Appendix C

The Cost of Capital[1]

Investors in pharmaceutical research and development (R&D) put up their money because they expect, on average, to get returns that adequately compensate them for the time and risk involved. Just as the interest rate on bank deposits is a payment for the use of depositors' money (or capital), the return on an investment in R&D is a payment the company or its investors get from the use of their capital. Riskier investments require higher dollar returns; otherwise, investors would put their money in safe investments like U.S. Treasury bills or bank certificates of deposit. The riskier the investment, the higher the required return. The rate of return that investors must be able to expect from money invested with a given level of risk is referred to as the investment's ''cost of capital. '

Risk and the Cost of Capital

How does one measure the riskiness of an investment? This is the key question in estimating the cost of capital for any project. Were there no risk the cost of capital would be the same as the interest rate on U.S. Treasury bills.

Pharmaceutical industry executives often emphasize the particular riskiness of R&D. Analogies to drilling for oil are common: R&D involves dry holes and a few gushers. According to one industry executive, pharmaceutical R&D is like "wildcatting in Texas" (188). Data on the dropout rate for drugs under development support these notions that R&D is, indeed, an uncertain and risky undertaking.

The risk that is accounted for in the cost of capital is different from these conventional notions about the riskiness of R&D. Modem finance theory differentiates between two different kinds of investor risk: diversifiable risk and undiversifiable risk (59). The ''wildcatting' risks of drug R&D are diversifiable; that is, the investor can diversify his or her portfolio across a large number of such projects (or firms undertaking such projects) and obtain, on average, an expected cash flow that is very predictable. Thus, the risk associated with low probabilities of successful drug development can be eliminated by diversifying the investment portfolio across a large number of projects.

The undiversifiable, or systematic, risk is the risk the investor cannot eliminate through diversification of his or her portfolio of investments. Suppose, for example, that prescription drug sales were closely linked to the state of the economy, perhaps because high unemployment produces more people without health insurance. Then, investment in pharmaceutical R&D would have a great deal of systematic risk because returns on R&D would depend on the state of the economy as a whole, and investors cannot diversify away these economywide risks.

The cost of capital for a given investment reflects only the portion of the investment's risk that is undiversifiable. The technical risks of project failure do not affect the required rate of return for an investment, though they do alter the potential cash flow expected from an investment.[3]

---

[1] This chapter draws heavily from a background paper on the cost of capital prepared by Stuart Myers and Lakshmi" Shyam-Sunder (285).

[2] The cost of capital is also referred to as the "opportunity cost of capital,' because the investor expects to get at least as much return as he or she can get from other opportunities to invest at the same level of risk.

[3] This concept of cost of capital is based on the Capital Asset Pricing Model (CAPM), which depends for its validity on the efficiency of capital markets. The validity of the CAPM theory is impossible to test (352a); consequently, the CAPM model has not been validated (96). Recently, researchers have presented analyses that question whether the CAPM is an adequate predictor of returns in the market (129). Nevertheless, the CAPM approach remains one of the most widely used models of expected returns, and no better practical alternatives to estimating the cost of capital presently exist.

AN EXAMPLE

Consider two hypothetical pharmaceutical R&D projects. Each project involves a newly synthesized compound with identical development costs and probabilities of being approved for marketing by the U.S. Food and Drug Administration (FDA). Clinical testing on each will take 2 years and cost $10 million (spent evenly over the 2-year testing period). Suppose also that the company's history with drug development suggests each drug has a 24-percent chance of ultimately reaching the market. The technical risks and R&D costs of the two drugs are therefore identical,

If either drug is successful in getting to market, it will produce net cash inflows (revenues less the costs of production, marketing, etc.) whose value is not known with certainty. To keep the example simple, suppose that the product life for either drug is just 1 year-after the first year of marketing, a new product replaces it and its revenues fall to zero. Each drug has the possible net cash inflows shown in table C-1.

Although both drugs have identical average or ''expected' cash flows, the distribution of possible outcomes is different. Suppose project A is for a drug in a well-known family of analgesic products whose potential revenues are relatively certain, On the other hand, suppose project B is a very costly drug for patients with end-stage renal disease. It will be accepted and sold only if Medicare, which covers all end-stage renal disease patients regardless of age, agrees to pay for it. Once Medicare covers the drug, however, its revenues are completely certain. Although the "expected" net cash inflows from each drug are the same, the risk profile of the two drugs differs dramatically. Project B's cash flows are much riskier than project A's cash flows, because the firm can win big or lose big with that project, whereas once drug A is approved, its potential revenues vary in a narrow band.

Despite the fact that project B's expected cash flow is riskier than that of project A, that risk is largely diversifiable, because it is unique to the project and depends only on the Medicare coverage decision which, we can assume, is unaffected by the state of the economy. Project A's risk, on the other hand, may reflect undiversifiable, or systematic, risk because demand for analgesics may vary with the state of the economy. Although the total risk of project B is much larger, the cost of capital for project B would actually be lower than the cost of capital for project A.

Table C-I—Potential Net Cash flows From Two Hypothetical R&D Projects

Project A		Project B	
Probability y	Potential revenue ($ million)	Probability	Potential revenue ($million)
0.33	$25	0.50	$0
0.33	50	0.50	100
0.33	75		
Expected net cash flow	50		50

SOURCE: Office of Technology Assessment, 1993.

How does the cost of capital affect decisions to invest in R&D projects? To assess whether the investment is worth its $10 million R&D cost, company managers (on behalf of their investors) would compute the net present value (NPV) of the investment by converting all future expected cash flows (both into and out of the firm) into their present value at the time the investment decision is made using the cost of capital appropriate to the project as the discount rate.[4] The algebraic sum of the present values of all the expected cash flows is the NPV of the investment. If the NPV is greater than zero, the investment is worth it and will compensate investors at a rate of return that exceeds the cost of capital.

Suppose we knew project A's cost of capital was 13 percent, while Project B's cost of capital was 10 percent. Then

$$NPV_A = -\$5 - \$5/(1+0.13) + 0.24[\$50/(1+0.13)^2] = -\$0.03 \text{ million.}$$

and

$$NPV_B = -\$5 - \$5/(1+0.10) + 0.24[\$50/(1+0.10)^2] = \$0.37 \text{ million.}$$

The NPV of project A is less than zero, so the project does not earn a high enough return to cover its cost of capital. Project B, on the other hand, does earn enough to repay its investment at its cost of capital. The company would decide to go forward with project B and forego project A, a result that would seem

[4] The present value (i.e., the value today) of $1.00 that an investor expects to receive 1 year hence, for example, is $0,91 when the cost of capital is 10 percent ($1 .00/(1 +1. 10)).

counterintuitive to those who focus on total risks rather than on undiversifiable risks.

MEASURING UNDIVERSIFIABLE RISK

If the cost of capital is determined by the undiversifiable part of a project's risk, how can that risk be measured? At the level of the company (which can be considered a collection of investments), a standard approach to measuring undiversifiable risk for equity investors is to estimate the historical relationship between the firm's stock: market returns and the returns from the stock market as a whole (59,96). If the firm's stock market returns are strongly associated with returns in the stock market as a whole, the relationship will be strong, and the firm has a high degree of undiversifiable risk. A measure of the strength of this relationship is refereed to as the firm's "beta." If beta equals 1, the fro's equity has a risk profile that is average for the stock market. If beta is greater than 1, the firm's equity risk is higher than the average risk in the stock market. (In that case, swings in market returns are magnified in the company-when the overall stock market goes up, the company's stock market value goes up even more; when the market goes down, the company's stock market value goes down even more.) A beta of zero means that the firm has virtually no undiversifiable risk: its returns are completely uncorrelated with the stock market.

Although the riskiness of a company depends on how investors view its future performance, company betas are estimated from the historic relationship of the company's stock to the overall stock market. The assumption is that the systematic riskiness of a company today is probably similar to its riskiness in the recent past. Betas for individual firms and for industries are computed. from stock market price and returns data available in several databases for publicly traded firms.

The Cost of Capital for the Pharmaceutical Industry

The cost of equity capital for a company as a whole is given by the following formula:

$$r_e = r_f + ß(r_m - r_f)$$

where r_f is the rate of return to risk-free securities; $(r_m - r_f)$ is the risk premium for the equity market as a whole, and ß (beta) is the firm-specific risk premium reflecting added or reduced risk of the firm's security in relation to a diversified market portfolio. The cost of equity capital for an industry can be estimated with the same formula, by weighting the individual firms' betas by the relative market value of each firm in the industry.

In a contract paper for OTA, **Myers** and Shyam-Sunder estimated that the risk-free rate in January 1990 was 6.8 percent and the market risk premium over the 70-year long period ending in December 1990 was 8.7 percent (285).[5] Myers and Shyam-Sunder also estimated market-value-weighted equity betas for a sample of 17 large U.S. pharmaceutical firms by regressing excess returns (over the Treasury bill rate) for pharmaceuticals against the excess returns on Standard and Poor's 500 composite index for 60-month periods ending in December 1979, December 1984, and December 1989. The estimated betas at those three points in time were 0.97,0.66, and 0.98, respectively (285). Taken together, these estimates imply a nominal (i.e., unadjusted for investors' inflation expectations) cost of equity capital of 18 percent, 16.4 percent and 15.4 percent at the beginning of 1980,1985, and 1990, respectively. After adjusting for inflation expectations at each time, the real cost of equity capital was 10.3, 10.9, and 10.4 percent.

Equity is only one kind of capital that companies raise. Debt financing is also used, and the cost of debt capital is generally lower than the cost of equity capital, because bondholders must be paid before stockholders are paid dividends.[6] The weighted average cost of capital, r*, is the blended cost of the firm's debt and equity capital (285,409):

$$r^* = r_d(1-t_C)\,(D/V) + r_e(E/V)$$

where r_d and r_e are the cost of capital for debt and equity, respectively, D/V is the ratio of debt to market value of the firm, E/V is the ratio of equity to the market value of the firm, and t_C is the marginal corporate tax rate. The cost of debt is reduced by the amount of the corporate income tax because interest is

[5] The market risk premium has declined over the past70 years. If the premium is measured over the post-World War II era, it is 8.3 percent, which would lower the cost of capital to the industry.

[6] The cost of equity capital increases as the firm takes on more debt (%). Empirical estimates of the cost of equity capital for an industry are therefore based on the observed capital structure (i.e., the ratio of debt to equity) in the industry. This approach assumes that the capital structure of firms in an industry is optimal.

deductible from business income and therefore costs the company less than it would without taxes.[7]

Myers and Shyam-Sunder calculated the cost of debt capital for a sample of 17 pharmaceutical companies. In January 1990, the market value weighted cost of debt for pharmaceuticals was 9.1 percent (285). The January 1990 cost of debt net of taxes, with a marginal tax rate of 34 percent, is therefore 6.0 percent. Before the Tax Reform Act of 1986 lowered marginal tax rates, the marginal tax rate was 46 to 48 percent, which would imply a net after-tax cost of debt of 4.9 percent.

Pharmaceutical firms have little debt, so the total cost of capital is close to the cost of equity capital. Based on all of the information given above, Myers and Shyam-Sunder estimated the real cost of capital for 17 pharmaceutical firms at the start of the year in 1980, 1985, and 1990 at 9.9, 10.7, and 10.2 percent respectively.

The Cost of Capital for Pharmaceutical R&D Projects

Companywide betas represent a weighted average of betas for the different individual investments that pharmaceutical companies make, including investments in R&D, manufacturing plant and equipment, and marketing,[8] Consequently, R&D investments are likely to have betas that differ from the companywide average. And, different projects will probably have different betas, as the stylized example above demonstrated. It is impossible to estimate a precise beta for each project, because historic data on returns to projects that are similar to it do not exist. Thus, while it is possible to make a reasonably accurate estimate of the companywide beta at any point in time for a pharmaceutical firm, it is not possible to directly estimate the beta for R&D projects.

Some general statements can be made about the cost of capital for R&D compared with the cost of capital for manufacturing or financial investments. Spending money on R&D can be thought of as buying an option, or opportunity, to invest in manufacturing a drug. Without the R&D, there would be no opportunity to invest because a product would not exist. In order to actually manufacture the drug that the R&D produces, however, a company must make a fixed investment in plant and equipment. This necessary fixed investment is much like a fixed debt obligation-its claims must be met before the firm can actually reap the benefits of the R&D. Just as high fixed debts increase a company's riskiness to stockholders, who are last in line to be paid, so too does the fixed manufacturing investment increase the riskiness of the R&D investment. Consequently, the R&D is riskier than investment in plant and equipment (285).

Because the weighted average cost of capital for the firm as a whole includes investments in manufacturing and other operations as well as in R&D, the cost of capital for R&D must be higher than the weighted average cost of capital, while the cost of capital for investments in manufacturing and marketing must be less than the weighted average cost of capital.

R&D projects are in reality ***sequential*** investments that buy opportunities for further R&D along the way. Early in the R&D process there are high fixed obligations to be met before the company can actually begin to earn money, so the cost of capital is higher (other things being equal) for money invested very early in the process than for the money invested later, as the project approaches market approval. Therefore, early R&D projects are riskier than later projects and have a higher cost of capital.

Not only does early R&D produce an option on future investments and revenues, but it also produces information that reduces the uncertainty about the value of the project (96,330,352). Since R&D projects can be abandoned at any point in the process (or at least at certain project milestones), the investment in early R&D can be viewed as an investment in information that allows the firm to reduce the uncertainty of its later investments.

Suppose, for example, a new compound stands one chance in 100 of reaching the market, but $1 million

[7] Although debt interest is untaxed at the corporate level, it is fully taxed at the personal level. Equity returns, on the other hand, are taxed fully at the corporate level and lightly at the personal level to the extent that much of the equity returns are in the form of capital gains, which are taxed only when the gains are realized (391,392). At the investor level, the personal and corporate tax systems combine to largely eliminate the overall tax advantage of debt (273). This implies that at the firm level, the cost of equity should be lower than the cost of debt of comparable risk (392). Together, these findings imply that the cost of equity capital as calculated in the formulas given above may be overstated when beta is less than one and understated when beta is greater than one (391). Since the beta for the pharmaceutical industry was slightly less than one, the cost of equity capital in the pharmaceutical industry may be slightly overstated.

[8] Although R&D and advertising and promotion are treated as current expenditures in firms' accounting statements, if they lead to increases in revenues in later years, they arc in principal investments, and stock prices would reflect this fact.

330-067 - 93 - 10 : QL 3

spent early on animal toxicology testing will either show it to be too toxic and therefore not worth additional R&D expenditures or increase its chances of success to, say, 1 in 10. Any money spent after the animal testing is completed would face vastly better odds than would be the case if the firm were required to commit to the full course of R&D at the very beginning of the project. The information produced by the $1-million expenditure is valuable and may justify early speculative R&D projects whose NPV, viewed from the beginning of the project, may appear to be negative (352).

This "information-producing" function of R&D essentially adds to the value of the R&D investment or, stated another way, dampens the effective cost of capital for R&D to more closely approximate the cost of capital for investments in manufacturing capacity for an approved drug. Although the betas and, therefore, the cost of capital for R&D projects are always higher than those for investment in ongoing operations, how much higher depends on the interplay between the information value of the investment and the fixed investment required to realize the returns from R&D.

To summarize, although the cost of capital for R&D must be higher than that for manufacturing, and it is higher the earlier in the research process the project is, there is currently available no practical approach to estimating just how high the cost of capital actually is for any **set** of R&D investments. The best that can be done to get a rough quantitative estimate of the cost of capital for pharmaceutical R&D projects is to examine the betas of firms that invest largely in R&D and that have relatively little investment in ongoing operations.

Stewart (409) estimated the cost of capital for business risk for 1,000 publicly traded companies in the United States and Canada. Companies whose main business was providing R&D services (R&D laboratories) had a cost of capital for business risk that was approximately 4.5 percentage points higher than the cost of capital for business risk for the drug companies in his sample. A recent update of the Myers and Shyam-Sunder paper by Shyam-Sunder found only a 2.7 percentage point difference in the net cost of capital between 30 biotechnology firms and 19 large pharmaceutical firms as of December 1990 (285). The results of these studies suggest that a 4-percentage point differential in the cost of capital from the beginning to the end of the research process provides a reasonable outer boundary for calculation of the capitalized costs of R&D.

Comparing Pharmaceutical and Nonpharmaceutical Costs of Capital

This section describes OTA's procedures for estimating the difference between the cost of capital for the pharmaceutical industry and the cost of capital for the comparison firms used in the Baber and Kang study of pharmaceutical industry profitability (27).

At OTA's request, Baber and Kang estimated the internal rate of return (IRR) over a 12-year period (1976-87) for a sample of pharmaceutical companies and two comparison groups matched with the pharmaceutical companies according to sales, sales growth and R&D intensity (27). The IRR is the compound annual interest rate earned by investments in the companies over the period of study. Baber and Kang demonstrated that, after adjusting for distortions in financial accounting data, the difference in IRR between the pharmaceutical industry and the comparison groups over the period studied was 2 to 3 percentage points per year, a far smaller difference than traditional profitability analyses tend to show (27).

In their comparative profitability study, Baber and Kang did not address the question of whether a 2 to 3 percentage point difference in IRRs can be explained by a difference in risk (and, therefore, in costs of capital) between the pharmaceutical industry and other companies. To investigate this issue, OTA estimated the relative riskiness and differences in the cost of capital between the pharmaceutical firms and the nonpharmaceutical firms studied by Baber and Kang.

OTA's method for comparing the costs of capital is based in large part on procedures and information supplied by Myers and Shyam-Sunder in their OTA contract report (285). Although Myers and Shyam-Sunder laid out general procedures for estimating betas and weighted average costs of capital, they were asked by OTA to supply specific estimates only for the pharmaceutical industry. To estimate cost of capital differences between the pharmaceutical industry and the nonpharmaceutical firms sampled by Baber and Kang, OTA pieced together information provided by Myers and Shyam-Sunder as well as data provided by Baber and Kang on the specific samples of firms studied.

The Baber and Kang study examines nominal rates of return without adjusting for inflation. Therefore,

OTA's estimates of the cost of capital for each sample are nominal as well.

EVIDENCE ON BETAS

Estimation of beta, the correlation of a firm's returns with market returns, requires data that are available only for publicly traded firms. Hence, beta can be estimated only for a subsample of firms in the Baber and Kang study, although these firms represent a high proportion of total market values in these samples. Betas also vary over time, so the period over which they are estimated can affect the ultimate results.

OTA had two sources of evidence on pharmaceutical betas. First, as described earlier, Myers and Shyam-Sunder estimated market value-weighted equity betas for a sample of 17 large U.S. pharmaceutical firms by regressing excess returns (over the Treasury bill rate) against excess returns on Standard and Poor's 500 composite index for 60-month periods ending in December 1979; December 1984; and December 1989.[9] Estimated betas were 0.97, 0.66, and 0.98 respectively (285).

Second, Baber and Kang calculated market-value weighted betas for each year of the 12-year study period by regressing total firm returns against total market returns over the previous 240 months for companies for which data were available (24,224). Table C-2 shows the calculated betas and the number of firms included in each year's calculation. The calculated weighted average betas change slightly from year to year, as the sample of firms changes and as the market value weights change, but they are very stable.[10] The mean across all study years of the weighted average betas is 0.90 for pharmaceuticals, 1.00 for control firms matched by sales, and 1.29 for control firms matched by sales and R&D. OTA used these estimates of beta for the sake of consistency across samples.

EVIDENCE ON THE RISK-FREE RATE

Myers and Shyam-Sunder observed that the appropriate risk-free rate is the short-term Treasury bill rate, but this must be adjusted for forecasts that will govern the firm's long-term investments (285). The short-term Treasury bill rate averaged 5.76 percent in the period 1957-87 (23,223). Myers and Shyam-Sunder obtained a risk-free rate by subtracting an historical term premium (1.2 percent) from the 20-year Treasury bond yield. In December 1989, the net rate was 6,81 percent (285).

EVIDENCE ON THE MARKET RISK PREMIUM

The realized market risk premium (over the risk-free rate) is highly volatile over time, while expected risks are assumed to be stable over long periods. Therefore, the market risk premium is typically estimated over a long period of time (198). Myers and Shyam-Sunder found an arithmetic mean of 8.7 percent for excess market return over the Treasury bill rate for the period 1926-89 (285). The market risk premium declined in the post-war period, however, and the premium for the period 1947-88 was 8.3 percent (285).

In an unrelated study, Stewart estimated the market risk premium by comparing Standard and Poor's 500 stocks with long-term (20-year) U.S. Treasury bonds from 1925 to 1989 (409). He found that the risk premium was only 5.8 percent over the period. This would imply a risk premium over the Treasury bill rate (adjusted for long-term forecasts) of just 7.0 percent.

EVIDENCE ON THE AFTER-TAX COST OF DEBT

Myers and Shyam-Sunder calculated the cost of debt capital for a sample of 17 pharmaceutical companies based on Moody's industrial bond ratings. As of December 1989, the market value weighted cost of debt for pharmaceuticals was 9.1 percent (285).[11] The cost of debt net of taxes, with a marginal tax rate of 34 percent, was therefore 6.0 percent. At the pretax-reform marginal tax rate of 46 percent, the net after-tax cost of debt would have been 4.9 percent.

At OTA's request, Baber and Kang calculated the mean ratio of after-tax interest payments to the book value of long-term debt between 1975 and 1987 for the 15 largest firms in each of the three samples in this

9 All of the firms included in Myers and Shyam-Sunder's analysis of the pharmaceutical industry are part of the Baber and Kang pharmaceutical sample.

10 Betas estimated over a long period of observation tend to be more stable than those based on shorter periods. For example, Myers and Shytim-Sunder's estimate of betas for the pharmaceutical industry, which are based on 5 years' worth of data, vary more widely than do the estimates made by Baber and Kang. But, too long a period of historical observation can obscure the effects of changes in an industry's riskiness over time. Part of the variation in the estimates of Myers and Shyam-Sunder is probably random, but part may also be due to changes from the mid-1970s through the late 1980s in the riskiness of the industry.

11 Overall, U.S. corporate bond yields averaged 10.87 between 1973 and 1989 (1).

Table C-2—Weighted Average Betas

Year	Pharmaceuticals n[a]	Pharmaceuticals beta	Control firms matched by sales and growth n[a]	Control firms matched by sales and growth beta	Control firms matched by sales and R&D n[a]	Control firms matched by sales and R&D beta	Samples with R&D greater than 5% of sales: Pharmaceuticals n[a]	Samples with R&D greater than 5% of sales: Pharmaceuticals beta	Samples with R&D greater than 5% of sales: Control firms matched by sales and growth n[a]	Samples with R&D greater than 5% of sales: Control firms matched by sales and growth beta	Samples with R&D greater than 5% of sales: Control firms matched by sales and R&D n[a]	Samples with R&D greater than 5% of sales: Control firms matched by sales and R&D beta
1975	20	0.88	22	0.97	23	1.24	14	0.88	14	0.91	13	1.28
1976	20	0.88	22	0.97	24	1.27	14	0.87	14	0.93	14	1.31
1977	20	0.89	22	0.98	25	1.28	14	0.88	14	0.95	14	1.33
1978	21	0.90	22	0.98	27	1.27	14	0.88	14	0.95	15	1.32
1979	21	0.89	22	1.00	28	1.30	14	0.88	14	0.97	16	1.34
1980	21	0.90	23	1.01	29	1.30	14	0.89	15	0.98	17	1.34
1981	21	0.90	25	1.04	29	1.33	14	0.89	16	1.00	17	1.38
1982	24	0.91	25	1.02	30	1.30	16	0.90	16	1.00	18	1.33
1983	24	0.92	25	1.02	30	1.30	16	0.91	16	1.00	17	1.34
1984	25	0.93	25	1.02	31	1.30	17	0.93	16	1.01	17	1.34
1985	25	0.93	25	1.01	32	1.30	17	0.93	16	0.99	18	1.35
1986	25	0.93	25	1.01	31	1.30	16	0.92	16	0.98	17	1.35
1987	25	0.92	24	1.00	31	1.28	16	0.92	15	0.97	17	1.32
mean		0.90		1.00		1.29		0.90		0.97		1.33

[a] n = number of firms in sample.

R W. Baber and S.-H. Kang, "An Empirical Investigation of Accounting Rates of Return for Pharmaceutical Industry 1975-1987, draft report prepared for the Office of Technology Assessment, August 1990.

study. These ratios were 5,64 percent for pharmaceuticals, 4.92 percent for the control sample matched by sales and 5.72 percent for the control sample matched by R&D, Although these ratios area crude measure of the cost of debt, the rate for the pharmaceutical sample is close to the after-tax rate estimated by Myers and Shyam-Sunder.

ESTIMATES OF COST OF CAPITAL

OTA estimated the weighted average cost of capital for the three samples based on the evidence summarized above. Because the control firms have much higher debt-to-equity ratios than do the pharmaceutical companies, OTA used parameter estimates that would tend to understate the cost of debt and overstate the cost of equity. The computed costs of capital are therefore biased in favor of a higher cost of capital in the pharmaceutical industry.

Specifically, OTA assumed the pretax cost of debt is 9 percent for all three samples, the risk-free rate is 6.8 percent, and the market risk premium is 8.7 percent. These parameters are consistent with those of Myers and Shyam-Sunder (285). Betas were assumed to follow those calculated in table C-2. Table C-3 summarizes the calculations for the pharmaceutical firms and the two control groups.

Because these estimates of the cost of capital are based on high estimates of the risk-free rate and the market premium, they should not be viewed as accurate estimates of the actual cost of capital over the period. Moreover, the cost of capital is a moving target over time; a single estimate provides only a rough approximation of its value. Yet, they do provide a reasonably accurate (indeed, a conservative) test of **differences in the cost of capital** among the samples of firms examined by Baber and Kang.

Table C-3—Weighted Average Cost of Capital, 1976-87

	Pharmaceuticals	Control sample I	Control sample II
Characteristics of industry[a]			
Market value of equity ($ million)	$1,288	$453	$562
Value of debt ($ million)	$ 85	$116	$129
Average firm value ($ million)	$1,373	$569	$691
Assumptions			
Beta	0,9	1.0	1.29
Cost of debt (pretax)	0.09	0.09	0.09
Marginal tax rate	0.46	0.46	0.46
Risk-free rate (r_f)	0.068	0.068	0.068
Market risk premium (r_m-r_f)	*0.087*	*0.087*	*0.087*
Results			
Cost of equity capital (r_e)	0.146	0.155	0.18
Cost of capital (r')	0.14	0.133	0.155

a Based on 15 largest firms in each sample.

KEY: Control sample 1: Firms similar to pharmaceutical in terms of sales and sales growth.
Control sample II: Firms similar to pharmaceuticals in terms of sales and R&D industry.

SOURCE: Office of Technology Assessment, 1993.