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Formulating the Imputed Cost of Equity Capital for Priced Services at Federal Reserve Banks

- To comply with the provisions of the Monetary Control Act of 1980, the Federal Reserve devised a formula to estimate the cost of equity capital for the District Banks' priced services.
- In 2002, this formula was substantially revised to reflect changes in industry accounting practices and applied financial economics.
- The new formula, based on the findings of an earlier study by Green, Lopez, and Wang, averages the estimated costs of equity capital produced by three different models: the comparable accounting earnings method, the discounted cash flow model, and the capital asset pricing model.
- An updated analysis of this formula shows that it produces stable and reasonable estimates of the cost of equity capital over the 1981-2000 period.

1. Introduction

The Federal Reserve System provides services to depository financial institutions through the twelve Federal Reserve Banks. According to the Monetary Control Act of 1980, the Reserve Banks must price these services at levels that fully recover their costs. The act specifically requires imputation of various costs that the Banks do not actually pay but would pay if they were commercial enterprises. Prominent among these imputed costs is the cost of capital.

The Federal Reserve promptly complied with the Monetary Control Act by adopting an imputation formula for the overall cost of capital that combines imputations of debt and equity costs. In this formula—the private sector adjustment factor (PSAF)—the cost of capital is determined as an average of the cost of capital for a sample of large U.S. bank holding companies (BHCs). Specifically, the cost of capital is treated as a composite of debt and equity costs.

When the act was passed, the cost of equity capital was determined by using the comparable accounting earnings (CAE) method,[1] which has been revised several times since 1980. One revision expanded the sample to include the fifty

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largest BHCs by assets. Another change averaged the annual estimates of the cost of equity capital over the preceding five years. Both revisions were made largely to avoid imputing an unreasonably low—and even negative—cost of equity capital in years when adverse market conditions impacted bank earnings. The latter revision effectively ameliorates that problem but has a drawback: the imputed cost of equity capital lags the actual market cost of equity by about three years, thus making it out of sync with the business cycle. This drawback does not necessarily result in an over- or underestimation of the cost of equity capital in the long run, but it can lead to price setting that does not achieve full economic efficiency.[2]

After using the CAE method for two decades, the Federal Reserve wanted to revise the PSAF formula in 2002 with the goal of adopting an imputation formula that would:

1. provide a conceptually sound basis for economically efficient pricing,
2. be consistent with actual Reserve Banks' financial information,
3. be consistent with economywide practice, and particularly with private sector practice, in accounting and applied financial economics, and
4. be intelligible and justifiable to the public and replicable from publicly available information.

The Federal Reserve's interest in revising the formula grew out of the substantial changes in research and industry practice regarding financial economics over the two decades since 1980. These changes drove the efforts to adopt a formula that met the above criteria. Of particular importance was general public acceptance of and stronger statistical corroboration for the scientific view that financial asset prices reflect market participants' assessments of future stochastic revenue streams. Models that reflected this view—rather than the backward-looking view of asset-price determination implicit in the CAE method—were already in widespread use in investment banking and for regulatory rate setting in utility industries.

After considering ways to revise the PSAF, the Board of Governors of the Federal Reserve System adopted a new formula for pricing services based on an earlier study (Green, Lopez, and Wang 2000). In that study, we showed that our proposed approach would provide more stable and sensible estimates of the cost of equity capital for the PSAF from 1981 through 1998. To that end, we surveyed quantitative models that might be used to impute a cost of equity capital in a way that conformed to theory, evidence, and market practice in financial economics. Such models compare favorably with the CAE method in terms of the first, third, and fourth criteria identified above.[3] We then proposed an imputation formula that averages the estimated costs of equity capital from a discounted cash flow (DCF) model and a capital asset pricing model (CAPM), together with the estimates from the CAE method.

In this article, we describe and give an updated analysis of our approach to estimating the cost of equity capital used by the Federal Reserve System. The article is structured as follows. We begin with a review of the basic valuation models used to estimate the cost of equity capital. In Section 3, we discuss conceptual issues regarding the selection of the BHC peer group used in our calculations. Section 4 describes past and current approaches to estimating the cost of equity capital and presents estimates of these costs. Section 5 investigates alternative approaches. We then summarize our approach and its application, noting its usefulness outside the Federal Reserve System.

2. Review of Basic Valuation Models

A model must be used to impute an estimate from available data because the cost of equity capital used in the PSAF is unobservable. From 1983 through 2001, the PSAF used the CAE method—a model based solely on publicly available BHC accounting information. This model can be justified under some restrictive assumptions as a version of the DCF model of stock prices. If actual market equilibrium conformed directly to theory and if data were completely accurate, the DCF model would presumably yield identical results to the CAPM, which is a standard financial model using stock market data.

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Although related to one another, the CAE, DCF, and CAPM models do not yield identical estimates mainly because each has its own measurement inaccuracy. The accounting data used in the CAE method do not necessarily measure the quantities that are economically relevant in principle; the projected future cash flows used in the DCF model are potentially incorrect; and the overall market portfolio assumed within the CAPM is a theoretical construct that cannot be approximated accurately with a portfolio of actively traded securities alone. However, in practice, these models are commonly used: the CAE method is popular in the accounting profession, the DCF model is widely used to determine the fair value of an asset, and the CAPM is frequently used as the basis for calculating a required rate of return in project evaluation.

In this section, we review these three models. We conclude that each provides useful insights into the cost of equity capital and all three should be incorporated in the PSAF calculations.

2.1 The Comparable Accounting Earnings Model

The estimate of the cost of equity capital used in the original implementation of the PSAF is based on the CAE method. According to this method, the estimate for each BHC in the specified peer group is calculated as the return on equity (ROE), defined as

$$ROE \equiv \frac{net\ income}{book\ value\ of\ the\ equity}.$$

The individual ROE estimates are averaged to determine the average BHC peer group ROE for a given year. The CAE estimate actually used in the PSAF is the average of the last five years of the average ROE measures.

When interpreting the past behavior of a firm's ROE or forecasting its future value, we must pay close attention to the firm's debt-to-equity mix and the interest rate on its debt. The exact relationship between ROE and leverage is expressed as

$$ROE = (1 - tax\ rate)\left[ROA + (ROA - interest\ rate)\frac{debt}{equity}\right],$$

where ROA is the return on assets, the interest rate is the average borrowing rate of the debt, and equity is the book value of equity. The relationship has the following implications. If there is no debt or if the firm's ROA equals the interest rate on its debt, its ROE will simply be equal to $(1 - \text{tax rate}) \times$ ROA. If the firm's ROA exceeds the interest rate, its ROE will exceed $(1 - \text{tax rate}) \times$ ROA by an amount that will be greater the higher the debt-to-equity ratio is. If ROA exceeds the borrowing rate, the firm will earn more on its money than it pays out to creditors. The surplus earnings are available to the firm's equity holders, which raises ROE. Therefore, increased debt will make a positive contribution to a firm's ROE if the firm's ROA exceeds the interest rate on the debt.

To understand the factors affecting a firm's ROE, we can decompose it into a product of ratios as follows:

$$ROE = \frac{net\ profit}{pretax\ profits} \times \frac{pretax\ profits}{EBIT} \times \frac{EBIT}{sales} \times \frac{sales}{assets} \times \frac{assets}{equity}.$$

- The first factor is the *tax-burden ratio*, which reflects both the government's tax code and the policies pursued by the firm in trying to minimize its tax burden.
- The second factor is the *interest-burden ratio*, which will equal 1 when there are no interest payments to be made to debt holders.[4]
- The third factor is the *return on sales*, which is the firm's operating profit margin.
- The fourth factor is the *asset turnover*, which indicates the efficiency of the firm's use of assets.
- The fifth factor is the *leverage ratio*, which measures the firm's degree of financial leverage.

The tax-burden ratio, return on sales, and asset turnover do not depend on financial leverage. However, the product of the interest-burden ratio and leverage ratio is known as the *compound leverage factor*, which measures the full impact of the leverage ratio on ROE.

Although the return on sales and asset turnover are independent of financial leverage, they typically fluctuate over the business cycle and cause the ROE to vary over the cycle. The comparable accounting earnings method has been criticized for being "backward looking" because past earnings may not be a good forecast of expected earnings owing to cyclical changes in the economic environment. As a firm makes its way through the business cycle, its earnings will rise above or fall below the trend line that might more accurately reflect sustainable

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economic earnings. A high ROE in the past does not necessarily mean that a firm's future ROE will remain high. A declining ROE might suggest that the firm's new investments have offered a lower ROE than its past investments have. The best forecast of future ROE in this case may be lower than the most recent ROE.

Another shortcoming of the CAE method is that it is based on the book value of equity. Thus, it cannot incorporate changes in investor expectations of a firm's prospects in the same way that methods based on market values can. Use of book value rather than market value exemplifies the general problem of discrepancies between accounting quantities and actual economic quantities. The discrepancy precludes a forward-looking pricing formula for equity in this instance. It is important to incorporate forward-looking pricing methods for equity capital into the PSAF. The methods described below mitigate the problems of accounting measurement.

2.2 The Discounted Cash Flow Model

The theoretical foundation of corporate valuation is the DCF model, in which the stock price equals the discounted value of all expected future dividends. The mathematical form of the model is

$$P_0 = \sum_{t=1}^{\infty} \frac{D_t}{(1+r)^t},$$

where P_0 is the current price per share of equity, D_t is the expected dividend in period t, and r is the cost of equity capital. Because the current stock price P_0 is observable, the equation can be solved for r, provided that projections of future dividends can be obtained.

It is difficult to project expected dividends for all future periods. To simplify the problem, financial economists often assume that dividends grow at a constant rate, denoted by g. The DCF model then reduces to the simple form of

$$P_0 = \frac{D_1}{r-g},$$

and the cost of equity capital can be expressed as

$$r = \frac{D_1}{P_0} + g.$$

If the estimates of the expected dividend D_1, P_0, and g are available, the cost of equity capital can be easily calculated. Finance practitioners often estimate g from accounting statements. They assume that reinvestment of retained earnings generates the same return as the current ROE. Under this assumption, the dividend growth rate is estimated as $(1-\rho) \times \mathrm{ROE}$, where ρ is the dividend payout ratio. The estimate of the cost of equity capital is therefore

$$r = \frac{D_1}{P_0} + (1-\rho) \times ROE.$$

Although the assumption of constant dividend growth is useful, firms typically pass through life cycles with very different dividend profiles in different phases. In early years, when there are many opportunities for profitable reinvestment in the company, payout ratios are low, and growth is correspondingly rapid. In later years, as the firm matures, production capacity is sufficient to meet market demand as competitors enter the market and attractive reinvestment opportunities may become harder to find. In the mature phase, the firm may choose to increase the dividend payout ratio, rather than retain earnings. The dividend level increases, but thereafter it grows at a slower rate because of fewer growth opportunities.

To relax the assumption of constant growth, financial economists often assume multistage dividend growth. The dividends in the first T periods are assumed to grow at variable rates, while the dividends after T periods are assumed to grow at the long-term constant rate g. The mathematical formula is stated as

$$P_0 = \sum_{t=1}^{T-1} \frac{D_t}{(1+r)^t} + \frac{D_T}{(1+r)^{T-1}(r-g)}.$$

Many financial information firms provide projections of dividends and earnings a few years ahead as well as long-term growth rates. For example, the Institutional Brokers Estimate System (IBES) surveys a large sample of equity analysts and reports their forecasts for major market indexes and individual stocks. Given the forecasts of dividends and the long-term growth rate, we can solve for r as an estimate of the cost of equity capital.

Myers and Boruchi (1994) demonstrate that the assumption of constant dividend growth may lead financial analysts to unreasonable estimates of the cost of equity capital. They show, however, that the DCF model with multistage dividend growth gives an economically meaningful and statistically robust estimate. We therefore recommend the implementation of the DCF model with multistage dividend growth rates for the cost of equity capital used in the PSAF.

2.3 The Capital Asset Pricing Model

A widely accepted financial model for estimating the cost of equity capital is the CAPM. According to this model, the cost of equity capital (or the expected return) is determined by the systematic risk of the firm. The mathematical formula underlying the model is

$$r = r_f + (r_m - r_f)\beta,$$

where r is the expected return on the firm's equity, r_f is the risk-free rate, r_m is the expected return on the overall market portfolio, and β is the equity beta that measures the sensitivity of the firm's equity return to the market return.

Using the CAPM requires us to choose the appropriate measure of r_f and the expected market risk premium $r_m - r_f$ and to calculate the equity beta. The market risk premium can be obtained from a time-series of market returns in excess of Treasury bill rates. The simplest estimation is the average of historical risk premiums, which is available from various financial services firms such as Ibbotson Associates. The equity beta is calculated as the slope coefficient in the regression of the equity return on the market return. The equity beta can also be obtained from financial services firms such as ValueLine or Merrill Lynch.

The classic empirical study of the CAPM was conducted by Black, Jensen, and Scholes (1972) and updated by Black (1993). They show that the model has certain shortcomings: the estimated security market line is too flat, the estimated intercept is higher than the risk-free rate, and the risk premium on beta is lower than the market risk premium. To correct this, Black (1972) extended the CAPM to a model that does not rely on the existence of a risk-free rate, and this model seems to fit the data well for certain sets of portfolios. Fama and French (1992) argue more broadly that there is no relation between the average return and beta for U.S. stocks traded on the major exchanges. They find that the cross section of average returns can be explained by two characteristics: the firm's size and the book-to-market ratio. The study led some people to believe that the CAPM was dead.

However, there are challenges to the Fama and French study. One group of challenges focuses on statistical estimations. Most notably, Kothari, Shanken, and Sloan (1995) argue that the results obtained by Fama and French are partially driven by survivorship bias in the data. Knez and Ready (1997) argue that extreme samples explain the Fama and French results. Another group of challenges focuses on economic issues. For example, Roll (1977) argues that common stock indexes do not correctly represent the model's market portfolio. Jagannathan and Wang (1996) demonstrate that missing assets in such proxies for the market portfolio can be a partial reason for the Fama and French results. They also show that the business cycle is partially responsible for the results.

Turning to estimates of the cost of equity capital for specific industries using the CAPM, Fama and French (1997) conclude that the estimates are imprecise with standard errors of more than 3 percent per year. These large standard errors are the result of uncertainty about the true expected risk premiums and imprecise estimates of industry betas. They further argue that these estimates are surely even less precise for individual firms and projects. To overcome these problems, finance practitioners have often adjusted such betas and the market risk premium estimated from historical data. For example, Merrill Lynch provides adjusted betas. Vasicek (1973) provides a method of adjustment for betas, which is more sophisticated than the method used by Merrill Lynch. Barra Inc. uses firm characteristics—such as the variance of earnings, variance of cash flow, growth in earnings per share, firm size, dividend yield, and debt-to-asset ratio—to model betas. Barra's approach was developed by Rosenberg and Guy (1976a, 1976b); these practices can be found in standard graduate business school textbooks, such as Bodie, Kane, and Marcus (1999).

Given that the capital asset pricing model remains the industry standard and is readily accepted in the private sector, it should be incorporated into the estimation of the cost of equity capital for the private sector adjustment factor.

Considering the ongoing debate, how much faith can we place in the CAPM? First, few people quarrel with the idea that equity investors require some extra return for taking on risk. Second, equity investors do appear to be concerned principally with those risks that they cannot eliminate through portfolio diversification. The capital asset pricing model captures these ideas in a simple way, which is why finance professionals find it the most convenient tool with which to grip the slippery notion of equity risk. The CAPM is still the most widely used model in classrooms and the financial industry for calculating the cost of capital. This fact is evident in such popular corporate finance textbooks as Brealey and Myers (1996) and Ross, Westerfield, and Jaffe (1996). Given that the capital asset pricing model remains the industry standard and is readily accepted in the private sector, it should be incorporated into the estimation of the cost of equity capital for the private sector adjustment factor.

3. Conceptual Issues Involving the Proxy Banks

The first element of the cost of equity is determining the sample of bank holding companies that constitute the peer group of interest. The sample consists of BHCs ranked by total assets. The year-end summary published in the *American Banker* is usually the source for this ranking. Table 1 lists the BHCs in the peer group for the PSAF calculation in 2001. The number of BHCs in the peer group has changed over time. For 1983 and 1984, the group consisted of the top twelve BHCs by assets. From 1985 to 1990, the group consisted of the top twenty-five BHCs by assets, and since 1991, it has consisted of the top fifty. For the PSAF of a given year—known as the PSAF year—the most recent publicly available accounting data are used, which are the data in the BHCs' annual reports two years before the PSAF year. For example, the Federal Reserve calculated the 2002 PSAF in 2001 using the annual reports of 2000, which were the most recent publicly available accounting data. We refer to 2000 as the data year corresponding to PSAF year 2002.

Table 1

Bank Holding Companies Used in Calculating the Private Sector Adjustment Factor in 2001

AllFirst Financial	KeyCorporation
AmSouth Corporation	LaSalle National Corp.
Associated Banc Corp.	Marshall & Isley Corp.
BancWest Corp.	MBNA Corp.
BankAmerica Corporation	Mellon Bank Corporation
Bank of New York	M & T Bank Corp.
Bank One Corporation	National City Corporation
BB & T Corp.	Northern Trust Corp.
Charter One Financial	North Fork Bancorp.
Chase Manhattan Corporation	Old Kent Financial Corp.
Citigroup	Pacific Century Financial Corp.
Citizens Bancorp.	PNC Financial Corporation
Comerica Incorporated	Popular, Inc.
Compass Bancshares	Regions Financial
Fifth Third Bank	SouthTrust Corp.
Firstar Corp.	State Street Boston Corp.
First Security Corp.	Summit Bancorp.
First Tennessee National Corp.	SunTrust Banks Inc.
First Union Corporation	Synovus Financial
Fleet Financial Group, Inc.	Union Bank of California
Harris Bankcorporation, Inc.	Union Planters Corp.
Hibernia Corp.	U.S. Bancorp.
HSBC Americas, Inc.	Wachovia Corporation
Huntington Bancshares, Inc.	Wells Fargo & Company, Inc.
J.P. Morgan	Zions Bancorp.

Source: *American Banker.*

3.1 Debt-to-Equity Ratio and Business-Line Activities

The analysis presented in this article is based on the assumption that the calculation of the Reserve Banks' cost of capital is based on data on the fifty largest BHCs by assets, as is currently done. This choice was made, and will likely continue to be made, despite the knowledge that the payments services provided by Federal Reserve Banks are only a segment of the lines of business in which these BHCs engage. Some of these lines (such as lending to firms in particularly volatile segments of the economy) intuitively seem riskier than the financial services that the Federal Reserve Banks provide. Moreover, there are differences among the BHCs in their mix of activities. These observations raise some related conceptual issues, which we discuss below.

Two preliminary observations set the stage for this discussion. First, the Monetary Control Act of 1980 does not direct the Federal Reserve to use a specific formula or even indicate that the Reserve Banks' cost of capital should necessarily be computed on the basis of a specific sample of firms rather than on the basis of economywide data. The act does require the Federal Reserve to answer, in some reasonable way, the counterfactual question of what the Reserve Banks' cost of capital would be if they were commercial payment intermediaries rather than government-sponsored enterprises. Second, the largest BHCs do not constitute a perfect proxy for the Reserve Banks if that question is to be answered by reference to a sample of individual firms, and indeed no perfect proxy exists. Obviously, commercial banks engage in deposit-taking and lending businesses (as well as a broad spectrum of other businesses that the Gramm-Leach-Bliley Act of 1999 has further widened) in addition to their payments and related correspondent banking lines of business. Very few BHCs even report separate financial accounting data on lines of business that are closely comparable to the Reserve Banks' portfolios of financial service activities. Neither do other classes of firms that conduct some business comparable to that of the Reserve Banks, such as data-processing firms that provide check-processing services to banks, seem to resemble the Reserve Banks more closely than BHCs do. The upshot is that, unless the Federal Reserve were to convert to a radically different private sector adjustment factor methodology, it cannot avoid having to determine the Reserve Banks' counterfactual cost of capital from a sample of firms that is not perfectly appropriate for the task.

A conceptual issue regarding the BHC sample is that the cost of a firm's equity capital should depend on the firm's lines of business and on its debt-to-equity ratio. A firm engaged in riskier activities (or, more precisely, in activities having risks with higher covariance with the overall risk in the economy) should have a higher cost of capital. There is some indirect, but perhaps suggestive, evidence that the Federal Reserve Banks' priced services may be less risky, on the whole, than some business lines of the largest BHCs. Notably, the Federal Deposit Insurance Corporation has a formula for a risk-weighted capital-to-assets ratio. According to this formula, the collective risk-weighted capital-to-assets ratio of the Federal Reserve Banks' priced services is 30.8 percent.[5] This ratio is substantially higher than the average ratio in the BHC sample.

Unless the Federal Reserve were to convert to a radically different private sector adjustment factor methodology, it cannot avoid having to determine the Reserve Banks' counterfactual cost of capital from a sample of firms that is not perfectly appropriate for the task.

The Miller-Modigliani theorem implies that a firm with a higher debt-to-equity ratio should have a higher cost of equity capital, other things being equal, because there is risk to equity holders in the requirement to make a larger, fixed payment to holders of debt regardless of the random profit level of the firm. For the purposes of this theorem (and of the economic study of firms' capital structure in general), debt encompasses all fixed-claim liabilities on the firm that are contrasted with equity, which is the residual claim. In the case of a bank or BHC, debt thus includes deposits as well as market debt (that is, bonds and related financial instruments that can be traded on secondary markets). The current PSAF methodology sets the ratio of market debt to equity for priced services based on BHC accounting data. The broader debt-to-equity ratio that an imputation of equity to the Federal Reserve Banks would imply—and that seems to be the most relevant to determining the equity price—might not precisely equal the average ratio for the sample of BHCs. Moreover, a proposal to base the imputed amount of Federal Reserve Bank equity on bank regulatory capital requirements rather than directly on the BHC sample average would also affect the comparison between the imputed debt-to-equity ratio of the Federal Reserve Banks and the average debt-to-equity ratio of the BHCs.

3.2 Value Weighting versus Equal Weighting

Another conceptual issue is how to weight the fifty BHCs in the peer group sample to define their average cost of equity capital. Currently, the PSAF is calculated using an equally weighted average of the BHCs' costs of equity capital according to the CAE method. An obvious alternative would be to take a value-weighted average; that is, to multiply each BHC's cost of equity capital by its stock market valuation and divide the sum of these weighted costs by the total market valuation of the entire sample. Other alternatives—such as weighting the BHCs according to the ratio of their balances due to other banks to their total assets—could conceivably be adopted.

How might one make the task of calculating a counterfactually required rate of return set by the Monetary Control Act operational? Perhaps the best way to approach this question is to consider how an initial public offering of equity would be priced for a firm engaging in the Reserve Banks' priced service lines of business (and constrained by its corporate charter to limit the scope of its business activities, as the Reserve Banks must). The firm's investment bank could calculate jointly the cost-minimizing debt-to-equity ratio for the firm and the rate of return on equity that the market would require of a firm engaged in that business and having that capital structure.[6] If the investment bank could study a sample of perfectly comparable, incumbent firms with actively traded equity (which, however, the Federal Reserve cannot do), and if markets were perfectly competitive so that the required return on a dollar of equity were equated across firms, then it would not matter how data regarding the various firms are weighted. Any weighting scheme, applied to a set of identical observations, would result in an average that is also identical to the observations.

How observations are weighted becomes relevant when: 1) competitive imperfections make each firm in the peer group an imperfect indicator of the required rate of equity return in the industry sector where all of the firms operate; 2) as envisioned xin the case of Reserve Banks and BHCs, each firm in the comparison sample is a "contaminated observation" because it engages in some activities outside the industry sector for which the appropriate cost of equity capital is being estimated; or 3) for reasons such as discrepancies between accounting definitions and economic concepts, cost data on the sample firms are known to be mismeasured, and the consequences of this mismeasurement can be mitigated by a particular weighting scheme.

Let us consider each of these complications separately. In considering competitive imperfections, it is useful to distinguish between imperfections that affect the implicit value of projects within a firm and those that affect the value of a firm as an enterprise. To a large extent, the value of a firm is an aggregate of the values of the various investment projects in which it engages. This is why, in general, the total value of two merged firms is not dramatically different from the sum of their values before the merger; the set of investment projects within the merged firms is just the union of the antecedent firms' sets of projects. If each investment project is implicitly priced with error, and if those errors are statistically independent and identically distributed, then the most accurate estimate of the intrinsic value of a project is the equally weighted average across projects of their market valuations. If large firms and small firms comprise essentially similar types of projects, with a large firm simply being a greater number of projects than a small firm, then equal weighting of projects corresponds to the value weighting of firms. Thus, in this benchmark case, the investment bank should weight the firms in its comparison sample by value, and by implication, the Federal Reserve should weight BHCs by value in computing the cost of equity capital used in the PSAF.

However, some competitive imperfections might apply to firms rather than to projects. Until they were removed by recent legislation, restrictions on interstate branching arguably constituted such an imperfection in banking. More generally, the relative immobility of managerial talent is often regarded as a firm-level imperfection that accounts for the tendency of mergers (some of which are designed to transfer corporate control to more capable managers) to create some increase in the combined value of the merged firms. If such firm-level effects were believed to predominate in causing rates of return to differ between BHCs, then there would be a case for using equal weighting rather than value weighting to estimate most accurately the appropriate rate of return on equity in the sector as a whole. Although it would be possible in principle to defend equal weighting on this basis, our impression is that weighting by value is the firmly entrenched practice in investment banking and applied financial economics, and that this situation presumably reflects a judgment that value weighting typically is conceptually the more appropriate procedure.

The second reason why equal weighting of BHCs might be appropriate is that smaller BHCs are regarded as more closely comparable to Reserve Banks in their business activities than are larger ones. In that case, equal weighting of BHCs would be one way to achieve overweighting relative to BHC values, which could be defended if these were less contaminated observations of the true cost of equity to the Reserve Banks. Such a decision would be difficult to justify to the public, however. Although some people perceive that payments and related correspondent banking services are a relatively insignificant part of the business in some of the largest BHCs, this perception appears not to be documentable directly by information in the public domain. In particular, as we have discussed, the financial reports of BHCs are seldom usable for this purpose.

It might be possible to make an indirect, but convincing, case that the banks owned by some BHCs are more heavily involved than others in activities that are comparable to those of the Reserve Banks. For example, balances due to other banks might be regarded as an accurate indicator of the magnitude of a bank's correspondent and payments business because of the use of these balances for settlement. In that case, the ratio between due-to balances and total assets would be indicative of the prominence of payments-related activities in a bank's business. Of course, if this or another statistic was to be regarded as an appropriate indicator of which BHC observations were "uncontaminated," then following that logic to its conclusion would suggest weighting the BHC data by the statistic itself, rather than making an ad hoc decision to use equal weighting.

The third reason why equal weighting of BHCs might be appropriate is that it mitigates some defect of the measurement procedure itself. In fact, this is a plausible explanation of why equal weighting may have been adopted for the CAE method in current use. Equal weighting minimizes the effect of extremes in the financial market performance of a few large BHCs. In particular, when large banks go through difficult periods (such as the early 1990s), the estimated required rate of return on equity could become negative if large, poorly performing BHCs received as heavy a weight as their value before their decline would warrant. Because the CAE method is a backward-looking measure, such sensitivity to poor performance would be a serious problem. In contrast, with forward-looking methods such as the DCF or CAPM, poor performance during the immediate past year would not enter the required-return computation in a way that would mechanically force the estimate of required return downward. In fact, particularly in the CAPM method, the poor performance might raise the estimate of risk (that is, market beta) and therefore raise the estimate of required return. Moreover, at least after an initial year, a BHC that had performed disastrously would have a reduced market value and would thus automatically receive less weight in a value-weighted average.

In summary, there are grounds to use equal weighting to mitigate defective measurement in the CAE method, but those grounds do not apply with much force to the DCF and CAPM methods. If an average of several estimates of the equity cost of capital was to be adopted for the PSAF, there would be no serious problem with continuing to use equal weighting to compute a CAE estimate, insofar as that weighting scheme is effective, while using value weighting to compute DCF and CAPM estimates if value weighting would be preferable on other grounds.

4. Analysis of Past and Current Approaches

4.1 Estimates Based on the CAE Method

Up to 2001, the cost of equity capital in the PSAF was estimated using the CAE method. Table 2, column 4, reports these estimates on an after-tax basis from 1983 through 2002. Although the CAE methodology remained relatively constant over this period, a number of minor modifications, described below, were made over the years.

For each BHC in the peer group for a given PSAF year, accounting information reported in the BHC's annual report from the corresponding data year is used to calculate a measure of return on equity. The pretax ROE is calculated as the ratio of the BHC's after-tax ROE, defined as the ratio of its after-tax net income to its average book value of equity, to one minus the appropriate effective tax rate. The variables needed for these calculations are directly reported in or can be imputed from BHC annual reports. The BHC peer group's pretax ROE is a simple average of the individual pretax ROEs. To compare the CAE results with those of other methods that are calculated on an after-tax basis, we multiply the pretax ROE measures by the adjustment term (1 – median tax rate), where the median tax rate for a given year is based on the individual tax rates calculated from BHC annual reports over a period of several years. These average after-tax ROEs are reported in the third column of Table 2.[7]

For PSAF years 1983 and 1984, the after-tax CAE estimates used in the PSAF calculations, as reported in the fourth column of Table 2, were simply the average of the individual BHCs' pretax ROEs in the corresponding data years multiplied by their median tax adjustment terms. However, for subsequent years, rolling averages of past years' ROE measures were used in the PSAF. The rolling averages were introduced to reduce the volatility of the yearly CAE estimates and to ensure that they remain positive. For PSAF years 1984 through 1988, the after-tax CAE measures were based on a three-year rolling average of annual average pretax ROEs multiplied by their median tax adjustment terms. Since PSAF year 1989, a five-year rolling average has been used.[8]

Table 2

Equity Cost of Capital Estimates Based on the Comparable Accounting Earnings (CAE) Method

Data Year	Number of BHCs	After-Tax ROE	CAE	GDP Growth	NBER Business Cycle	PSAF Year	One-Year T-Bill
1981	12	12.69	12.69	2.45	Recession begins in July	1983	8.05
1982	12	12.83	12.83	-2.02	Recession ends in November	1984	9.22
1983	25	12.56	12.89	4.33		1985	8.50
1984	25	9.80	11.75	7.26		1986	7.09
1985	25	12.03	11.85	3.85		1987	5.62
1986	25	12.59	11.85	3.42		1988	6.62
1987	25	-0.01	9.49	3.40		1989	8.34
1988	25	18.92	10.54	4.17		1990	7.24
1989	50	7.44	10.11	3.51		1991	6.40
1990	50	-0.01	7.58	1.76	Recession begins in July	1992	3.92
1991	50	5.80	6.11	-0.47	Recession ends in March	1993	3.45
1992	50	13.39	8.85	3.05		1994	3.46
1993	50	16.39	8.43	2.65		1995	6.73
1994	50	14.94	10.06	4.04		1996	4.91
1995	50	15.73	13.00	2.67		1997	5.21
1996	50	16.75	15.22	3.57		1998	5.22
1997	50	16.57	15.95	4.43		1999	4.33
1998	50	15.62	15.93	4.37		2000	5.63
1999	50	17.13	16.44	4.11		2001	5.24
2000	50	17.27	16.58	3.75		2002	5.94

Source: Authors' calculations.

Notes: BHC is bank holding company; ROE is return on equity; NBER is National Bureau of Economic Research; PSAF is the private sector adjustment factor. The Treasury bill rate is aligned with the PSAF year.

As discussed in Section 2.1, the two factors that link ROE calculations to the business cycle are return on sales and asset turnover (that is, the ratio of sales to book-value assets). As shown in Table 2, the average ROE measure tends to fluctuate with real GDP growth. Dramatic examples of this correlation are seen for data years 1990 and 1991. Because of the recession beginning in July 1990 and the increasing credit problems in the banking sector at that time, the average ROE for the BHC peer group is actually negative. The CAE measure for that year (PSAF year 1992) was positive because of the five-year rolling average. In 1991, the average ROE was again positive, but the CAE measure (used for PSAF year 1993) dipped to its low of 6.11 percent. This measure was only about 3 percentage points above the one-year Treasury bill rate, obtained from the Center for Research in Security Prices bond file, for that PSAF year (as reported in the last column of Table 2). This measure is low compared with the CAE measure for PSAF year 2000, which is more than 10 percentage points greater than this risk-free rate. Clearly, the influence of the business cycle on the comparable accounting earnings measure is a cause for concern, especially given the two-year lag between the data and private sector adjustment factor years.

The influence of the business cycle on the comparable accounting earnings measure is a cause for concern, especially given the two-year lag between the data and private sector adjustment factor years.

A major deficiency of the CAE measure of equity capital costs is its "backward-looking" nature, as previously noted. This characteristic becomes quite problematic when the economy has just recovered from a recession. For example, as of 1992, when the economy had already recovered and experienced a real GDP growth rate of 3.05 percent (reported in the fifth column of Table 2), the negative average ROE observed in 1990 was still used in the CAE measure. As a result, the CAE measure used for the PSAF was at or below 10 percent until 1995, even though the after-tax ROE over this period averaged about 15 percent.

There are two reasons for the backward-looking nature of the CAE measure. The most important is its reliance on the book value of equity, which adjusts much more slowly than the market value of equity. Investors directly incorporate their expectations of a BHC's performance into the market value of equity, but not into the book value. For example, an interest rate increase should also raise the cost of equity capital, but a capital cost measure based on book values would remain unchanged. As pointed out by Elton, Gruber, and Mei (1994), because the cost of equity capital is a market concept, such accounting-based methods are inherently deficient. The CAE method is also backward looking because it uses a rolling average of past ROE estimates. This historical average exacerbates the lag of the CAE method in response to the business cycle.

4.2 Estimates Based on the DCF Method

According to the DCF method, the measure of a BHC's equity cost of capital is calculated by solving for the discount factor, given the BHC's year-end stock price, the available dividend forecasts, and a forecast of its long-term dividend growth rate. For our implementation, we used equity analyst forecasts of the BHC peer group's earnings, which are converted into dividend forecasts by multiplying them by the firm's latest dividend payout ratio. Specifically, we worked with the consensus earnings forecasts provided by IBES. Although several firms provide aggregations of analysts' earnings forecasts, we use the IBES forecasts because they have a long historical record and have been widely used in industry and academia. IBES was kind enough to provide the historical data needed for our study.[9]

An important concern here is the possibility of systematic bias in the analyst forecasts. De Bondt and Thaler (1990) argue that analysts tend to overreact in their earnings forecasts. The study by Michaely and Womack (1999) finds that analysts with conflicts of interest appear to produce biased forecasts; the authors find that equity analysts tend to bias their buy recommendations for stocks that were underwritten by their own firms. However, Womack (1996) demonstrates that equity analyst recommendations appear to have investment value. Overall, the academic literature seems to find that consensus (or mean) forecasts are unbiased. For example, Laster, Bennett, and Geoum (1999) provide a theoretical model in which the consensus of professional forecasters is unbiased in the Nash equilibrium, while individual analysts may behave strategically in giving forecasts different from the consensus. For macroeconomic forecasts, Zarnowitz and Braun (1993) document that consensus forecasts are unbiased and more accurate than virtually all individual forecasts. In view of these findings, we chose to use the consensus forecasts produced by IBES, rather than rely on individual analyst forecasts.

The calculation of the DCF measure of the cost of equity capital is as follows. For a given PSAF year, the BHC peer group is set as the largest fifty BHCs by assets in the calendar year two years prior.[10] For each BHC in the peer group, we collect the available earnings forecasts and the stock price at the end of the data year. The nature of the earnings forecasts available varies across the peer group BHCs and over time—that is, the IBES database contains a variable number of quarterly and annual earnings forecasts, and in some cases, it does not contain a long-term dividend growth forecast. These differences typically owe to the number of equity analysts providing these forecasts.[11] Once the available earnings forecasts have been converted to dividend forecasts using the firm's latest dividend payout ratio, which is also obtained from IBES, the discount factor is solved for and converted into an annualized cost of equity capital.

As shown in the second column of Table 3, the number of BHCs for which equity capital costs can be calculated fluctuates because of missing forecasts. To determine the DCF measure for the peer group, we construct a value-weighted average[12] of the individual discount factors using year-end data on BHC market capitalization. The DCF measures are presented in the third column of Table 3. The mean of this series is about 13.25 percent, with a time-series standard deviation of about 1.73 percent. Overall, the DCF method generates stable measures of BHC cost of equity capital. In the fourth column of Table 3, we report the cross-sectional standard deviation of the individual BHC discount factors for each year as a measure of dispersion. The cross-sectional standard deviation is relatively large around 1989 and 1990, but otherwise, it has remained in a relatively narrow band of around 2 percent. These estimates of equity capital costs are close to the long-run historical average return of the U.S. equity market, which is about 11 percent (see Siegel [1998]). More important, they imply a consistent premium over the risk-free rate, which is an economically sensible result.

Unlike the CAE estimates, the DCF estimates are mostly "forward looking." In principle, we determine the BHCs' cost of equity by comparing their current stock prices and expectations of future cash flows—both of which are market measures. However, some past accounting information is used. For example, the future dividend-payout ratio for a BHC is assumed constant at the last reported value. Nevertheless, the discounted cash flow measure is forward looking because the consensus analyst forecasts will deviate from past forecasts if there is a clear expected change in BHC performance.

4.3 Estimates Based on the CAPM Method

The capital asset pricing model for measuring BHC equity cost of capital is based on building a portfolio of BHC stocks and determining the portfolio's sensitivity to the overall equity market. As shown in Section 2.3, the relevant equation is $r = r_f + (r_m - r_f)\beta$. Thus, to construct the CAPM measure, we need to determine the appropriate BHC portfolio and its monthly stock returns over the selected sample period. We also need to estimate the portfolio's sensitivity to the overall stock market (that is, its beta), and construct the CAPM measure using the beta and the appropriate measures of the risk-free rate and the overall market premium.

As in the DCF method, the BHC peer group for a given PSAF year is the top fifty BHCs ranked by asset size for the corresponding data year. However, for the CAPM method, we need to gather additional historical data on stock prices in order to estimate the market regression equation. The need for historical data introduces two additional questions.

Table 3

Equity Cost of Capital Estimates Based on the Discounted Cash Flow (DCF) Method

Data Year	Number of BHCs	DCF Estimate	Standard Deviation	PSAF Year	One-Year T-Bill
1981	26	10.52	2.55	1983	8.05
1982	24	9.43	2.15	1984	9.22
1983	27	10.89	1.31	1985	8.50
1984	26	14.93	3.29	1986	7.09
1985	31	13.48	2.31	1987	5.62
1986	34	13.63	1.99	1988	6.62
1987	37	15.38	3.27	1989	8.34
1988	44	14.67	2.56	1990	7.24
1989	44	14.24	5.44	1991	6.40
1990	45	14.54	5.49	1992	3.92
1991	46	11.82	3.80	1993	3.45
1992	45	11.99	2.35	1994	3.46
1993	48	12.47	4.93	1995	6.73
1994	48	13.15	2.41	1996	4.91
1995	48	12.24	2.11	1997	5.21
1996	45	12.47	2.21	1998	5.22
1997	44	13.78	2.18	1999	4.33
1998	43	15.09	2.00	2000	5.63
1999	43	15.13	2.91	2001	5.24
2000	37	15.23	2.41	2002	5.94

Source: Authors' calculations.

Notes: BHC is bank holding company; PSAF is the private sector adjustment factor. The Treasury bill rate is aligned with the PSAF year.

The first question concerns which sample period should be used for the beta calculation. Choosing the sample period over which to estimate a portfolio's beta has presented researchers with an interesting challenge. Much empirical work has shown that portfolio betas exhibit time dependence (for example, see Jagannathan and Wang [1996] and their references). For our purposes, we chose to use a rolling ten-year sample period; that is, for a given PSAF year, the stock return data used to estimate the beta of a peer group portfolio is a ten-year period ending with the corresponding data year. The choice of a ten-year period provides a reasonable trade-off between estimation accuracy and computational convenience. Because we chose a monthly frequency, we use 120 observations to estimate the portfolio beta for a given PSAF year.[13]

The second data question is how to handle mergers in our study. This issue is important in light of the large degree of BHC consolidation that occurred in the 1990s. Our guiding principle was to include all of the BHC assets present in the BHC peer group portfolio at the end of our sample period throughout the entire period. In effect, mergers require us to analyze more than a given PSAF year's BHC peer group in the earlier years of the ten-year sample period. For example, the merger between Chase and J.P. Morgan in 2000 requires us to include both stocks in our peer group portfolio for PSAF year 2002, even though one BHC will cease to exist. This must be done over the entire 1991-2000 data window. Clearly, this practice will change the number of firms in the portfolio and the market capitalization weights used to determine the peer group portfolio's return over the 120 months of the sample period.

To our knowledge, there is no readily accessible and comprehensive list of publicly traded BHC mergers from 1970 to the present. However, we were able to account for all BHC mergers through the 1990s and for large BHC mergers before the 1990s. We constructed our sample of mergers between publicly traded BHCs using the work of Pilloff (1996) and Kwan and Eisenbeis (1999), as well as some additional data work.[14] Thus, the calculations presented in Table 3 do not account for every public BHC merger over the entire sample period. Further work is necessary to compile a complete list and incorporate it in the CAPM estimates. However, because the majority of large BHC mergers occurred in the 1990s, the results will not likely change much once the omitted mergers are accounted for.

Once the appropriate elements of the peer group portfolio for the entire ten-year period have been determined, the value-weighted portfolio returns at a monthly frequency are calculated.[15] The risk-free rate is the yield on one-month Treasury bills. We run twenty separate regressions and estimate twenty portfolio betas because we must estimate the cost of equity capital for each data year from 1981 through 2000. After estimating our betas, we construct the CAPM estimate of equity capital costs for each year. The market premium $r_m - r_f$ is constructed as the average of this time-series from July 1927, the first month for which equity index data are widely available, to the December of the data year (Wang 2001). We multiply this average by the estimated beta and add the one-year Treasury bill yield as of the first trading day of the PSAF year. The source for the individual stock data is the Center for Research in Security Prices.

As reported in the fifth column of Table 4, the average estimated cost of BHC equity capital for the 1981-2000 sample period was 15.09 percent, with a standard deviation of 1.49 percent. The key empirical result here is that the portfolio betas of the BHC peer group (the second column of the table) rise sharply in data year 1991 (PSAF year 1993), stay at about 1.15 for several years, then rise again in 1998. Up until 1990, we cannot reject the null hypothesis that beta is equal to 1, but after 1990, the hypothesis is strongly rejected, as shown in the third column by the p-values of this test. Although beta increased markedly over the sample, the CAPM estimates in

Table 4

Equity Cost of Capital Estimates Based on the Capital Asset Pricing Model (CAPM)

Data Year	Portfolio Beta	p-Value for Beta = 1	Market Premium	CAPM Estimate	PSAF Year	One-Year T-Bill
1981	0.91	0.29	7.76	18.05	1983	8.05
1982	0.99	0.89	7.82	16.07	1984	9.22
1983	1.02	0.81	7.91	17.18	1985	8.50
1984	1.05	0.56	7.67	15.99	1986	7.09
1985	1.01	0.94	7.92	16.05	1987	5.62
1986	0.98	0.78	7.96	13.82	1988	6.62
1987	0.94	0.41	7.84	12.17	1989	8.34
1988	0.93	0.35	7.90	15.20	1990	7.24
1989	0.94	0.40	8.07	15.14	1991	6.40
1990	1.01	0.89	7.73	15.26	1992	3.92
1991	1.17	0.02	8.02	14.02	1993	3.45
1992	1.20	0.00	7.99	12.98	1994	3.46
1993	1.18	0.01	7.99	12.20	1995	6.73
1994	1.17	0.01	7.81	14.52	1996	4.91
1995	1.17	0.02	8.09	15.47	1997	5.21
1996	1.15	0.04	8.20	15.06	1998	5.22
1997	1.15	0.04	8.43	15.57	1999	4.33
1998	1.32	0.00	8.58	16.02	2000	5.63
1999	1.22	0.00	8.53	15.93	2001	5.24
2000	1.09	0.15	8.13	15.18	2002	5.94

Source: Authors' calculations.

Notes: PSAF is the private sector adjustment factor. The Treasury bill rate is aligned with the PSAF year.

the fifth column did not rise as much because the level of the risk-free rate, shown in the last column, was lower over these years.

4.4 Estimates Based on the Combined Approach

Although clearly related, these three methods for calculating the BHC equity cost of capital are based on different assumptions, models, and data sources. The question about which method is "correct" or "most correct" is difficult to answer directly. We know that all models are simplifications of reality and hence misspecified (that is, their results cannot be a perfect measure of reality). In certain cases, the accuracy of competing models can be compared with observable outcomes, such as reported BHC earnings or macroeconomic announcements. However, because the equity cost of capital cannot be directly observed, we cannot make clear quality judgments among our three proposed methods. Table 5 shows the main differences in the information used in the three models and the major potential problem with each model.

In light of these observations, we proposed a way to calculate the BHC equity cost of capital that incorporates all three measures. We thought it might be disadvantageous to ignore any of the measures because each one has information the others lack. As surveyed by Granger and Newbold (1986) and Diebold and Lopez (1996), the practice of combining different economic forecasts is common in the academic and practitioner literature and it is generally seen as a relatively costless way of combining overlapping information sets on an ex-post basis. Focusing specifically on the equity cost of capital, Pastor and Stambaugh (1999) use Bayesian methods to examine how to incorporate competing ROE measures and decision makers' prior beliefs into a single measure. Wang (2002) demonstrates that the result of decision makers' prior beliefs over different models can be viewed as a shrinkage estimator, which is the weighted average of the estimates from the individual models. Wang shows that the weight in the average represents the model's importance to or impact on the result. Following this literature and absent a single method that directly encompasses all three information sets, we propose to combine our three measures within a given PSAF year using a simple average; that is,

$$COE_{combined} = \frac{1}{3}COE_{CAE} + \frac{1}{3}COE_{DCF} + \frac{1}{3}COE_{CAPM},$$

where COE is the estimated cost of equity capital derived from the method indicated by the subscript. This average has been used in the Federal Reserve Banks' PSAF since 2002.

The choice of equal weights over the three COE measures is based on three priorities. First, we want to maintain some continuity with current practice, and thus want to include the CAE method in our proposed measure. Second, in light of our limited experience with the DCF and CAPM methods and the historical variation observed among the three measures over the twenty-year period of analysis summarized in Tables 2-4, we do not have a strong opinion on which measure is best suited to our purposes. Third, since the three models use quite different information, it is very likely that one model is less biased than the other two in one market situation but more biased in another. The bottom line is that we have no convincing evidence or theory to argue that one model is superior. Hence, we choose an equally weighted average as the simplest possible method for combining the three measures. In terms of Bayesian statistics, the equal weights represent our subjective belief in the models.

Of course, experience may change our belief in these models. For example, for several years, the New York State Public Service Commission used a weighted average of different COE measures to determine its allowed cost of equity capital for the utilities it regulates. As reported by DiValentino (1994), the commission initially chose a similar set of three COE methods and applied equal weights to them. Recently, the commission reportedly changed its weighting scheme to place a two-thirds weight on the DCF method and a one-third weight on the CAPM method. Although our current recommendation is equal weights across the three methods, future reviews of the PSAF framework could lead to a change in these weights.

As shown in Table 6, the combined measure has a mean value of 13.16 percent and a standard deviation of 1.32 percent. As expected, the averaging of the three ROE measures smoothes out this measure over time and creates a series with

Table 5

Comparison of the Comparable Accounting Earnings (CAE), Discounted Cash Flow (DCF), and Capital Asset Pricing Model (CAPM) Methods

Method	Information Used	Potential Problem
CAE	Accounting data	Backward looking
DCF	Forecasts and prices	Analyst bias
CAPM	Equilibrium restrictions	Pricing errors

Table 6

Equity Cost of Capital Estimates Based on Combined Methods

	Estimated Cost of Equity Capital				
Data Year	CAE	DCF	CAPM	Combined	PSAF Year
1981	12.69	10.52	18.05	13.75	1983
1982	12.83	9.43	16.07	12.78	1984
1983	12.89	10.89	17.18	13.65	1985
1984	11.75	14.93	15.99	14.23	1986
1985	11.85	13.48	16.05	13.80	1987
1986	11.85	13.63	13.82	13.10	1988
1987	9.49	15.38	12.17	12.35	1989
1988	10.54	14.67	15.20	13.47	1990
1989	10.11	14.24	15.14	13.16	1991
1990	7.58	14.54	15.26	12.46	1992
1991	6.11	11.82	14.02	10.65	1993
1992	8.85	11.99	12.98	11.27	1994
1993	8.43	12.47	12.21	11.04	1995
1994	10.06	13.15	14.52	12.58	1996
1995	13.00	12.24	15.47	13.57	1997
1996	15.22	12.47	15.06	14.25	1998
1997	15.95	13.78	15.57	15.10	1999
1998	15.93	15.09	16.02	15.68	2000
1999	16.44	15.18	15.93	15.83	2001
2000	16.58	15.23	15.18	15.66	2002
Mean	11.91	13.25	15.09	13.42	
Standard deviation	3.06	1.73	1.49	1.48	

Source: Authors' calculations.

Note: CAE is the comparable accounting earnings method; DCF is the discounted cash flow model; CAPM is the capital asset pricing model; PSAF is the private sector adjustment factor.

less variation than the three individual series. Individual differences between the combined and the individual measures range between -5 percent and 5 percent over this historical period. However, the average differences are less than 2 percent but not statistically different from zero. Note also that the deviations of the DCF and CAPM measures from the one-year risk-free rate are not as large as they are for the CAE measure because of their greater sensitivity to general market and economic conditions. This property is obviously passed on to the combined ROE measure through averaging.

It is difficult to quantify our judgment on the estimates obtained using various methods. However, it is clear that the combined estimate is much more stable than the other estimates from the three basic models. The CAE estimate has the highest standard deviation while the combined estimate has the smallest standard deviation. The average CAE estimate over the past years is the lowest because the CAE estimate was much lower during recession years. However, the CAPM estimate is high for the 1996-2000 period for two reasons: high valuation of stock markets and high betas for large banks. Table 4 shows that the market premium was higher during the 1996-2000 period than during the early years. It also shows that the betas were high during the 1996-99 period. In Sections 5.1 and 5.2, we demonstrate that the betas are high because of the heavy weights of large banks, which had high betas during these years. Declines in stock market prices in 2000 pulled down the CAPM estimate to 15.18 percent, but the CAE estimate continued shooting up to 16.58 percent. The discrepancy in the estimates emphasizes the need to use all three methods to incorporate alternative information in the PSAF. The CAE uses the accounting information, the DCF uses earnings forecasts, and the CAPM uses stock prices. Our combined method thus prevents large errors when particular information is not reliable in some market situations.

> *Our combined method [for calculating the cost of equity capital] prevents large errors when particular information is not reliable in some market situations.*

5. Analysis of Alternative Approaches

5.1 Sensitivity to Weighting Methods

An important point to consider is that the equity cost of capital estimated by the CAPM method for some of the largest BHCs rose substantially in the early 1990s, partially because of increases in their market betas. Table 7 presents betas for 1990 and 1991 as well as their differences for twenty large BHCs, listed by their differences in beta. These increases might be due to artifacts of measurement error and, of course, equal weighting would help minimize them. However, an estimate of equity capital costs would be more credible if it was based on a weighting scheme that was chosen ex ante on grounds of conceptual appropriateness, rather than for its ability to minimize the influence of previously observed data. The decision to average several measurements of equity costs of capital is based on the idea that each method will be subject to some error, and that averaging across methods will diminish the errors' influence. That is exactly what would happen if a value-weighted CAPM measure was averaged with two other measures that do not exhibit such marked differences between large and small BHCs.

The impact that weighting methods could have on the measurement of equity capital costs used in the PSAF can be determined from Tables 8-10, which show, respectively, the DCF, CAPM, and combined estimates under equal weighting schemes. As shown in Table 8, the differences between the two weighting schemes for the DCF estimates are not substantial for most years in the sample period. The mean difference is 30 basis points with a standard deviation of 50 basis points. Clearly, the individual estimates generated by the DCF method are not very sensitive to the size of the BHCs for all years except 1998. A possible reason for this result is that equity analysts provide reasonably accurate forecasts of the cash flows from BHC investment projects, which are relatively observable and publicly reported ex post. As we discussed, if firm values are roughly the sum of their project values regardless of firm size, then equal weighting and value weighting of estimates for banks should be similar. This result should hold for projects in competitive product markets.

Table 9 presents the difference between the two weighting schemes according to the CAPM method. With respect to the market betas for the BHC peer group portfolios, the largest change occurred in 1991, when the beta increased from a value of roughly 1 to 1.17 under the value-weighting scheme. This measure of BHC risk remained at that level during the 1990s. However, the market beta under equally weighted schemes has not deviated far from 1. The increase in value-weighted beta in the latter part of the sample period can be attributed to two related developments in the banking industry. First, the betas of many large BHCs rose in 1991 and remained high over the period (Table 7). Second, the market value of the largest BHCs increased markedly during the 1990s as a share of the market value of the BHC peer group (Table 11). As of 1998, the top twenty-five BHCs accounted for about 90 percent of this market value, and the top five accounted for more than 40 percent. This increase can be attributed to the unprecedented number of mergers among large BHCs in recent years. The impact of these developments on the CAPM estimates was similar. Starting from 1991, the difference between the equity cost of capital estimates based on value-weighted and equally weighted averages has been greater than 1 percentage point (Table 9).

The impact on the combined measure was weaker than the impact on the CAPM measure because of averaging across the methods (Table 10). However, the differences between the value-weighted and equally weighted measures are still

Table 8
Differences in the Discounted Cash Flow Estimates Due to Weighting Scheme

Data Year	Value-Weighted	Equally Weighted	Difference
1981	10.52	10.39	0.13
1982	9.43	10.31	-0.88
1983	10.89	10.55	0.34
1984	14.93	14.06	0.87
1985	13.48	12.95	0.53
1986	13.63	13.49	0.14
1987	15.38	14.73	0.65
1988	14.67	13.91	0.76
1989	14.24	14.75	-0.51
1990	14.54	13.81	0.73
1991	11.82	11.58	0.24
1992	11.99	11.45	0.54
1993	12.47	12.70	-0.23
1994	13.15	13.19	-0.04
1995	12.24	12.14	0.10
1996	12.47	11.98	0.49
1997	13.78	13.26	0.52
1998	15.09	14.06	1.03

Source: Authors' calculations.

Table 7
Twenty Largest Changes in Individual Bank Holding Company Betas, 1990-91

Bank Holding Company	1990 Beta	1991 Beta	Difference
BankAmerica Corp.	0.94	1.28	0.33
Security Pacific Corp.	1.18	1.49	0.30
Shawmut National Corp.	0.84	1.09	0.25
Chase Manhattan Corp.	1.20	1.42	0.22
U.S. Bancorp	0.99	1.21	0.22
First Chicago Corp.	1.24	1.45	0.21
Wells Fargo	1.12	1.32	0.20
Fleet Financial Group	0.95	1.15	0.20
Norwest Corp.	1.11	1.30	0.19
Manufacturers Hanover Corp.	0.89	1.08	0.19
First Interstate Bancorp	1.00	1.17	0.17
NationsBank Corp.	1.19	1.37	0.17
Chemical Banking Corp.	1.02	1.19	0.17
First Bank System Inc.	1.21	1.37	0.17
Bank of New York	1.07	1.23	0.16
J. P. Morgan	0.88	1.04	0.16
Meridian Bancorp	0.67	0.83	0.16
Bank of Boston Corp.	1.19	1.34	0.16
NBD Bancorp	1.02	1.15	0.13
Bankers Trust	1.20	1.32	0.13

Source: Authors' calculations.

Table 9
Capital Asset Pricing Model (CAPM) Estimates under Different Weighting Schemes

	Portfolio Beta			CAPM Estimates		
Data Year	Value-Weighted	Equally Weighted	Difference	Value-Weighted	Equally Weighted	Difference
1981	0.91	0.94	-0.03	18.05	18.25	-0.20
1982	0.99	1.00	-0.01	16.07	16.16	-0.09
1983	1.02	1.00	0.01	17.18	17.07	0.11
1984	1.05	1.02	0.03	15.99	15.75	0.24
1985	1.01	1.01	-0.01	16.05	16.12	-0.07
1986	0.98	0.97	0.01	13.82	13.74	0.08
1987	0.94	0.93	0.02	12.17	12.05	0.13
1988	0.93	0.90	0.03	15.20	14.94	0.27
1989	0.94	0.92	0.02	15.14	14.96	0.18
1990	1.01	0.98	0.03	15.26	15.02	0.24
1991	1.17	1.03	0.14	14.02	12.93	1.09
1992	1.20	1.04	0.16	12.98	11.73	1.24
1993	1.18	1.00	0.17	12.20	10.81	1.40
1994	1.17	1.00	0.17	14.52	13.20	1.32
1995	1.17	0.99	0.17	15.47	14.08	1.39
1996	1.15	0.98	0.17	15.06	13.67	1.38
1997	1.15	0.99	0.16	15.57	14.24	1.33
1998	1.32	1.09	0.23	16.02	14.01	2.01

Source: Authors' calculations.

noticeable in the latter half of the 1990s. In conclusion, the use of equally weighted averages to estimate the cost of equity capital under the DCF and CAPM methods provides reasonable empirical results with some theoretically appealing properties. However, the use of value-weighted averages is more closely in line with current academic and industry practice.

5.2 Rolling versus Cumulative Betas

A crucial element of the CAPM method is the estimation of a portfolio's market beta. Many issues related to this estimation are addressed in academic research, but the most important one here is the choice between estimating beta using all available years of data or using a shorter period of recent data. The first option is referred to as a *cumulative beta,* the second is referred to as a *rolling beta*. In our proposed CAPM method, we estimated a rolling beta based on the past ten years of monthly data, following common industry practice. In this section, we discuss the relative advantages and disadvantages of cumulative and rolling betas.

The rationale for using a rolling beta is to capture the time variation of the systematic risk common across firms. Much of the academic literature demonstrates the time-varying nature of this risk. A rolling beta helps to account for this by ignoring data observed more than a certain number of years ago. Earlier data are viewed as irrelevant to the estimation of the current beta. However, this modeling method has a basic conceptual flaw. If we assume that the past ten years of data give an unbiased estimate of the current beta, we are assuming that the current beta was the same during the ten-year period. If we do this every year, we implicitly assume a constant beta across all years, in which case we should use a cumulative beta. To avoid this, we can assume that systematic risk changes slowly over time. Under this assumption, both a rolling beta and a cumulative beta are biased, but a rolling beta should have a smaller bias.

The time variation observed in the rolling beta is, however, not equivalent to the time variation of true systematic risk. The time variation of the rolling beta consists of both the variation due to the changes in the systematic risk, which is what we want to measure, and the variation due to small sample estimation noise, which we want to avoid. We obviously face a trade-off here. Adding more past data to the estimation of rolling betas reduces the estimation noise but also reduces the total variation of the rolling beta, obscuring the variation of the systematic risk that can be captured. Therefore, the time variation of the rolling beta reported in Table 3 cannot be viewed simply as the variation of the systematic risk of BHCs. It is the variation of the average systematic risk during a ten-year period compounded with estimation noise. The actual variation of the true systematic risk in a given year can be larger or smaller than the variation observed in the rolling betas.

Although it is difficult to determine the portion of the time variation of the rolling beta associated with changes in the systematic risk, the cyclic behavior of the rolling betas reported in Table 4 suggests that there were fundamental changes in BHC risk. The rolling betas were relatively low in the early 1980s and increased during the mid-1980s. The beta for PSAF year 1990 was practically 1, but then rose sharply, as we discussed. After staying between 1.15 and 1.20 from 1993 to 1999, the beta jumped to 1.32 in PSAF year 2000.

Why might BHC risk have changed over these years? For the PSAF, it is especially important to understand if these changes were due to changes in the nature of the payments services and traditional banking businesses or due to other nontraditional banking businesses. If the time variation of risk did not arise from payments services and traditional banking, we would most likely want to avoid incorporating it into the PSAF calculation.

A common, but not yet unanimous, view is that a secular trend of increasing market betas reflects the gravitation of BHCs—particularly some of the largest ones—toward lines of business that are more risky than traditional banking. If this were so—particularly the asymmetry between the largest BHCs and the others—then an equally weighted, rolling-beta estimate of market betas ought to exhibit smaller time variation than the analogous, value-weighted estimate. Table 9 corroborates this conjecture. It thus provides some, but far from conclusive, inductive support for the view that secularly increasing betas do not primarily reflect conditions in the payments business. If this is true, the varying BHC risk captured by the rolling beta may not be appropriate for the PSAF if we want to measure the risk in BHCs' payments businesses. Evidence from the equally weighted scheme suggests that the beta of the traditional banking business might be constant. If so, a constant beta would be more accurately estimated with a longer time period, rather than with a series of short ones. Thus, the cumulative beta could minimize the estimation noise and better reveal the risk of the traditional banking business.

Table 12 presents the CAPM results with both the rolling and cumulative estimation periods using the value-weighting scheme. As we see, the cumulative beta stays very close to 1 with a mean of 1.00 and a standard deviation of 0.03, showing little

Table 10

Differences in Combined Estimates Due to Weighting Scheme

PSAF Year	Data Year	Value-Weighted	Equally Weighted	Difference
1983	1981	13.75	13.78	-0.02
1984	1982	12.78	13.10	-0.32
1985	1983	13.65	13.50	0.15
1986	1984	14.23	13.86	0.37
1987	1985	13.80	13.64	0.15
1988	1986	13.10	13.03	0.07
1989	1987	12.35	12.09	0.26
1990	1988	13.47	13.13	0.34
1991	1989	13.16	13.27	-0.11
1992	1990	12.46	12.14	0.32
1993	1991	10.65	10.21	0.44
1994	1992	11.27	10.68	0.59
1995	1993	11.04	10.65	0.39
1996	1994	12.58	12.15	0.42
1997	1995	13.57	13.07	0.50
1998	1996	14.25	13.63	0.62
1999	1997	15.10	14.49	0.62
2000	1998	15.68	14.66	1.02

Source: Authors' calculations.

Note: PSAF is the private sector adjustment factor.

Table 11

Percentage Share of Market Value of Top Fifty Bank Holding Companies (BHCs)

	Percentage Share of Market Value		
Data Year	Top Five BHCs	Top Ten BHCs	Top Twenty-Five BHCs
1981	29	46	70
1982	32	45	67
1983	23	35	59
1984	23	35	57
1985	22	33	55
1986	17	26	47
1987	18	28	50
1988	17	28	49
1989	19	30	53
1990	22	34	58
1991	20	32	56
1992	22	34	58
1993	22	35	61
1994	22	35	61
1995	23	37	65
1996	29	46	75
1997	29	46	76
1998	42	63	88

Source: Authors' calculations.

variation over time because of the long historical samples used in the estimation. The impact on the estimates of the equity cost of capital are clear: the estimates based on the cumulative beta remain more than 1 percentage point lower than those based on the rolling beta during the 1990s. Table 13 shows a similar impact for the combined estimates.

In conclusion, the use of cumulative betas to estimate the equity cost of capital under the CAPM method provides reasonable empirical results with some theoretically appealing properties. However, the use of rolling betas more closely matches current industry practice.

5.3 Multibeta Models

Empirical evidence suggests that additional factors may be required to characterize adequately the behavior of expected stock returns. This naturally leads to the consideration of multibeta pricing models. Theoretical arguments also suggest that more than one factor is required given that the CAPM will apply period by period only under strong assumptions. Two main theoretical approaches exist: the arbitrage pricing theory (APT), developed by Ross (1976), is based on arbitrage arguments, and the intertemporal capital asset pricing model (ICAPM), developed by Merton (1973), is based on equilibrium arguments.

The mathematical formula for these multibeta models is

$$r = r_f + \gamma_1 \beta_1 + \ldots + \gamma_k \beta_k ,$$

where r is the cost of equity capital, β_k measures the sensitivity of the firm's equity return to the k^{th} economic factor, and γ_k measures the risk premium on the k^{th} beta. Given the economic factors, the parameters in the multibeta model can be estimated from the combination of time-series and cross-sectional regressions. Shanken (1992) and Jagannathan and Wang (1998) describe this estimation procedure.

The main drawback of the multibeta models is that economic theory does not specify the factors to be used in them. The task of identifying the factors is left to empirical research. The first approach is to start from economic intuition; Chen, Roll, and Ross (1986) select five economic factors—the market return, industrial production growth, a default premium, a term premium, and inflation. The second approach is to identify factors based on statistical analysis; Connor and Korajczyk (1986) use the asymptotic principal component method to extract factors from a large cross section

TABLE 12
Differences in Value-Weighted Capital Asset Pricing Model (CAPM) Estimates Due to Estimation Period

Data	Portfolio Beta			CAPM Estimates		
Year	Rolling	Cumulative	Difference	Rolling	Cumulative	Difference
1981	0.91	0.92	0.00	18.05	18.06	-0.01
1982	0.99	0.96	0.03	16.07	15.84	0.23
1983	1.02	0.97	0.05	17.18	16.79	0.38
1984	1.05	0.98	0.06	15.99	15.50	0.49
1985	1.01	1.00	0.01	16.05	15.99	0.07
1986	0.98	1.00	-0.03	13.82	14.04	-0.22
1987	0.94	0.99	-0.05	12.17	12.54	-0.37
1988	0.93	0.98	-0.05	15.20	15.58	-0.38
1989	0.94	0.99	-0.05	15.14	15.53	-0.39
1990	1.01	1.03	-0.02	15.26	15.39	-0.13
1991	1.17	1.04	0.13	14.02	13.01	1.01
1992	1.20	1.04	0.16	12.98	11.69	1.29
1993	1.18	1.03	0.15	12.20	11.01	1.20
1994	1.17	1.03	0.14	14.52	13.44	1.08
1995	1.17	1.02	0.15	15.47	14.29	1.18
1996	1.15	1.02	0.13	15.06	14.00	1.06
1997	1.15	1.02	0.12	15.57	14.54	1.04
1998	1.32	1.04	0.28	16.02	13.61	2.41

Source: Authors' calculations.

TABLE 13
Differences in Value-Weighted Combined Estimates Due to Estimation Period

PSAF Year	Data Year	Rolling Sample	Cumulative Sample	Difference
1983	1981	13.75	13.71	0.04
1984	1982	12.78	12.99	-0.22
1985	1983	13.65	13.41	0.24
1986	1984	14.23	13.77	0.45
1987	1985	13.80	13.60	0.20
1988	1986	13.10	13.13	-0.03
1989	1987	12.35	12.26	0.09
1990	1988	13.47	13.35	0.13
1991	1989	13.16	13.46	-0.30
1992	1990	12.46	12.26	0.20
1993	1991	10.65	10.23	0.42
1994	1992	11.27	10.66	0.61
1995	1993	11.04	10.71	0.32
1996	1994	12.58	12.23	0.35
1997	1995	13.57	13.14	0.43
1998	1996	14.25	13.73	0.52
1999	1997	15.10	14.58	0.52
2000	1998	15.68	14.53	1.15

Source: Authors' calculations.

Note: PSAF is the private sector adjustment factor.

of stock returns. The third approach is to identify factors based on empirical observation; Fama and French (1993) construct two factors to mimic the risk captured by firm size and the book-to-market ratio.

In business school classrooms and according to industry practice, multibeta models are sometimes used to estimate the cost of equity capital. For example, Elton, Gruber, and Mei (1994), Bower and Schink (1994), Bower, Bower, and Logue (1984), and Goldenberg and Robin (1991) use multibeta models to study the cost of capital for utility stocks. Antoniou, Garrett, and Priestley (1998) use the APT model to calculate the cost of equity capital when examining the impact of the European exchange rate mechanism. However, different studies use entirely different factors.

Recent academic studies have comprehensively examined the differences in estimating the cost of equity capital using the CAPM and multibeta models. Fama and French (1997) conclude that when their proposed three-beta model (1993) is used, estimates of the cost of equity capital for industries are still imprecise. Like the CAPM, the three-beta model often produces standard errors of more than 3 percent per year. Using Bayesian analysis, Pastor and Stambaugh (1999) reach a similar conclusion. They show that uncertainty about which model to use is less important, on average, than within-model parameter uncertainty.

The main drawback of the multibeta models is that economic theory does not specify the factors to be used in them.

Multibeta models could be employed to calculate the equity cost of capital used in the PSAF. However, because there is no consensus on the factors, adoption of any particular model would be subject to criticism. Because the academic literature shows that multibeta models do not substantially improve the estimates, the gain in accuracy would likely be too small to justify the burden of defending a deviation from the CAPM method. We therefore do not recommend using multibeta models to calculate the cost of equity capital in the PSAF.

Nevertheless, we present some numerical results based on the Fama and French (1993) model. These results indicate that any additional accuracy provided by multibeta models is clearly outweighed by the added difficulties in specifying and estimating them. The following empirical results support this conclusion, at least for pricing in the PSAF.

The Fama and French model includes the excess market return, $r_m - r_f$, as well as four other factors. SMB is the spread between the return on stocks with low and high market capitalizations. HML is the spread between the return on stocks with low book-to-market ratios and those with high ratios. TERM is the spread between long- and short-term Treasury debt securities. DEF is the spread between long-term corporate bonds and long-term Treasury bonds. The model is

$$r - r_f = \beta_1 (r_m - r_f) + \beta_2 \overline{SMB} + \beta_3 \overline{HML} + \beta_4 \overline{TERM} + \beta_5 \overline{DEF} ,$$

where $\overline{\mathrm{SMB}}$ is the expectation of SMB. The same applies to other factors. As in the CAPM method, we estimate the betas by running the regression of the historical excess returns onto the five factors in the model. We use the time-series of SMB and HML provided by French. We obtain the time-series of TERM and DEF from Ibottson Associates.

As before, we estimate the expectation of each of our factors by taking its average from July 1927 to December of the data year. The averages are used in the above equation to obtain an estimate of the risk premium. Table 14 provides the results for data years 1988 through 1998 and the estimates for the risk premiums and their standard errors. Each column labeled by a regression variable contains the corresponding coefficient estimates and their *t*-statistics. The α is always negative. The standard error of the estimated risk premium (the second column) is always around 3 percent, as reported in the third column. This is consistent with Fama and French (1997), who argue that their 1993 model does not offer better estimates of the industry cost of capital than the CAPM does. Therefore, the Fama-French model does not serve our purpose.

5.4 Dynamic Models

The CAPM and multifactor models are static models, which have difficulties capturing the effects of a changing economic environment. One solution to this problem is to use a short and recent historical data sample to estimate the models. However, this approach is often criticized as being based on inefficient model estimation. Furthermore, this practice depends on the assumption that the expected returns and risk do not change substantially within the selected data sample.

Another solution is to construct dynamic models. One approach, developed in the late 1980s, is to use generalized autoregressive conditional heteroskedasticity (GARCH) models to estimate the CAPM with conditional expected return and volatility. This approach was first implemented by

Bollerslev, Engle, and Wooldridge (1988) to estimate the CAPM with time-varying covariance. In the 1990s, there were many extensions and improvements to the original specification of the GARCH capital asset pricing model. Another approach, first implemented by Harvey (1989), is to model the conditional expected returns and variances as linear functions of instrument variables, such as various kinds of interest rates. Ferson and Harvey (1999) argue that the instrument variables improve the estimates of the expected equity returns in comparison with the CAPM and multibeta models.

The most rigorous dynamic models consider the consumption-portfolio choice over multiple periods. However, these models rely on aggregate consumption data and perform poorly in explaining the risk premiums on financial assets. The empirical difficulties of the dynamic asset pricing models are convincingly demonstrated by Hansen and Singleton (1982), Mehra and Prescott (1985), and Hansen and Jagannathan (1991). Hansen and Jagannathan (1997) find that the improvements of various sophisticated dynamic models over the static CAPM are not substantial.

Although widely applied and extended in academic research, none of these dynamic models has been used to estimate the cost of equity capital in either the industry or in business schools. Therefore, we do not recommend introducing these models into private sector adjustment factor calculations.

Table 14

Regression Results for Multibeta Model Based on Bank Holding Company Peer Group Portfolios

Data Year	$r - r_f$	σ	α	$r_m - r_f$	HML	SMB	TERM	DEF
1988	9.95	3.04	-0.43	0.98	0.42	0.05	0.43	0.56
			(1.47)	(13.09)	(3.71)	(0.41)	(4.51)	(2.11)
1989	10.26	3.03	-0.46	0.99	0.44	0.07	0.42	0.55
			(1.63)	(13.70)	(3.88)	(0.59)	(4.48)	(2.08)
1990	10.33	3.13	-0.58	1.04	0.45	0.11	0.41	0.49
			(2.07)	(14.06)	(3.88)	(0.98)	(4.19)	(1.78)
1991	10.76	3.14	-0.45	1.06	0.44	0.11	0.41	0.47
			(1.64)	(14.88)	(3.85)	(1.03)	(4.22)	(1.73)
1992	10.92	3.10	-0.41	1.06	0.45	0.13	0.40	0.47
			(1.56)	(15.30)	(4.26)	(1.21)	(4.25)	(1.74)
1993	10.98	3.03	-0.43	1.05	0.45	0.11	0.39	0.50
			(1.71)	(15.61)	(4.53)	(1.11)	(4.27)	(1.92)
1994	10.64	2.98	-0.38	1.05	0.45	0.08	0.38	0.51
			(1.61)	(16.15)	(4.66)	(0.84)	(4.19)	(1.99)
1995	10.67	2.87	-0.30	1.04	0.43	0.05	0.38	0.46
			(1.34)	(16.43)	(4.64)	(0.52)	(4.4)	(1.87)
1996	10.75	2.84	-0.23	1.05	0.44	0.03	0.37	0.47
			(1.05)	(16.94)	(4.82)	(0.28)	(4.35)	(1.93)
1997	11.15	2.85	-0.21	1.07	0.45	-0.02	0.37	0.46
			(0.98)	(17.65)	(5.05)	(0.18)	(4.37)	(1.88)
1998	11.10	2.82	-0.23	1.09	0.41	-0.04	0.33	0.58
			(1.07)	(18.61)	(4.67)	(0.44)	(3.96)	(2.43)

Source: Authors' calculations.

Note: HML is the spread between the return on stocks with low and high book-to-market ratios; SMB is the spread between the return on stocks with low and high market capitalizations; TERM is the spread between long- and short-term Treasury debt securities; DEF is the spread between long-term corporate bonds and long-term Treasury bonds.

6. Conclusion

In this article, we review the theory and practice of using asset pricing models to estimate the cost of equity capital. We also analyze the current approach, adopted by the Federal Reserve System in 2002, used to estimate the Federal Reserve Banks' cost of equity capital in the calculation of the private sector adjustment factor. The approach is based on a simple average of three methods as applied to a peer group of bank holding companies. The three methods estimate the cost of equity capital from three perspectives—a historical average of comparable accounting earnings, the discounted value of expected future cash flows, and the equilibrium price of investment risk. We show that the current approach would have provided stable and sensible estimates of the cost of equity capital for the PSAF over the past twenty years.

In addition, we discuss important conceptual issues regarding the construction of the peer group of bank holding companies needed for this exercise. Specifically, we examine the questions of whether to use value-weighted or equally weighted averages in our calculations and whether to use rolling or cumulative sample periods with which to estimate the capital asset pricing model. Although these alternative approaches provide reasonable empirical results with some theoretically appealing properties, the current approach more closely matches industry practice as well as the academic literature.

Our study also has broader implications for the analysis of the cost of equity. For example, regulators of utility and telecommunication companies face estimation issues similar to those faced by the Federal Reserve. In fact, this study builds on previous studies of utility and telecommunication regulations (DiValentino 1994; Mullins 1993). Furthermore, our results have applicability to calculations used in the valuation of private companies.

Appendix: Technical Details of the Discounted Cash Flow (DCF) and Capital Asset Pricing Model (CAPM) Methods

The DCF Method

Our source for the consensus earnings per share (EPS) forecasts is Institutional Brokers Estimate System (IBES), a company that collects and summarizes individual equity analysts' forecasts. IBES adds EPS forecasts to its database when two conditions are met. First, at least one analyst must produce forecasts on a company; second, sufficient ancillary data (such as actual dividends) must be publicly available. Consensus forecasts are made by taking a simple average across all reported analyst forecasts. Other data providers are Thomson/First Call, Zacks, and Value Line; however, we chose IBES forecasts because they have a long historical record and have been widely used in the academic literature.

For a given private sector adjustment factor (PSAF) year, we calculate the discount factor for each bank holding company (BHC) in the peer group. In every case, we use the last available stock price for the corresponding data year and the last reported set of consensus EPS forecasts (that is, the forecast set) in that year. We then average these discount rates across the peer group for each year, using either value-weighted or equally weighted schemes.

The forecast set we use for a given data year for a given BHC consists of all the consensus forecasts published in the last month for which data are available. Typically, the last month is December, but it may be earlier. Each EPS forecast in the forecast set is for a future fiscal quarter (forecast quarter) or future fiscal year (forecast year). Typically, a forecast set includes up to four forecast quarters and five forecast years as well as a long-term EPS growth rate estimate. To transform the EPS forecasts into the necessary dividend forecasts, we multiply them by the BHC's dividend payout ratio for the last quarter available, which is assumed constant over time.

We need to interpolate quarterly EPS forecasts from the annual ones because dividends are typically paid on a quarterly basis and because a maximum of four quarterly forecasts is available. The procedure we use is explained below. Although there are variations on the procedure depending on which EPS forecasts are available, two assumptions apply in every case. First, we assume that the sum of the quarterly forecasts in a given forecast year equals the annual forecast. Second, we assume that the quarterly EPS is a linear function of time. Although the general upward trend usually observed in an EPS may not be linear, it is plausible and the simplest to implement. These conditions make the interpolation of the annual EPS forecasts beyond the first forecast year into quarterly EPS forecasts straightforward; that is, $Q_1 = A/10$; $Q_2 = 2Q_1$; $Q_3 = 3Q_1$; and $Q_4 = 4Q_1$, where A is the annual EPS forecast.

At times, such interpolation is necessary in the first forecast year. In a few cases, the forecast set includes an EPS forecast for some, but not all, forecast quarters in the first forecast year. Given an annual EPS forecast A and n quarterly EPS estimates Q_i (with $n < 4$) for the first forecast year, the interpolated EPS forecast for quarter $n+1$ is set as

$$Q_{n+1} = Q_n + S_n,$$

where

$$S_n = \frac{A - \sum_{i=1}^{n} Q_i + (4-n)Q_n}{\sum_{i=0}^{4-n} (4-n-i)}.$$

The interpolated forecasts for Q_{n+2} and later forecast quarters within the first forecast year are simply calculated by adding S_n to the forecast for the previous forecast quarter. For cases in which there are no quarterly EPS forecasts for the first forecast year, we use the EPS forecast for the fourth quarter of the prior year (denoted Q_{4b}), regardless of whether it is actual or interpolated. The interpolated EPS forecast for the first quarter of the first forecast year is

$$Q_1 = Q_{4b} + S_{4b},$$

where

$$S_{4b} = \frac{A - 4Q_{4b}}{10},$$

and A is the annual EPS forecast for the first forecast year. All subsequent quarterly forecasts are estimated by adding S_n to the previous forecast quarter.

On occasion, only annual forecasts are available. In these cases, we estimate the first forecast quarter's EPS as

$$Q_1 = \frac{A_1 - 6S_0}{4},$$

where

$$S_0 = \frac{A_1 - A_0}{4},$$

and A_0 is the annual EPS forecast for the data year and A_1 is the annual EPS forecast for the first forecast year (that is, one year later than the data year). This formula assumes that quarterly EPS is a linear function of time with the slope implied by the change in annual EPS from the data year to the first forecast year.

Once all of the available EPS forecasts are converted to a quarterly frequency, we transform them into dividend forecasts using the BHC's dividend payout ratio for the last historical quarter. We assume this ratio is constant. The final element needed to solve for the BHC's discount rate is the dividend growth rate at a quarterly frequency, denoted *g*. IBES provides consensus forecasts of *g* when they are available. However, when such forecasts are not available, we exclude the BHC from the sample. Although a dividend growth rate could be imputed using additional accounting data, we simplify the procedure by limiting ourselves to the data provided in the IBES database. This condition does not exclude many BHCs from our calculations. The most important factor in limiting our BHC peer group calculations for a given year is the number of BHCs without analyst forecasts, which is most severe in the early 1980s and not much of a factor by the late 1990s.

Once the data are in place, we numerically solve for *r* for each BHC. The average of *r* across all BHCs in the peer group in a given data year, using either a value-weighted or equally weighted averaging scheme, is the estimated BHC cost of equity capital for the data year. We use the market capitalization as of the last trading day of the data year.

The CAPM Method

Because CAPM estimates are derived from a statistical model, we can generate corresponding standard errors for them. The variance of the CAPM estimate from the true but unknown value can be expressed as

$$E[(\hat{r}-r)^2] = E[(\hat{\beta}\hat{f}-\beta f)^2],$$

where r is our portfolio's monthly risk premium $r - r_f$, $f = r_m - r_f$, and $\hat{\beta}$, $\hat{r}$, and $\hat{f}$ are our estimates of β, r, and f, respectively. Using a Taylor expansion of $r = \beta f$, we can approximate the above equation as

$$E[(\hat{r}-r)^2] = E[\beta^2(\hat{f}-f)^2 + f^2(\hat{\beta}-\beta)],$$

or, equivalently,

$$Var(\hat{r}) = \beta^2 Var(\hat{f}) + f^2 Var(\hat{\beta}),$$

where $Var(\hat{\beta})$ is the variance of our beta estimate and $Var(\hat{f})$ is the variance of the mean of *f*. These two variances can be easily estimated from the available data, and $Var(\hat{r})$ can be calculated from the above equation. An estimate of the standard error of our CAPM estimate $\hat{r}$ is simply the square root of $Var(\hat{r})$.

Endnotes

1. The Federal Reserve refers to the CAE method for the PSAF as the bank holding company model.

2. See Gilbert, Wheelock, and Wilson (2002) for a study on the Federal Reserve System's efficiency in payments services.

3. The second criterion does not bear directly on the cost of capital but is germane to other aspects of the PSAF.

4. EBIT is defined as earnings before interest and tax payments.

5. The Board of Governors of the Federal Reserve System is our source for this figure.

6. The Miller-Modigliani theorem of financial economics states that, as a benchmark case, a firm's total cost of capital should be independent of its debt-to-equity ratio. In a theoretical benchmark case, all capital structures are optimal. Departures from the benchmark case, such as disparate tax treatment of interest income, dividend income, and capital gains, typically imply the existence of a particular debt-to-equity ratio that minimizes the total cost of capital.

7. Note that an alternative measure of the average after-tax ROE for the BHC peer group in a given year is simply the average of the individual BHC's after-tax ROE. This measure could be seen as more appropriate for our purposes because it is based on just two accounting items, that is, the ratio of reported after-tax net income to average shareholder equity. Because fewer accounting items are used in this measure, it should be less susceptible to measurement errors due to differences between accounting variables and economic concepts. However, this approach is currently not used in the PSAF calculations.

8. Note that the annual after-tax ROE estimates reported in the third column of Table 2 do not exactly average to the reported after-tax CAE estimates in the fourth column because of minor differences in the tax rates used in the calculations.

9. A more detailed discussion of the use of IBES forecasts in this study can be found in the appendix.

10. Note that this sample is larger than the sample used in the CAE approach before PSAF year 1991.

11. Analysts' earnings forecasts for a firm are included in the IBES database when they meet two criteria. First, at least one analyst must produce forecasts on the firm; second, sufficient ancillary data, such as actual dividends, must be publicly available.

12. We examine the impact of weighting methods on the estimated cost of equity capital in Section 5.1.

13. In Section 5.2, we examine how the sample period affects the CAPM estimates of equity capital costs.

14. We thank Eli Brewer for sharing his database of publicly traded BHC mergers in the 1990s.

15. In Section 5.1, we examine the empirical impacts of weighting methods on the CAPM estimates of equity capital costs.

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