(0.023)	**(0.000)**	**(0.002)**	(0.163)		(0.156)	**(0.000)**	**(0.001)**	(0.056)	
Large	0.005	**0.685**	-0.125	0.158	42.2%	0.002	**0.788**	0.196	0.418	73.4%
	(0.300)	**(0.000)**	(0.416)	(0.320)		(0.691)	**(0.000)**	(0.347)	(0.056)	
Small	**0.010**	**0.622**	**0.579**	0.185	55.4%	0.007	**0.778**	**0.847**	0.293	83.4%
	(0.029)	**(0.000)**	**(0.000)**	(0.230)		(0.078)	**(0.000)**	**(0.000)**	(0.124)	

Table 5

Illustrative Cost of Capital Estimates by Sector and Group

The estimated costs of capital for the CAPM and FF models equal:

$$\hat{k}_{j,CAPM} = 0.05 + 0.07\hat{\beta}_{j,CAPM} \text{ and } \hat{k}_{j,FF} = 0.05 + 0.07\hat{\beta}_{j,MKT-RF} + 0.03\hat{\beta}_{j,SML} + 0.04\hat{\beta}_{j,HML}.$$

The statistics $\hat{k}_{0.025}$ and $\hat{k}_{0.975}$ represent the 95% confidence interval for $\hat{k}$.

			2001-2005			2006-2008		
Model	Sector	Group	$\hat{k}$	$\hat{k}_{0.025}$	$\hat{k}_{0.975}$	$\hat{k}$	$\hat{k}_{0.025}$	$\hat{k}_{0.975}$
CAPM	Pharmaceutical	All	9.8%	8.3%	11.4%	9.3%	7.8%	10.7%
		Large	9.6%	7.8%	11.3%	9.5%	8.2%	10.8%
		Small	10.6%	8.1%	13.1%	8.6%	5.5%	11.8%
	Biotechnology	All	14.2%	11.6%	16.9%	11.8%	9.8%	13.7%
		Large	14.1%	11.3%	16.9%	10.2%	8.6%	11.9%
		Small	14.5%	11.6%	17.3%	13.2%	10.3%	16.1%
	Device	All	9.6%	8.5%	10.8%	11.2%	9.9%	12.5%
		Large	9.2%	7.9%	10.6%	10.9%	9.5%	12.2%
		Small	9.8%	8.3%	11.2%	11.4%	9.9%	12.9%
FF	Pharmaceutical	All	9.8%	6.9%	12.7%	9.1%	6.7%	11.5%
		Large	9.4%	6.4%	12.4%	9.5%	7.3%	11.6%
		Small	10.8%	6.3%	15.2%	8.0%	3.1%	12.8%
	Biotechnology	All	10.6%	6.0%	15.3%	12.9%	9.8%	16.0%
		Large	9.1%	4.0%	14.1%	10.9%	8.2%	13.6%
		Small	13.6%	8.5%	18.8%	14.9%	10.5%	19.2%
	Device	All	11.3%	9.4%	13.3%	13.7%	12.0%	15.4%
		Large	10.1%	7.6%	12.6%	12.8%	10.7%	14.9%
		Small	11.8%	9.4%	14.2%	14.2%	12.3%	16.0%

Table 6

Bivariate Correlations: Betas, R&D / Sales, Log Market Equity, and L-T Debt / Value

		$\hat{\beta}_{j,CAPM}$	$\hat{\beta}_{j,MKT-RF}$	$\hat{\beta}_{j,SMB}$	$\hat{\beta}_{j,HML}$	R&D / sales	Log mkt. equity	L-T debt / value
2001-2005	$\hat{\beta}_{j,CAPM}$	1.00						
	$\hat{\beta}_{j,MKT-RF}$	**0.89**	1.00					
	$\hat{\beta}_{j,SMB}$	**0.21**	0.00	1.00				
	$\hat{\beta}_{j,HML}$	**-0.43**	-0.06	0.11	1.00			
	R&D / sales	**0.63**	**0.47**	0.01	**-0.53**	1.00		
	Log mkt. equity	-0.11	0.07	**-0.70**	-0.04	0.00	1.00	
	L-T debt / value	0.09	0.15	**0.20**	**0.22**	0.03	-0.04	1.00
2006-2008	$\hat{\beta}_{j,CAPM}$	1.00						
	$\hat{\beta}_{j,MKT-RF}$	**0.96**	1.00					
	$\hat{\beta}_{j,SMB}$	0.10	-0.17	1.00				
	$\hat{\beta}_{j,HML}$	0.01	-0.05	-0.04	1.00			
	R&D / sales	**0.41**	**0.36**	0.19	-0.16	1.00		
	Log mkt. equity	**-0.30**	-0.18	**-0.44**	0.06	-0.15	1.00	
	L-T debt / value	0.04	0.04	-0.03	0.19	-0.03	-0.07	1.00

Note: Bold values significant at 0.05 level for two-tailed test.

Table 7

Cross-Sectional Determinants of CAPM and FF Beta Estimates

Risk Measure	Variable	2001-2005 (100 co.) Coef.	2001-2005 (100 co.) p-value	2006-2008 (99 co.) Coef.	2006-2008 (99 co.) p-value
$\hat{\beta}_{j,CAPM}$	Biotechnology	**0.282**	**0.041**	0.145	0.258
	Device	-0.002	0.986	**0.272**	**0.015**
	R&D / Sales	**1.173**	**0.000**	**1.052**	**0.025**
	Log Market Equity	-0.045	0.072	-0.043	0.128
	Constant	**1.187**	**0.006**	**0.822**	**0.006**
	Adj. R^2	0.434		0.263	
$\hat{\beta}_{j,MKT-RF}$	Biotechnology	**0.136**	**0.344**	0.120	0.397
	Device	0.022	0.882	**0.239**	**0.044**
	R&D / Sales	**0.827**	**0.000**	**0.982**	**0.036**
	Log Market Equity	0.019	0.503	-0.013	0.659
	Constant	0.274	0.585	0.556	0.083
	Adj. R^2	0.237		0.176	
$\hat{\beta}_{j,SMB}$	Biotechnology	0.193	0.211	0.092	0.694
	Device	-0.032	0.829	0.026	0.909
	R&D / Sales	-0.157	0.478	0.535	0.240
	Log Market Equity	**-0.305**	**0.000**	**-0.222**	**0.000**
	Constant	**4.715**	**0.000**	**2.223**	**0.000**
	Adj. R^2	0.504		0.212	
$\hat{\beta}_{j,HML}$	Biotechnology	-0.318	0.114	0.267	0.257
	Device	0.051	0.770	**0.646**	**0.013**
	R&D / Sales	**-1.144**	**0.000**	-0.246	0.568
	Log Market Equity	-0.002	0.961	0.087	0.114
	Constant	0.254	0.680	-0.945	0.128
	Adj. R^2	0.306		0.107	

Note: Bold values significant at 0.05 level for a two-tailed test with robust standard errors.