Before the
New York State Public Service Commission

In the Matter of

Consolidated Edison Company of New York, Inc.

Case 25-S-0741

March 2026

Prepared Exhibits of:

New York City ROE Panel

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On Behalf of:

The City of New York

Exhibit__ (NYCRP-1)

Appendix A: Rate of Return Component Definitions

Cost of Equity (COE): My COE recommendation is my opinion of the return investors require to provide equity capital to Con Edison based on current capital markets. Since investors must pay the market price of a stock to make an investment, investors' required returns are based on the return they expect to receive on the market price of stocks. In other words, Con Edison's COE is forward-looking and "market-based." My recommendation is consistent with the following legal standards set by the United States Supreme Court for a fair rate of return:

> The return to the equity owner should be commensurate with returns on investments in other enterprises having corresponding risks.[1]

And:

> [S]ufficient to . . . support its credit and . . . raise the money necessary for the proper discharge of its public duties.[2]

Cost of Debt: My cost of debt recommendation is based on the actual cost of debt paid by the utility to its sources of credit. For example, if a utility has issued a bond with a 3% interest rate three years ago, its authorized cost of debt should be 3%, even if interest rates are currently higher or lower than 3%.

Capital Structure: Capital structure is the percentage of equity and debt that makes up the finances of a utility. For example, if a utility raises $1 million of equity capital and $1 million of debt capital, I would say it has a capital structure containing 50% equity and 50% debt. My capital structure recommendation is based on my review of Con Edison's justification for its requested regulatory capital structure, the capital structure

[1] *Fed. Power Comm'n v. Hope Nat. Gas Co.*, 320 U.S. 591, 603 (1944).
[2] *Bluefield Water Works & Improvement Co. v. Pub. Serv. Comm'n of the State of W. Va.* 262 U.S. 679, 692-693 (1923).

ratios of other electric and gas utility companies, and the capital structure of Con Edison's parent, Consolidated Edison, Inc. As discussed below, the reported capital structure of a regulated subsidiary is often not representative of how the regulated utility was financed. For example, the parent of a regulated utility can report funds raised through debt financing at the holding company level as equity financing on the books of its regulated utility subsidiary. Therefore, it is important to make sure Con Edison's requested capital structure would not overcharge consumers by including a higher common equity ratio than is appropriate.[3]

Cost of Equity vs. Authorized ROE: The COE is the market-based return investors expect to earn on the market value of any given stock. In other words, the COE is the return investors expect to earn on the market price of equity. As it applies to this proceeding, it is the return on proxies for what investors would require to provide equity capital to Con Edison. The appropriate authorized ROE is based on the Commission's determination of the COE at the time of the proceeding, after reviewing the evidentiary record, which incorporates investor expectations. Once the Commission issues an authorized ROE, the market-based cost of equity will continue to fluctuate as capital markets inevitably continue to change. The authorized ROE is based on a snapshot of the COE, which is constantly changing.

Con Edison's authorized ROE should not be set based on authorized ROEs in other proceedings. Authorized ROEs set in past proceedings are not the right benchmark for Con Edison's cost of equity. They are accounting returns applied to book value, not measures of the return investors currently require on the market value of equity. A real estate analogy

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3 A higher common equity ratio, all else equal, results in higher rates for consumers because equity is more expensive than debt.

makes the point (Note: I discuss this same analogy in Appendix B regarding market-to-book ratios): if an investor buys a property for $100,000 and earns $6,000 per year in rent, that's a 6% return on book. If the property's market value later rises to $200,000 with rent unchanged, the return on market value falls to about 3.0%. Rent does not automatically rise to preserve a 6% book return; it is set by the market. The same is true for utility stocks. With market-to-book ratios well above 1.0 today, the market-based cost of equity is necessarily lower than authorized book returns.

In his 1970 book *The Economics of Regulation: Principles and Institutions*, regulatory economist Alfred Kahn wrote on why the cost of equity is lower than authorized returns when market-to-book ratios are significantly above one, saying:

> [T]he sharp appreciation in the prices of public utility stocks, to one and half and then two times their book value during this period, reflected ... a growing recognition that the companies in question were in fact being permitted to earn considerably more than their cost of capital. ... The source of the discrepancy between market and book value has been that commissions have been allowing r's [returns on equity] in excess of k [market cost of equity]; if instead they had set r equal to k, or proceeded at some point to do so ... the discrepancy between market and book value ... would have disappeared, or would never have arisen.[4]

Consistency with Regulatory Principles: Regarding claims that an ROE below recent authorizations is inconsistent with regulatory principles and risks impairing access to capital, I address this issue in virtually every case, and I anticipate Mr. Nowak will make the same argument in his rebuttal testimony here. The flaw is equating my recommendations with regulatory precedent rather than investor requirements. *Hope* and *Bluefield* require that the return be "commensurate with returns on investments in other

[4] Alfred Kahn, *The Economics of Regulation: Principles and Institutions*, Mass. Inst. Tech. at 48 (fn. 69), 50 (1970).

enterprises having corresponding risks"—that is, consistent with market-based investor expectations today. They do not require regulators to match or exceed prior authorizations in other states.

Authorized ROEs are backward-looking and become embedded in rates until the next case; they do not adjust dynamically with market conditions. Basing current decisions on averages of past authorizations creates a circular process that can drift out of alignment with actual investor expectations. By contrast, my recommendations are grounded in current capital market data—interest rates, inflation expectations, equity risk premiums, and forward-looking betas. That is the proper way to satisfy *Hope* and *Bluefield*.

Appropriate Rate of Return: The appropriate Rate of Return (ROR) is based upon the weighted overall cost of capital (WACC) of the current costs of debt and equity at the time of this proceeding. The weighted cost rate is calculated by multiplying the capital structure ratios of the sources of capital (debt, preferred equity, and common equity) times their respective cost rates.[5]

[5] WACC = Cost of Debt X Debt Ratio + COE X Common Equity Ratio + Cost of Preferred Equity X Preferred Equity Ratio.

Appendix B: Market-to-Book Ratios and the Market-Based COE

The Relationship Between Market Returns and Book Returns: A market-to-book ratio significantly above one indicates that the cost of equity for electric and gas utility companies is lower than the expected return on book equity. Calculating the cost of equity (investors' equity return expectations) is more complicated than calculating the return on a rental property, but the same concept applies regarding the relationship between market returns and book returns (as I also explain in Appendix A regarding authorized ROEs).

If an investor purchases an apartment for $100,000 and expects to receive $500 per month ($500 × 12 = $6,000 per year) in rent, they will expect an annual return of 6% ($6,000 / $100,000) on their investment. When the investor purchases the apartment, they would record the book value as $100,000 and the market value as $100,000, unless they determined that the purchase price was higher or lower than the market value. If the value of the apartment increases to $200,000, for example, the market-to-book ratio would increase to 2.0, and therefore, their return on book value would remain at about 6% while their return on the market value of the apartment would decrease to about 3.0%.

In this rental property example, an increasing market value results in a lower expected return on market (3.0%) compared to the expected return on book (6%) if the rent price remains constant. Rent prices do not increase to maintain an expected 6% return on book value; they are set by what the rental market reasonably can bear.

The same is true of utility stocks. An ROE is not established based on constant return on book (accounting) returns; it is set based on what investors in the market expect that market to return. In the case of a utility stock, an increasing market value results in a lower return on market for the same expected return on book. As this rental property example demonstrates, there is nothing inconsistent about investors expecting a lower return on the market price of an investment than on the book value of an investment. In fact, with market-to-book ratios of electric and gas utility companies significantly above one, it would be surprising if investors expected a return on market equal, or anywhere close, to the return on book.

Appendix C: Future-Oriented "B X R" Method

The "br" Approach to the Constant Growth DCF Model: There are claims alleging that the "br" approach to the constant growth DCF model is flawed because it relies on the value of the future expected return on book equity "r" to estimate what the earned return on equity should be. One common criticism is that it is not reasonable for the DCF to indicate a COE (market return) that is different (lower or higher) than the expected return on book equity (accounting). There are multiple reasons why this concern is unfounded:

1. The constant growth form of the equation using "br" is:

   $$k= D/P + (br + sv)$$

   In this equation, "k" is the variable for the COE, and "r" is the future expected return on equity. The COE, "k," is not the same variable as the future expected earned return on equity, "r." In fact, there often is a large difference between the two.

2. The correct value to use for "r" is the return on book equity expected by investors as of the time the stock price and dividend data are used to quantify the D/P term in the equation. Therefore, even if future events occur that may change what investors expect for "r," the computation of the COE "k" remains correct as of the time the computation was made.

3. The ability of a commission's ROE decision to influence future cash flow expectations is not unique to the retention growth DCF approach. The five-year analysts' earnings per share growth rate is a computation that is directly influenced by what earnings per share will be in 5 years. Allowed ROEs

impact earning – higher allowed returns lead to higher earnings growth because with higher allowed returns, more earnings are available for reinvestment.

Sustainable Growth vs. Short-Term Earnings Changes: While changes in the actual earned returns can impact growth above and beyond whatever growth results from earnings retention, large short-term changes in earnings per share caused by a perceived change in the future expected earned returns are unsustainable. The new perceived earned return on book equity should be part of the computation, but the one-time growth spurt to get there is no more indicative of the sustainable growth required in the constant growth DCF formula than the temporary negative growth that occurs when a company has a bad year.

A future-oriented "b x r" method is superior to a five-year earnings per share growth rate forecast in providing a long-term sustainable growth rate. The primary cause of sustainable earnings growth is the retention of earnings. A company is able to create higher future earnings by retaining a portion of the prior year's earnings in the business and purchasing new business assets with those retained earnings. There are many factors that can cause short-term swings in earnings growth rates, but the long-term sustainable growth is caused by retaining earnings and reinvesting those earnings. Factors that cause short-term swings include anything that causes a company to earn a return on book equity at a rate different from the long-term sustainable rate. Assume, for example, that a particular utility company is regulated so that it is provided with a reasonable opportunity to earn 9% on its equity. Should the company experience an event such as the loss of several key customers, or unfavorable weather conditions, which cause it to earn only 6% on equity in a given year, the drop from a 9% earned return on equity to a 6% earned return on equity would be concurrent with a very large drop in earnings per share. In fact, if a company did not issue any new shares of stock during the year, a drop from a 9% earned return on book equity to a 6% earned return on book equity would result in a 33.3% decline in earnings per share over the period.[6] However, such a drop in earnings would not be an indication of what is a long-term sustainable earnings per share growth rate. If the drop were caused by weather conditions, the drop in earnings would be immediately offset once normal weather conditions return. If the drop were from the loss of some key customers, the company would replace the lost earnings by filing for a rate increase to bring revenues up to the level required for the company to be given a reasonable opportunity to recover its cost of equity.

For the reasons above, changes in earnings per share growth rates that are caused by non-recurring changes in the earned return on book equity are inconsistent with long-term sustainable growth, but changes in earnings per share because of the reinvestment of additional assets are a cause of sustainable earnings growth. The "b x r" term in the DCF equation computes sustainable growth because it measures only the growth which a company can expect to achieve when its earned return on book equity "r" remains in equilibrium. If analysts have sufficient data to be able to forecast varying values of "r" in future years, then a complex, or multi-stage DCF method must be used to accurately quantify the effect. Averaging growth rates over sub-periods, such as averaging growth over the first five years with a growth rate expected over the subsequent period, will not

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[6] By definition, earned return on equity is earnings divided by book value. Therefore, whatever level of earnings is required to produce earnings of 6% of book would have to be 33.3% lower than the level of earnings required to produce a return on book equity of 9%.

provide an appropriate representation of the cash flows expected by investors in the future and, therefore, will not provide an acceptable method of quantifying the cost of equity using the DCF method. The choices are either a constant growth DCF, in which one growth rate derived using "b x r" should be used, or a complex DCF method in which the cash flow anticipated in each future year is separately estimated. Mr. Nowak has done neither. Instead, he mechanically adds analysts' five-year earnings per share growth rate to the dividend yield.

Flaws in Using Analysts' Five-Year EPS Growth Rates: Analysts' five-year earnings per share growth rates are earnings per share growth rates that measure earnings growth from the most currently completed fiscal year to projected earnings five years into the future. These growth rates are not indicative of future sustainable growth rates in part because the sources of cash flow to an investor are dividends and stock price appreciation. While both stock price and dividends are impacted in the long run by the level of earnings a company is capable of achieving, earnings growth over a period as short as five years is rarely in synchronization with the cash flow growth from increases in dividends and stock prices. For example, if a company experiences a year in which investors perceive that earnings temporarily dipped below normal trend levels, stock prices generally do not decline at the same percentage that earnings decline, and dividends are usually not cut just because of a temporary decline in a company's earnings. Unless both the stock price and dividends mirror every downswing in earnings, they cannot be expected to recover at the same growth rate that earnings recover. Therefore, growth rates such as five-year projected growth in earnings per share are not indicative of long-term sustainable growth rates in cash flow. As a result, they are not applicable for direct use in the simplified DCF method.

The use of five-year earnings per share growth rates directly in the DCF model is also improper. A raw, unadjusted, five-year earnings per share growth rate is usually a poor proxy for either short-term or long-term cash flow growth that an investor expects to receive. When implementing the DCF method, the time value of money is considered by equating the current stock price of a company to the present value of the future cash flows that an investor expects to receive over the entire time that they owns the stock. The discount rate required to make the future cash flow stream, on a net present value basis, equal to the current stock price is the cost of equity. The only two sources of cash flow to an investor are dividends and the net proceeds from the sale of stock at whatever time in the future the investor finally sells. Therefore, the DCF method is discounting future cash flows that investors expect to receive from dividends and from the eventual sale of the stock. Five-year earnings growth rate forecasts are especially poor indicators of cash flow growth, even over the five years being measured by the five-year earnings per share growth rate number.

Furthermore, a five-year earnings per share growth rate is a poor indicator of five-year cash dividend growth expectations. The board of directors of a company changes dividend rates based upon long-term earnings expectations combined with the capital needs of a company. Most companies do not decrease dividends simply because a company has a year in which earnings were below sustainable trends, and similarly they do not increase dividends simply because earnings for one year happened to be above long-term sustainable trends. Therefore, over any given five-year period, earnings growth is frequently very different from dividend growth. In order for earnings growth to equal dividend growth, at a minimum, earnings per share in the first year of the five-year earnings growth rate period would have to be exactly on the long-term earnings trend line expected by investors. Since earnings in most years are above or below the trend line, the earnings per share growth rate over most five-year periods is different from what is expected for dividend growth.

A five-year earnings per share growth rate is also a poor indication of future stock price growth. If a company happens to experience a year in which earnings decline below what investors believe is consistent with the long-term trend, then the stock price does not drop anywhere near as much as earnings drop. Similarly, if a company happens to experience a year in which earnings are higher than the investor-perceived long-term sustainable trend, the stock price will not increase as much as the earnings. In other words, the P/E ratio of a company will increase after a year in which investors believe earnings are below sustainable levels, and the P/E ratio will decline in a year in which investors believe earnings are higher than expected. Since stock price is one of the important cash flow sources to an investor, a five-year earnings growth rate is a poor indicator of cash flow, both because it is a poor indicator of stock price growth over the five years being examined, and because it is equally a poor predictor of dividend growth over the period.

Appropriate Use of Analysts' Consensus Growth Rates: This does not mean that analysts' consensus earnings per share growth rates are useless as an aid to projecting the future. Analysts' EPS growth rates are, however, very dangerous if used in a simplified DCF without proper interpretation. While they are not useful if used in their "raw" form, they can be very useful in computing estimates of what earned return on equity investors expect will be sustained in the future, and as such, are useful in developing long-term sustainable growth rates. This is exactly what I do in the application of my Constant Growth DCF Analysis.

Appendix D. Non-Constant Growth Form of the DCF Model

Annual vs. Quarterly Cash Flow Modeling: My non-constant growth DCF model uses annual expected cash flows. Although dividends are paid quarterly, I used the annual model because it is easier for observers to visualize what is happening. Modeling cash flows to be annual rather than when they are actually expected to occur causes a small overstatement of the COE.

The process of changing from an annual model to a quarterly model would require two changes. A quarterly model would show dividends being paid sooner and would also show earnings being available sooner. A company that receives its earnings sooner, rather than at the end of the year, has the opportunity to compound them. Since revenues, and therefore earnings, are essentially received every day, a company that is supposed to earn an annual rate of 9.00% on equity would have to earn only 8.62% if the return were compounded daily.[7] This reduction from 9.00% to 8.62% would then be partially offset by the impact of the quarterly dividend payment to bring the result of switching from the simplifying annual model closer to, but still a bit below, 9.00%.

The Role of Earnings and Retention Rates: By using cash flow expectations as the valuation parameter, the non-constant DCF model still relies on earnings. It relies on an expectation of future cash flows. Future cash flows come from dividends during the time the stock is owned and capital gains from the sale of the stock once it is sold. Since earnings impact both dividends and stock price, the non-constant DCF model still relies on earnings.

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[7] (1+.0862/365)^365=1.09=9.00%.

Every dollar of earnings is used for the benefit of stockholders, either in the form of a dividend payment, or earnings reinvested for future growth in earnings and/or dividends. Earnings paid out as a dividend have a different value to investors than earnings retained in the business. Recognizing this difference and properly considering it in the quantification process is a major strength of the DCF model and is why the non-constant DCF model I have set forth is an improvement over either the price-to-earnings ratio (P/E ratio) or dividend/price (D/P) methods. Comparing the P/E ratios and the dividend yield (D/P) are helpful as a rule of thumb, but they must be used with caution because, among other reasons, two companies with the same dividend yield can have a different COE if they have different retention rates. A DCF model is more reliable than these rules of thumb because it can account for different retention rates, among other factors.

Valuation of Retained Earnings vs. Dividends: There is a difference to investors in the value of earnings paid out as a dividend compared to the value of earnings retained in the business because the return on earnings retained in the business depends upon the opportunities available to that company. If a regulated utility reinvests earnings in needed "used and useful" utility assets, then those reinvested earnings have the potential to earn at whatever rate of return is consistent with ratemaking procedures allowed and the skill of management in prudently operating the system.

When an investor receives a dividend, he can either reinvest it in the same or another company or use it for other things, such as paying down debt or paying living expenses. Although an investor could theoretically use the proceeds from any dividend payments to simply buy more stock in the same company, when an investor increases his investment in a company by purchasing more stock, the transaction occurs at market price.

However, when the same investor sees his investment in a company increase because earnings are retained rather than paid as a dividend, the reinvestment occurs at book value. Stated within the context of the DCF terminology: earnings retained in the business earn at the future expected return on book equity "r," and dividends used to purchase new stock earn at the rate "k." When the market price exceeds book value (that is, the market-to-book ratio exceeds 1.0), retained earnings are worth more than earnings paid out as a dividend because "r" will be higher than "k." Conversely, when the market price is below book value, "k" will be higher than "r," meaning that earnings paid out as a dividend earn a higher rate than retained earnings.

Even if retained earnings are more valuable when the market-to-book ratio is above 1.0, a company might still choose to pay a dividend. Retained earnings are more valuable than dividends only if there are sufficient opportunities to profitably reinvest those earnings. Regulated utility companies are allowed to earn the cost of capital only on assets that are used and useful in providing utility service. Investing in assets that are not needed may not produce any return at all. For unregulated companies, opportunities to reinvest funds are limited by the demands of the business. For example, how many new computer chips can Intel profitably develop at the same time?

Flexibility of the Non-Constant DCF Model: Under the non-constant DCF model, it is not necessary for earnings and dividends to grow at a constant rate for the model to be able to accurately determine the cost of equity. Because the non-constant form of the DCF model separately discounts each and every future expected cash flow, it does *not* rely on any assumptions of constant growth. The dividend yield can be different from period to period, and growth can bounce around in any imaginable pattern without harming the accuracy of the answer obtained from quantifying those expectations. When the non-constant DCF model is correctly used, the answer obtained is as accurate as the estimates of future cash flow.

Appendix E. Capital Asset Pricing Model

Risk Free Rate: When looking for a security to calculate an estimate of the risk-free rate, it could be argued that it is appropriate to find one with a term or maturity that best matches the life of the asset being financed. In that sense, the 30-year Treasury bond yield can be argued to be ideal for this specific application. However, it is equally important to find a security that has a beta coefficient with the overall market as close to zero as possible, because by the very definition of the risk-free rate in the CAPM model, its movements should have no correlation to the movements of the market. And this is where the problem with the 30-year Treasury bond yield arises, as it has an established non-zero beta. The 3-month Treasury bill yield has a considerably lower beta, and therefore is superior in that respect to the 30-year Treasury bond yield. Neither one is a perfect fit on both fronts, which is why I have chosen to consider both as proxies for the risk-free rate to establish a range for my CAPM results.

It is important to recognize that current long-term Treasury bond yields represent a direct observation of investor expectations and there is no need to use “expert” forecasts such as Blue Chip to determine the appropriate risk-free rate to use in a CAPM analysis or any other cost of equity calculations.

Many economists and forecasters will continue to be quoted in the press prognosticating on possible developments that are truly unpredictable. The Nobel Laureate Economist Daniel Kahneman stated the following regarding forecasting:

> It is wise to take admissions of uncertainty seriously, but declarations of high confidence mainly tell you that an individual

> has constructed a coherent story in his mind, not necessarily that the story is true.[8]

Historical Beta: I calculate historical betas following the methodology used by Value Line, with some modifications. Specifically, Value Line adheres to the following guidelines:

1. Returns for each security are regressed against returns for the overall market in the following form:

   $$\ln (p^{I}_{t} / p^{I}_{t-1}) = a_{I} + B_{I} * \ln (p^{m}_{t} / p^{m}_{t-1})$$

   Where:

   - p^{I}_{t} is the price of the security I at time t
   - p^{I}_{t-1} is the price of the security I one week before time t
   - p^{m}_{t} and p^{m}_{t-1} are the corresponding values of the market index
   - B_I is the regression estimate of Beta for the security against the market index

2. The natural log of the price ratio is used as an approximation of each return and no adjustment is made for dividends paid during the week.

3. Weekly returns are calculated on one day of the week, with a stated preference for Tuesdays to minimize the effect of holidays as much as possible.

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8 DANIEL KAHNEMAN, *Thinking Fast and Slow*, p. 212(New York: Farrar, Straus, and Giroux, 2011).

4. Betas calculated using the regression method above are adjusted as per Blume (1971).[9] using the following formula:[10]

$$\text{Adjusted } B_I = 0.35 + 0.67 * \text{Calculated } B_I$$

There are four differences between my historical beta calculations and Value Line's calculations:

5. The first significant difference is that whereas Value Line uses the New York Stock Exchange Composite Index as the market index, I use the S&P 500 Index.

6. Another important difference is that whereas Value Line calculates weekly returns on one day of the week, with a stated preference for Tuesdays, I calculate weekly returns on all days of the week.

7. Value Line only calculates betas every 3 months in their quarterly company reports, whereas I use the same consistent methodology to calculate betas every week during the most recent 3 complete months (December 2025 through February 2026).

8. Value Line always uses a 5-year period for the return regression,[11] whereas I calculate historical betas for periods of 6 months, 2 years, and 5 years.

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[9] M. Blume, On the Assessment of Risk, *The Journal of Finance*, Vol. XXVI (March 1971) at www.stat.ucla.edu/~nchristo/Fiatlux/blume2.pdf.

[10] Michelfelder and Theodossiou (2013) have discredited the Blume adjustment for regulated public utility stocks, but Gombola and Kahl (1990) found that, while their betas do not approach unity, they are nonstationary. My use of the Blume adjustment, then, is "conservative", from the perspective of the City.

Michelfelder, R.A. & Theodossiou, P. (2013). Public utility beta adjustment and biased costs of capital in public utility rate proceedings, *Electricity Journal* 26(9), 60 68. https://doi.org/10.1016/j.tej.2013.09.017

Gombola, M. & Kahl, D. (1990). Time-series processes for utility betas: implications for forecasting systematic risk, *Financial Management* 19(3), 84–93. https://www.jstor.org/stable/3665827

[11] They offer betas calculated over different time periods on their website, including 3 years and 10 years.

In the following pages, I explain my rationale for making the four modifications above to Value Line's beta calculation methodology.

Choice of Market Index (S&P 500 vs. NYSE): A critical factor in the calculation of a beta coefficient is the choice of index to represent the overall market. Using exactly the same beta calculation methodology with a different market index will result in different values of beta for a given company or portfolio ¬– sometimes drastically different values. It is easy to jump to the conclusion that this points to a flaw in CAPM theory, as different values of beta would result in a different implied cost of equity. However, another key component of the CAPM, the market risk premium, also depends on the choice of the market index, which in theory would have an offsetting effect on the cost of equity calculation. This points to the most important aspect of selecting a market index for a CAPM analysis, which is to be consistent and use the same index for the calculation of beta as for the calculation of the market risk premium. This is a fundamental concept of the CAPM, and using betas based on one index with a market risk premium based on a different index yields invalid results.

As stated above, Value Line calculates its published betas based on the NYSE Composite Index. Most methodologies used to calculate the market risk premium, including those I rely on, are based on the S&P 500 Index, so using them in the CAPM together with Value Line betas exactly as published would yield invalid results.

For this reason, I calculate my historical betas versus the S&P 500 Index, making my CAPM approach entirely consistent.

As an aside related to my option-implied betas, using the S&P 500 Index consistently throughout my CAPM has the added benefit that this index has a much larger number of options traded, which makes the calculation of option-implied betas more reliable.

Daily vs. Single-Day Weekly Return Calculations: Using one day of the week to calculate weekly returns for use in the regression analysis used to calculate historical betas has the unintended effect of generating different values of betas depending on the day of the week that is used. To clarify, if one were to use Value Line's precise methodology for calculating a 5-year historical beta for a given company using weekly returns calculated on Tuesdays, the resulting beta value would be different than the resulting value if one were to use the same exact methodology, but using weekly returns calculated on Wednesdays, or any other day of the week. Even though 5-year historical betas should in theory be quite stable and should not change very much from one day to the next, calculating returns on only one day of the week results in differences that can be significant and make no sense conceptually.

It is easy to understand why it happens. Even though there is some correlation due to some overlap, the set of weekly returns calculated on Mondays is a completely different set of numbers than the set of weekly returns calculated on Tuesdays. As a result, there are five 5-year betas that can result from Value Line's methodology, and even though the Monday beta for a given company will change slowly from week to week, the change between the Monday beta and the Tuesday beta, calculated just one trading day apart, can be quite significant.

Since I became aware of this undesirable effect, I began calculating my historical betas based on an all-encompassing set of weekly returns calculated on every trading day in the beta calculation period. This methodology has the effect of averaging out the five possible betas that could result from using only one day of the week for the return calculations,[12] as Value Line does. In this way, a 5-year beta calculated on any two consecutive trading days would only change minimally, as it should.

Using a daily calculation of weekly returns could be criticized for the resulting overlap in a weekly return from Monday to Monday with that from Tuesday to Tuesday. However, given that the overlap is consistent and equal for the net effect of every trading day, no trading day is given undue weight in the regression. Even though the effect of each trading day appears 5 times in the weekly return data, there are also 5 times the total number of weekly returns in the overall set used in the regression, so any individual trading day has the same relative weight than in Value Line's methodology. The fact that the resulting beta value of this aggregate approach turns out to be a sort of average of the five possible values that would result from Value Line's methodology on different days of the week is the final confirmation that this is the superior approach for calculating a historical beta based on weekly returns.

Using a daily calculation of weekly returns has the added benefit of providing more data pairs to be used in historical beta calculations for shorter periods, such as for 6-month historical betas, where instead of 25 return pairs, the regression is performed on 117 return pairs.

Benefits of Independent Calculations & Statistical Significance: Doing my own historical beta calculations using Value Line's established methodology allows me to see how beta values change from week to week and to use the most up-to-date beta calculations

12 The resulting beta is not a direct arithmetic or geometric average of the other five betas, but rather a regression based on the union of all five possible sets of weekly returns.

instead of relying on stale beta values that can be more than 3 months old, inappropriate for the up-to-date snapshot of the market that I am taking.

Regarding the number of data point pairs necessary to estimate the relationship between two variables in a regression analysis, establishing a minimum number is somewhat subjective, though various authorities on statistics argue the number is between 3 and 8 data pairs. While one can broadly correctly generalize that the more data point pairs one uses, the more certain one can be about the significance of the results of any correlation analysis, this is very different from stating that one cannot achieve statistical significance with a relatively low number of data pairs. In fact, it is important to realize that one can achieve statistical significance with fewer than 10 data pairs, and that even hundreds of data pairs do not guarantee statistical significance. For precisely this reason, statisticians have developed a tool that helps determine statistical significance based on the number of data pairs in a regression analysis.

A "table of critical values" of Pearson's correlation, which can be readily found online[13] or in most statistics books, tells a statistician that for 25 data point pairs (implying N-2=23 "degrees of freedom"), a correlation, or beta, coefficient of 0.505 or higher will occur *by chance* with a probability of only 0.01.[14] As explained in more detail in the text regarding how to use the table of critical values,[15] any beta coefficient above this level, and certainly above the 0.353 3-month average for the recent 6-month betas for my RFC

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13 University of Connecticut, *r Critical Value Table*, available at: https://researchbasics.education.uconn.edu/r_critical_value_table/#

14 In fact, many researchers use a more lenient "alpha level" of 0.05 for determinations of statistical significance.

15 University of Connecticut, *Statistical Significance: Is there a relationship (difference) or isn't there a relationship (difference)?* at https://researchbasics.education.uconn.edu/statistical_significance

Proxy Group, by definition are considered statistically significant. The threshold for statistical significance for 117 data point pairs (implying 115 "degrees of freedom"), is so low that it is not even included in the table of critical values. The maximum "degrees of freedom" listed is 100, with an already very low threshold of 0.254.

Historical Blended Beta: I am not aware of any academic study specifically focused on the optimal relative weight of historical betas to predict future betas. However, the authors of the paper I relied upon for guidance on the calculation of my option-implied betas did attempt to quantify the predictive power of 6-month option-implied ("forward-looking") betas as well as that of 6-month ("180-day"), 1-year, and 5-year historical betas by back-testing historical predictions with actual *expost* results, or "realized" betas, for the 30 companies in the Dow Jones Index. In addition to using each of the betas above independently, they also measured the predictive power of a "mixed" beta consisting of a simple average of the six-month option-implied beta and the 6-month historical beta.

Their conclusions for predicting 6-month future betas are as follows:

> The forward-looking beta outperforms the other methods ten times, and the same is true for the 180-day historical beta. The mixed beta is the best performer in seven cases, and the 1-year historical beta in three cases. The 5-year historical beta is always outperformed by at least one other method, and it often ranks last. The 180-day historical beta clearly dominates the two other historical methods.[16]

Their conclusions for predicting 1-year and 2-year future betas are as follows:

> Somewhat unexpectedly, the performance of the forward-looking beta compared to that of the 180-day historical beta is much better [for the one-year prediction] than [for the six-month prediction], and this conclusion carries over to [the two-year prediction]. The mixed beta also perform [sic] well. It is perhaps not surprising that the performance of the 180-day historical beta [for the one- and two-year predictions] is poorer than [for the six-month prediction],

[16] Peter Christoffersen, Kris Jacobs, & Gregory Vainberg, *Forward-Looking Betas*, p. 16 (April 25, 2008) at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=891467.

> because the horizons used in the construction of realized betas are no longer equal to 180 days. What is harder to explain is why the correlation between realized beta and forward-looking beta is in many cases higher [for the one- and two-year predictions] than [for the six-month prediction]. Finally, it is also interesting that the 1-year and 5-year historical betas do not perform well [for the one-and two-year predictions]. In summary, [for the one-year prediction] either the forward-looking beta or the mixed beta is the best performer in nineteen out of thirty cases. [For the two-year prediction], this the case twenty-two times out of thirty.[17]

Their conclusions strongly support the use of 6-month historical betas, 6-month option-implied betas, and/or an average of the two as predictors of future betas 6 months, 1 year, or 2 years into the future. Therefore, considering a historical blended beta in conjunction with option-implied betas to calculate the cost of equity is consistent with research findings that coming historical and option-implied betas is the best predictor of future betas.

We decided on the composition of my historical blended betas primarily based on the conclusions of the authors above. Though the predictive power of longer-term historical betas seems to be quite reduced, it is not zero, so in an effort to preserve the effect of longer-term market trends in my historical blended betas, I chose to incorporate 5-year historical betas.

Market Risk Premium: I used a cumulative probability of 50.0% in the calculation of my option-implied growth for the S&P 500, which results in a value of 7.82% as of February 28, 2026 and a value of 7.65% for the weighted average of the 3 months ending on that date. As stated above, a cumulative probability of 50% represents the median of the probability distribution, or in this case the option-implied market consensus, which is why I have chosen to use this level.

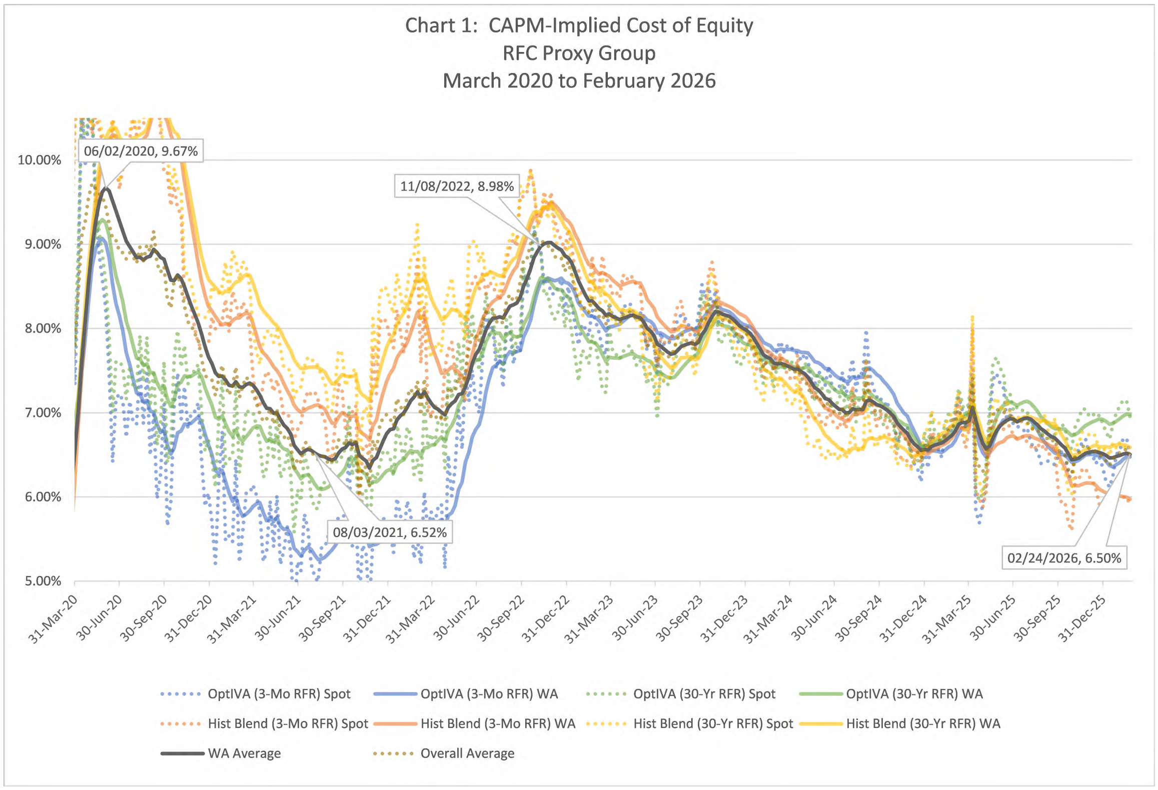
[17] *Id. at 17.*

The cumulative probabilities referred to in this case are directly comparable to the cumulative probabilities I have used or referred to in his prior filed testimonies. In late 2020, after significant efforts related to the complexities in processing extremely large volumes of option data, I was finally able to use option-implied volatility and option-implied skewness to come up with a log-normal distribution that approximates the probability distribution of the possible trajectories for the S&P 500 implied by the options market as of any given day, as explained above. All of the testimonies I have filed since then, starting in 2021, have used this complete and superior approach along with a cumulative probability of 50%, representing the median of the probability distribution, or the option-implied market consensus, to estimate expected market growth. Any references to cumulative probability in these testimonies are directly comparable.

Prior to incorporating skewness into the approximation, I used a normal function to estimate the same probability distribution referred to above. Using a normal distribution as an approximation is a simplification used commonly in economics, including in the Black-Scholes formula for a single option. However, unlike a skewed log-normal distribution, a normal distribution has the same median and mean, meaning that when applied in this case, the option-implied market consensus of this simplified approximation implies market growth of 0%. As a result, before using log-normal distributions, I had to resort to finding an adequate level of cumulative probability above 50% to estimate market growth, which is admittedly somewhat subjective. To be conservative, I often used a cumulative probability of 68.3%, which is the probability found within one standard deviation of the mean of a normal distribution, which I understood would lead to a conservatively high estimate for market growth.

It is important to point out that the cumulative probabilities of the simplified normal distribution approximation I used in cases before 2021 cannot be directly compared to the cumulative probabilities of the superior log-normal distribution approximation, which takes skewness into account. The considerably improved approximation based on a log-normal distribution eliminates all subjectivity in arriving at the implied market consensus and allows a much better measure of implied cumulative probabilities of deviations from that market consensus.

APPENDIX A. CAPM-IMPLIED COST OF EQUITY FOR RFC PROXY GROUP OVER TIME SINCE ONSET OF COVID PANDEMIC



Notes regarding the content of this chart:

- *The information in this chart is the property of Rothschild Financial Consulting ("RFC") and may not be used for any purpose without the express written consent of RFC. Even when the underlying data are publicly available from another source, the results of analyses performed by RFC and the way of presenting the data are and remain the property of RFC.*

- *The data presented herein may not agree 100% with past recommendations by RFC for numerous reasons, including differences in the underlying proxy group and the fact that this chart represents only results based on the CAPM, whereas RFC usually bases recommendations on the CAPM and other models, such as various forms of the DCF.*

Appendix G: Resume of Aaron L. Rothschild

SUMMARY

Financial professional providing U.S. public utility commissions financial tools and expert testimony to assist in rate setting for regulated utility companies (e.g., regulated electric distribution providers, natural gas pipelines). Relevant experience includes developing and applying methodologies that directly measure investors' equity return expectations based on stock option prices, applied mathematics research for utility industry as an affiliate of the New England Complex Systems Institute, and serving as Head of Business Analysis for a major U.S. telecom firm in Asia Pacific.

EXPERIENCE

Rothschild Financial Consulting, Ridgefield, CT **November 2001- present**
Independent consulting firm specializing in utility sector
President

- Provide financial expert testimony (e.g., rate of return and M&A) to regulators, policy makers, foundations, and consumer groups in utility rate case proceedings, including representing the California Public Advocates Office and the Wild Tree Foundation in the ongoing California water and energy cost of capital proceedings
- Developed cost of equity models that have been adopted by the Public Service Commission of South Carolina in 2020 (decision upheld by the South Carolina Supreme Court in September 2021) and the Connecticut Public Utilities Regulatory Authority in September 2021
- Developing market-based cost of equity methodology in ongoing regulated natural gas pipeline case before the Federal Energy Regulatory Commission (FERC), including proposing replacing equity analyst earnings per-share forecasts (IBES, Value Line) with options-implied growth expectations to determine authorized return on equity (ROE)
- Present at utility regulation conferences (NARUC/NASUCA and MARC) regarding rate of return, power purchase agreements, complex systems science, and subsidy auctions

360 Networks, Hong Kong **January 2001 - October 2001**
Pioneer of the fiber optic telecommunications industry
Senior Manager

- Business development and investment evaluation
- Negotiated landing rights and formed local partnerships in Korea, Japan, Singapore, and Hong Kong for $1 billion undersea cable project
- Structured fiber optic bandwidth swapping agreement with Enron and Global Crossing
- Established relationships with Hong Kong based Investment Bankers to communicate Asia Pacific objectives and accomplishments to Wall Street

Dantis, Chicago, IL **July 2000- December 2000**
Start-up managed data-hosting services provider
Director

- Built capital raise valuation models and negotiated with potential investors
- Team raised $100M from venture capital firm through valuation negotiations and internal strategic analysis

MFS, MCI-WorldCom, Chicago, Hong Kong, Tokyo **September 1996- July 2000**
American Telecommunications Company
Head of Business Analysis for Japan operations

- Managed staff of 5 business development analysts
- Raised $80M internally for Japanese national fiber network expansion plan by conducting an investment evaluation and presenting findings to CEO of international operations in London, UK
- Built financial model for local fiber optic investment evaluation that was used by business development offices in Oak Brook, IL and Sydney, Australia

EDUCATION

Vanderbilt University, Nashville, TN **1994-1996**
MBA, Finance

- Completed business plan for Nextlink Communications in support of their national fiber optic network expansion, including identifying opportunities from passage of Telecom Act of 1996
- Developed analytical framework to evaluate predictability of rare events
- Provided financial and accounting analysis to Chicago's consumer advocate, the Citizens Utility Board (CUB) as a summer intern

Clark University, Worchester, MA **1990 - 1994**
BA, Mathematics

Appendix H: Testifying Experience of Aaron L. Rothschild

Filed Rate of Return Testimonies:

California

- Pacific Gas and Electric Company, Application 25-03-010, Rate of Return, July 2025
- Southern California Edison, Application 25-03-011, Rate of Return, July 2025
- San Diego Gas & Electric Company, Application 25-03-012, Rate of Return, July 2025
- Southern California Gas Company Application 25-03-013, Rate of Return, July 2025
- Pacific Gas and Electric, Application 22-04-008 et al, Rate of Return/Cost of Capital Mechanism, January 2024
- Liberty Utilities, Application A.23-05-004, Rate of Return, August 2023
- San Gabriel Water Company, Application 23-05-001, Rate of Return, August 2023
- Suburban Water Company, Application 23-05-003, Rate of Return, August 2023
- Great Oaks Water Company, Application 23-05-002, Rate of Return, August 2023
- Incumbent Local Exchange Carriers (ILECs), Application 22-09-003, Rate of Return, May 2023
- Pacific Gas and Electric Company, Application 22-04-008, Rate of Return, August 2022
- Southern California Edison, Application 22-04-009, Rate of Return, August 2022
- San Diego Gas & Electric Company, Application 22-04-012, Rate of Return, August 2022
- California American Water Company, Application 21-05-001, Rate of Return, January 2022
- California Water Service Company, Application 21-05-002, Rate of Return, January 2022
- Golden State Water Company, Application 21-05-003, Rate of Return, January 2022
- San Jose Water Company, Application 21-05-004, Rate of Return, January 2022
- Southern California Edison, Application 21-08-013, Rate of Return/Cost of Capital Mechanism, January 2022
- San Diego Gas & Electric Company, Application 21-08-014, Rate of Return/Cost of Capital Mechanism, January 2022
- Pacific Gas and Electric Company, Application 21-08-015, Rate of Return/Cost of Capital Mechanism, January 2022
- Pacific Gas and Electric Company, Application 21-01-004, Securitization, February 2021
- Pacific Gas and Electric Company, Application 20-04-023, Securitization, October 2020
- Southern California Edison, Application 20-07-008, Securitization, September 2020
- San Diego Gas & Electric Company, Application 19-04-017, Rate of Return, August 2019
- Southern California Gas Company, Application 19-04-016, Rate of Return, August 2019
- Pacific Gas and Electric Company, Application 19-04-015, Rate of Return, August 2019
- Southern California Edison, Application 19-04-014, Rate of Return, August 2019
- Liberty Utilities, Application A.18-05-006, Rate of Return, August 2018
- San Gabriel Water Company, Application 18-05-005, Rate of Return, August 2018
- Suburban Water Company, Application 18-05-004, Rate of Return, August 2018
- Great Oaks Water Company, Application 18-05-001, Rate of Return, August 2018

- California Water Service Company, Application 17-04-006, Rate of Return, August 2017
- California American Water Company, Application 17-04-003, Rate of Return, August 2017
- Golden State Water Company, Application 17-04-002, Rate of Return, August 2017
- San Jose Water Company, Application 17-04-001, Rate of Return, August 2017

Colorado
- Public Service Company of Colorado, Docket No. 11AL-947E, Rate of Return, March 2012

Connecticut
- Yankee Gas Service Company, Docket No. 24-14-01, Rate of Return, March 2025
- United Illuminating Company, Docket No. 24-10-04, Rate of Return, February 2025
- Connecticut Natural Gas Corporation, Docket No. 23-11-02, Rate of Return, February 2024
- The Southern Connecticut Gas Company, Docket No. 23-11-02, Rate of Return, February 2024
- The Connecticut Water Company, Docket No. 23-08-32, Rate of Return, December 2023
- United Illuminating Company, Docket No. 22-08-08, Rate of Return, December 2022
- Aquarion Water Company of Connecticut, Docket No. 22-07-01, Rate of Return, October 2022
- Eversource and United Illuminating, Docket No. 17-12-03RE11, Rate of Return / Interim Rate Reduction, April 2021
- United Water Connecticut, Docket No. 07-05-44, Rate of Return, November 2008
- Valley Water Systems, Docket No. 06-10-07, Rate of Return, May 2007

Delaware
- Tidewater Utilities, Inc., PSC Docket No. 11-397, Rate of Return, April 2012

District of Columbia
- Washington Gas Light Company, Formal Case No. 1180, Rate of Return, January 2025
- Washington Gas Light Company, Formal Case No. 1169, Rate of Return, May 2023

Florida
- Florida Power & Light (FPL), Docket No. 070001-EI, October 2007
- Florida Power Corp., Docket No. 060001 Fuel Clause, September 2007

New Jersey
- Aqua New Jersey, Inc., BPU Docket No. WR11120859, Rate of Return, April 2012

Maryland
- Delmarva Power & Light, Case No. 9317, Rate of Return, June 2013
- Columbia Gas of Maryland, Case No. 9316, Rate of Return, May 2013
- Potomac Electric Power Company, Case No. 9286, Rate of Return, March 2012
- Delmarva Power & Light, Case No. 9285, Rate of Return, March 2012

New Hampshire
- Public Service Company Of New Hampshire., Docket No. DG 24-07,0 Rate of Return, January 2025

- Liberty Utilities (Energy North Natural Gas) Corp., Docket No. DG 23-067, Rate of Return, February 2024
- Liberty Utilities (Granite State Electric) Corp., Docket No. DE 23-039, Rate of Return, December 2023

North Dakota
- Montana-Dakota Utilities Co., Case No. PU-20-379, Rate of Return, January 2021
- Otter Tail Power Company, Case No. PU-17-398, Rate of Return, May 2018
- Montana-Dakota Utilities Co., Case No. PU-15-90, Rate of Return, August 2015
- Northern States Power, Case No. PU-400-04-578, Rate of Return, March 2005

Pennsylvania
- Aqua Pennsylvania, Inc., Docket No. R-2024-3047822, Rate of Return, August 2024
- Peoples Natural Gas Company LLC, Docket No. R-2023-304459, Rate of Return, March 2024
- UGI Utilities, Inc. – Electric Division, Docket No. R-2022-3037368, Rate of Return, April 2023
- Pennsylvania American Water Company, Docket No. R-2022-3031672 and R-2022-3031673, Rate of Return, July 2022
- UGI Utilities, Inc. – Electric Division, Docket No. R-2021-3023618, Rate of Return, May 2021
- Pennsylvania American Water Company, Docket No. P-2021-3022426, Rate of Return, February 2021
- Audubon Water Company, Docket No. R-2020-3020919, Rate of Return, November 2020
- Pennsylvania American Water Company, Docket No. R-2020-3019369 and R-2020-3019371, Rate of Return, September 2020
- Twin Lakes Utilities, Inc., Docket No. R-2019-3010958, Rate of Return, October 2019
- City of Lancaster Sewer Fund, Docket No. R-2019-3010955, Rate of Return, October 2019
- Community Utilities of Pennsylvania Inc. Wastewater Division, Docket No. R-2019-3008948, Rate of Return, July 2019
- Community Utilities of Pennsylvania Inc. Water Division, Docket No. R-2019-3008947, Rate of Return, July 2019
- Newtown Artesian Water Company, Docket No. R-20019-3006904, Rate of Return, May 2019
- Hidden Valley Utility Services, L.P. – Wastewater Division, Docket No. R-2018-3001307, Rate of Return, September 2018
- Hidden Valley Utility Services, L.P. – Water Division, Docket No. R-2018-3001306, Rate of Return, September 2018
- The York Water Company, Docket No. R-2018-3000019, Rate of Return, August 2018
- SUEZ PA Pennsylvania, Inc., Docket No. R-2018-000834, Rate of Return, July 2018
- UGI Utilities, Inc. – Electric Division, Docket No. R-2017-2640058, Rate of Return, April 2018
- Wellsboro Electric Company, Docket No. R-2016-2531551, Rate of Return, December 2016
- Citizens’ Electric Company of Lewisburg, PA, Docket No. R-2016-2531550, Rate of Return, December 2016

- Columbia Gas of Pennsylvania, Inc., Docket No. R-2016-2529660, Rate of Return, June 2016
- Columbia Gas of Pennsylvania, Inc., Docket No. R-2015-2468056, Rate of Return, June 2015
- Pike County Light & Power Company, Docket No. R-2013-2397353 (gas), Rate of Return, April 2014
- Pike County Light & Power Company, Docket No. R-2013-2397237 (electric), Rate of Return, April 2014
- Columbia Water Company, Docket No. R-2013-2360798, Rate of Return, August 2013
- Peoples TWP LLC, Docket No. R-2013-2355886, Rate of Return, July 2013
- City of Dubois – Bureau of Water, Docket No. R-2013-2350509, Rate of Return, July 2013
- City of Lancaster – Sewer Fund, Docket No. R-2012-2310366, Rate of Return, December 2012
- Wellsboro Electric Company, Docket No. R-2010-2172665, Rate of Return, September 2010
- Citizens' Electric Company of Lewisburg, PA, Docket No. R-2010-2172662, Rate of Return, September 2010
- T.W. Phillips Gas and Oil Company, Docket No. R-2010-2167797, Rate of Return, August 2010
- York Water Company, Docket No. R-2010-2157140, Rate of Return, August 2010
- Joint Application of The Peoples Natural Gas Company, Dominion Resources, Inc. and Peoples Hope Gas Company LLC, Docket No. A-2008-2063737, Financial Analysis, December 2008
- York Water Company, Docket No. R-2008-2023067, Rate of Return, August 2008

South Carolina

- Kiawah Island Utility, Inc., Docket No., Rate of Return, 2025-243-WS, December 2025
- Duke Energy Carolinas, LLC., Docket No. 2025-172-E, Rate of Return, October 2025
- Duke Energy Progress, LLC., Docket No. 2025-154-E, Rate of Return, September 2025
- Duke Energy Carolinas, LLC., Docket No. 2025-65-E, Securitization, May 2025
- Dominion Energy South Carolina, Inc., Docket No. 2024-34-E, Rate of Return, June 2024
- Duke Energy Carolinas, LLC., Docket No. 2023-388-E, Rate of Return, April 2024
- Duke Energy Progress, LLC., Docket No. 2023-89-E, Securitization, September 2023
- Dominion Energy South Carolina, Inc., Docket No. 2023-170-G, Rate of Return, July 2023
- Duke Energy Progress, LLC., Docket No. 2022-254-E, Rate of Return, December 2022
- Daufuskie Island Utility Company, Inc., Docket No. 22-142-WS, Rate of Return, September 2022
- Piedmont Natural Gas Company, Inc., Docket No. 22-89-G, Rate of Return, July 2022
- Kiawah Island Utility, Inc., Docket No. 2021-324-WS, Rate of Return, February 2022
- Palmetto Wastewater Reclamation, Inc., Docket No. 2021-153-S, Rate of Return, September 2021
- Dominion Energy South Carolina, Inc., Docket No. 2020-125-E, Rate of Return, November 2020
- Palmetto Utilities, Inc., Docket No. 2019-281-S, Rate of Return, May 2020
- Palmetto Utilities, Inc., Docket No. 2019-281-S, Accounting, May 2020
- Blue Granite Water Company, Docket No. 2019-290-WS, Rate of Return, January 2020

Tennessee

- Limestone Water Utility Operating Company, Inc., Docket No. 24-00044, Rate of Return, December 2024
- Tennessee American Water Company, Inc., Docket No. 24-00032, Rate of Return, September 2024
- Kingsport Power Company D/B/A AEP Appalachian Power, Docket No. 21-00107, Rate of Return, March 2022

Vermont

- Central Vermont Public Service Corp., Docket No. 7321, Rate of Return, September 2007

Wisconsin

- American Transmission Company, LLC, ITC, Midwest, LLC, Case No. 19-CV-3418, financial and regulatory analysis regarding requested temporary injunction to halt the construction in Wisconsin of the proposed Cardinal-Hickory Creek transmission line, October 2021

Exhibit__(NYCRP-2)

Tables

Charts

TABLE 1: U.S. EQUITY RETURN EXPECTATIONS AMONG MAJOR FINANCIAL INSTITUTIONS	
J.P. Morgan Asset Management - Equity Long-Term Returns (2025) [1]	**6.7%**
Charles Schwab - 10-year U.S. Large Cap Returns (Jan 2026) [2]	**5.9%**
Horizon Actuarial Services, LLC Survey - 20 Year Horizon (August 2025) [3]	
U.S. Equity - Large Cap (4.8-9.3%, 50% Percentile - 7.1%)	**7.1%**
U.S. Equity - Small / Mid Cap (4.8-10.0%, 50% Percentile - 7.3%)	**7.3%**
Aswath Damodaran (Feb 2026) [4]	**8.5%**
Duff & Phelps / Kroll (September 2025) [5]	**8.5%**

Sources:

[1] J.P. Morgan Asset Management - 2025 Long-Term Capital Market Assumptions, 2024, page 30.
https://am.jpmorgan.com/us/en/asset-management/adv/insights/portfolio-insights/ltcma/

[2] Schwab's 2025 Long-Term Capital Market Expectations, January 3, 2025.
https://www.schwab.com/learn/story/whats-10-year-outlook-major-asset-classes

[3] Horizon Actuarial Services, LLC, Survey of Capital Market Assumptions Survey, August 2024, page 19.
Survey participants Include: Bank of New York Mellon, BlackRock, Goldman Sachs Asset Management, J.P. Morgan Asset Management, Merrill, Morgan Stanley Wealth Management, Royal Bank of Canada, UBS.

[4] New York University, Professor Aswath Damodaran
https://pages.stern.nyu.edu/~adamodar/

[5] Kroll Recommended U.S. ERP and Corresponding RFR to be Used in Computing Cost of Capital: January 2008 - Present,
https://www.kroll.com/en/insights/publications/cost-of-capital/recommended-us-equity-risk-premium-and-corresponding-risk-free-rates
Note: Duff & Phelps acquired Kroll in 2021 and rebranded itself as Kroll.
Note: J.P. Morgan's 2025 Long-Term Capital Market Assumptions is an annual report.

TABLE 2: RFC PROXY GROUP COMPOSITION

	Company Name	Ticker
1	AMEREN	AEE
2	AMERICAN ELEC. PWR.	AEP
3	ATMOS ENERGY CORP.	ATO
4	AVISTA CORP.	AVA
5	CMS ENERGY CORP.	CMS
6	CENTERPOINT EN'RGY	CNP
7	CHESAPEAKE UTIL.	CPK
8	DOMINION ENERGY	D
9	DTE ENERGY CO.	DTE
10	EVERSOURCE ENERGY	ES
11	ENTERGY CORP.	ETR
12	EVERGY, INC.	EVRG
13	EXELON CORP.	EXC
14	FIRST ENERGY	FE
15	IDA CORP, INC.	IDA
16	ALLIANT ENERGY	LNT
17	NEXTERA ENERGY	NEE
18	NI SOURCE INC.	NI
19	N.W. NATURAL	NWN
20	OGE ENERGY CORP.	OGE
21	ONE GAS, INC.	OGS
22	P.S. ENTERPRISE GP.	PEG
23	PINNACLE WEST	PNW
24	PORTLAND GENERAL	POR
25	PPL CORPORATION	PPL
26	SOUTHERN COMPANY	SO
27	SPIRE INC.	SR
28	SOUTHWEST GAS	SWX
29	WEC ENERGY GROUP	WEC
30	XCEL ENERGY	XEL

Table 3: Predicting Proxy Group Historical Dividend Growth

Indicator	MAPE Using Indicator with No Adjustment	Growth Correlation	MAPE using Indicator Adjusted to Growth Correlation
CPI	19.40%	96.50%	19.50%
Real GDP	23.70%	104.60%	22.40%
Nominal GDP	89.80%	53.00%	18.70%

Sources: Exhibit__(NYCRP-13), Exhibit__(NYCRP-14), Exhibit__(NYCRP-15)

Table 4: Summary of Long-Term Growth Rates

Indicator	Correlation with Historical Proxy Group Utility Dividend Growth	EIA Average Long-term Growth Rate	Average Long-Term Utility Dividend Growth, using EIA	CBO Average Long-term Growth Rate	Average Long-Term Utility Dividend Growth, using CBO
CPI	96.50%	2.08%	2.01%	2.31%	2.23%
Real GDP	104.60%	1.76%	1.84%	1.70%	1.78%
Nominal GDP	53.00%	3.88%	2.04%	3.80%	2.00%

Sources: Exhibit__(NYCRP-15), Exhibit__(NYCRP-16)

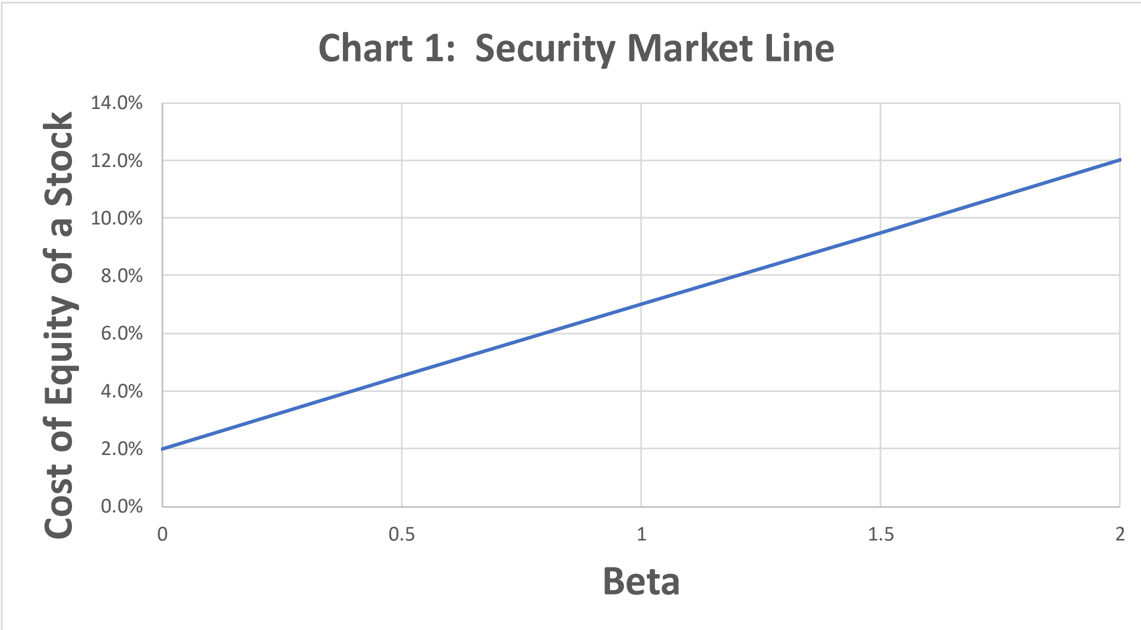


Chart 1: Security Market Line
Cost of Equity of a Stock
14.0%
12.0%
10.0%
8.0%
6.0%
4.0%
2.0%
0.0%
0
0.5
1
1.5
2
Beta

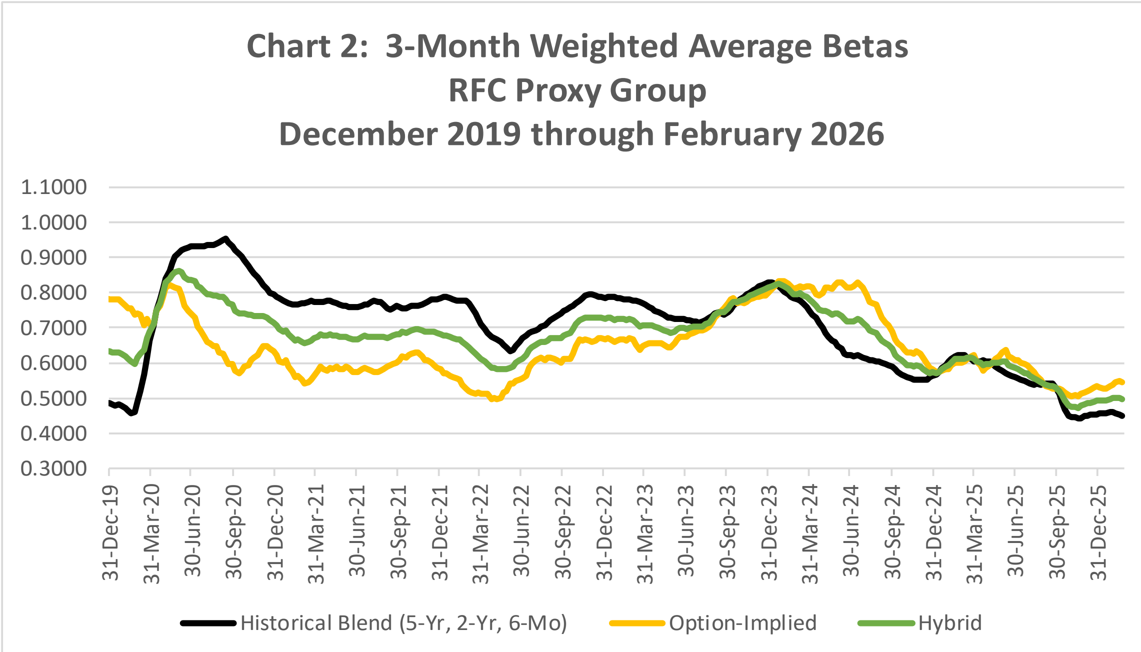


Chart 2: 3-Month Weighted Average Betas
RFC Proxy Group
December 2019 through February 2026
1.1000
1.0000
0.9000
0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
31-Dec-19
31-Mar-20
30-Jun-20
30-Sep-20
31-Dec-20
31-Mar-21
30-Jun-21
30-Sep-21
31-Dec-21
31-Mar-22
30-Jun-22
30-Sep-22
31-Dec-22
31-Mar-23
30-Jun-23
30-Sep-23
31-Dec-23
31-Mar-24
30-Jun-24
30-Sep-24
31-Dec-24
31-Mar-25
30-Jun-25
30-Sep-25
31-Dec-25
Historical Blend (5-Yr, 2-Yr, 6-Mo)
Option-Implied
Hybrid

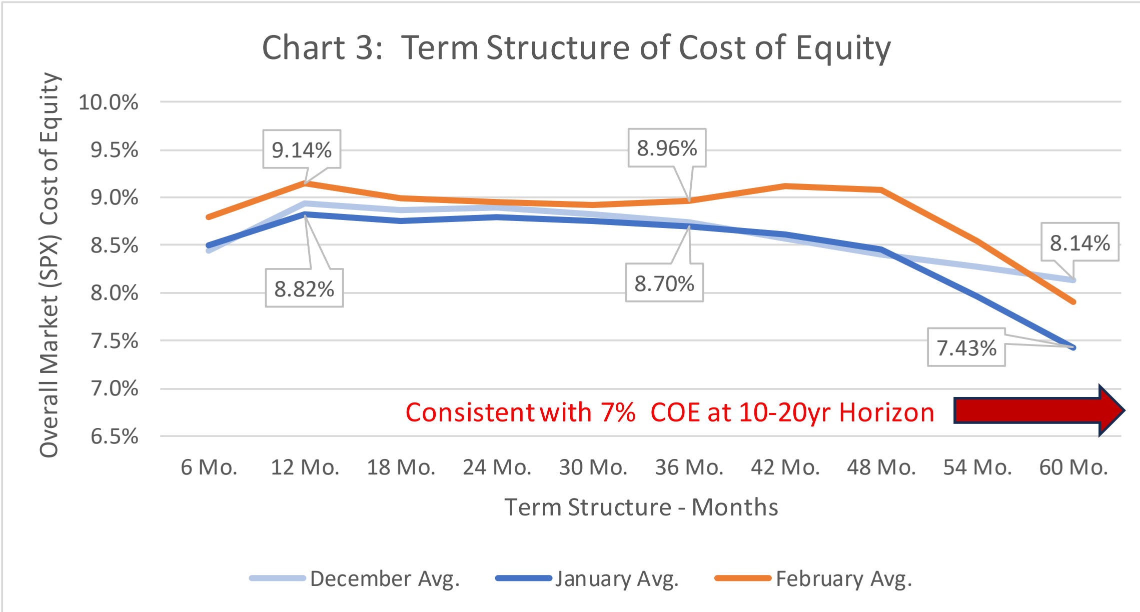


Chart 3: Term Structure of Cost of Equity
Overall Market (SPX) Cost of Equity
10.0%
9.5%
9.0%
8.5%
8.0%
7.5%
7.0%
6.5%
9.14%
8.96%
8.14%
8.82%
8.70%
7.43%
Consistent with 7% COE at 10-20yr Horizon
6 Mo.
12 Mo.
18 Mo.
24 Mo.
30 Mo.
36 Mo.
42 Mo.
48 Mo.
54 Mo.
60 Mo.
Term Structure - Months
December Avg.
January Avg.
February Avg.

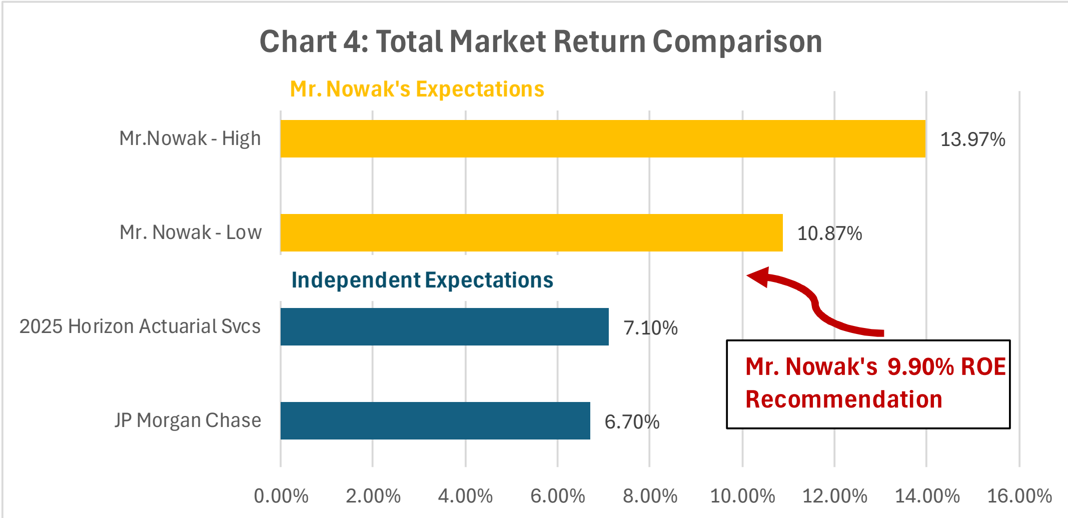


Chart 4: Total Market Return Comparison
Mr. Nowak's Expectations
Mr.Nowak - High
13.97%
Mr. Nowak - Low
10.87%
Independent Expectations
2025 Horizon Actuarial Svcs
7.10%
JP Morgan Chase
6.70%
Mr. Nowak's 9.90% ROE Recommendation
0.00%
2.00%
4.00%
6.00%
8.00%
10.00%
12.00%
14.00%
16.00%

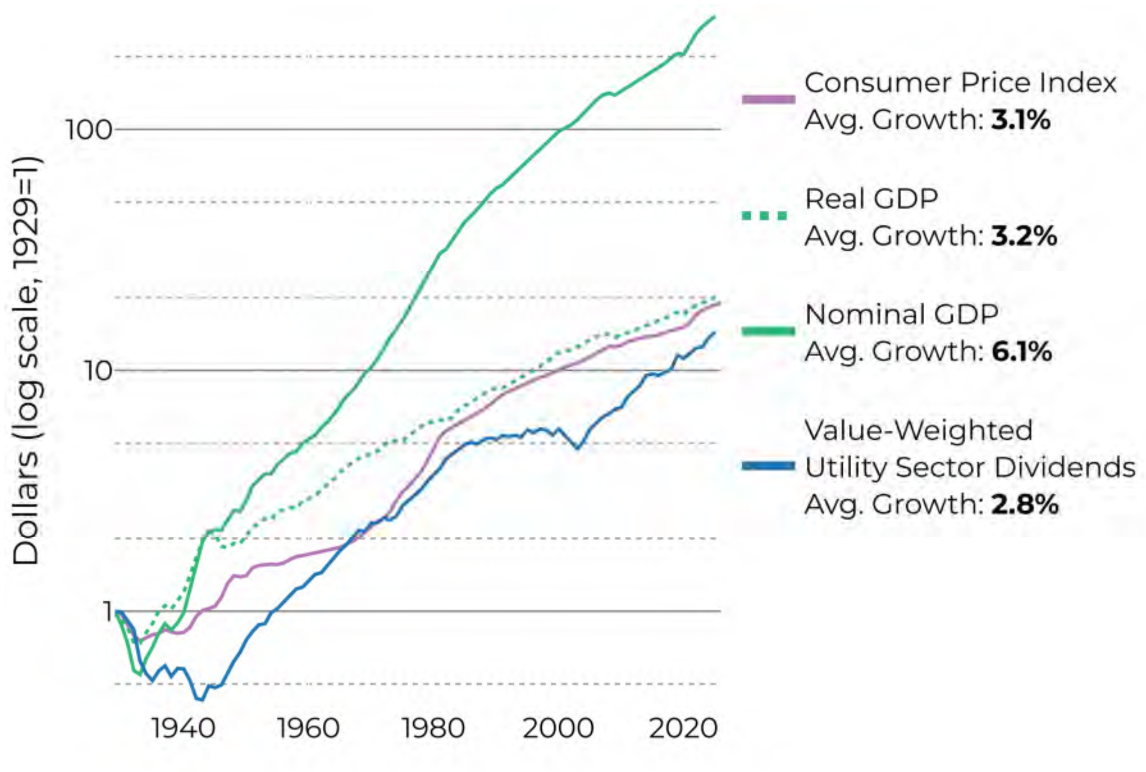


Chart 5: Historical Growth of Utility Dividends and Economic Indicators

Sources: Exhibit__(NYCRP-13), Exhibit__(NYCRP-14)

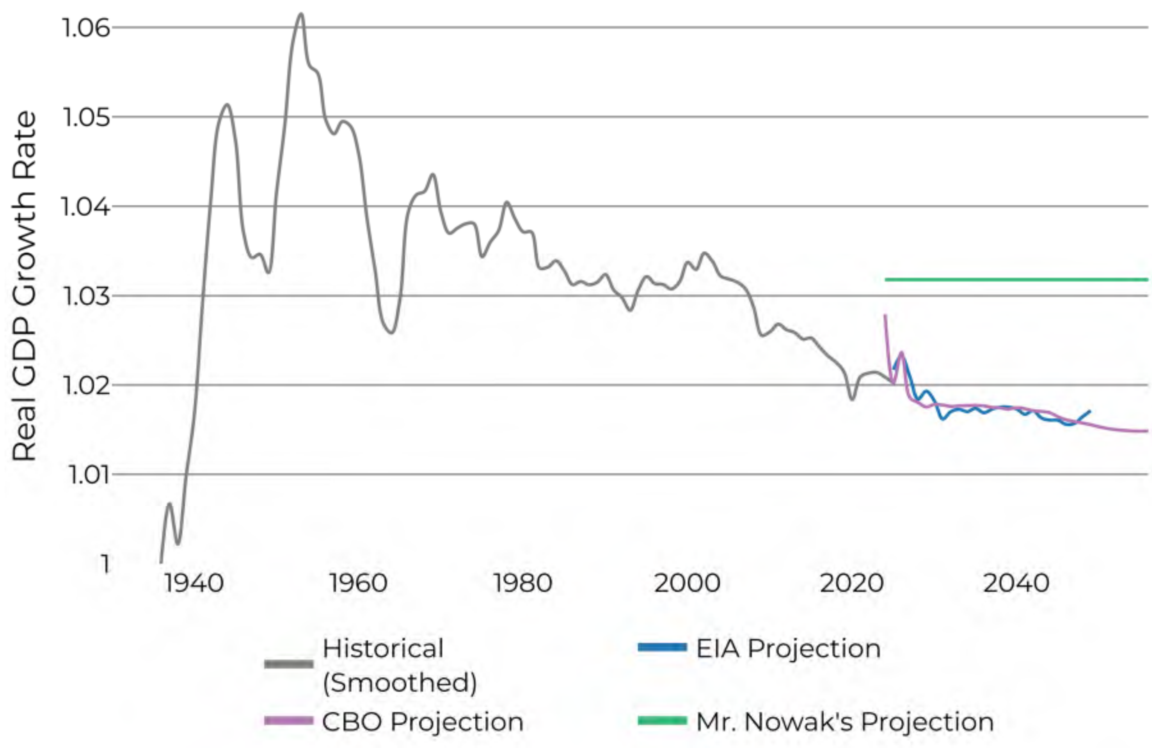


Chart 6: Historical and Projected GDP Growth

Sources: Exhibit__(NYCRP-14), Exhibit__(NYCRP-16)

Exhibit__(NYCRP-3)

Exhibit__(NYCRP-3)

OVERALL COST OF CAPITAL
Consolidated Edison Company of New York, Inc.

	Ratios		Cost Rate		Weighted Cost Rate
					[D]
Long-Term Debt	52.00%	[A]	4.89%	[B]	2.54%
Short-Term Debt	0.00%	[B]	0.00%	[B]	0.00%
Preferred Equity	0.00%	[B]	0.00%	[B]	0.00%
Common Equity	48.00%	[A]	8.04%	[C]	3.86%
	100.00%				**6.40%**

RECOMMENDED RANGES

		Low		High
Proxy Group Cost of Equity Range		7.91%		8.29%
Proxy Group Cost of Equity			8.04%	
Based on RFC Capital Structure Recommendation				
Capital Structure Risk Adjustment	[E]		0.00%	
Adjusted Recommended Cost of Equity Range		**7.91%**		**8.29%**
Company Specific Cost of Equity Recommendation			**8.04%**	
Cost of Capital Range		6.34%		6.52%
Comprehensive Cost of Capital Range				
Cost of Debt Range		4.89%		3.64%
Common Equity Ratio Range		48.00%		41.95%
Comprehensive Cost of Capital Range		6.34%		5.59%

Sources:
[A] A common equity ratio of 48% is on the high side of reasonableness because it is above the mean (43.93%) and median (44.50%) common equity ratio of the companies in my proxy group.
[B] Prepared Testimony of Accounting Panel, Page 7, lines 14-19
[C] Company Specific Cost of Equity Recommendation
[D] Ratios times Cost Rate
[E] It would be appropriate to adjust my ROE recommendation downward to account for the lower financial risk of my conservative capital structure recommendation, but I chose not to make this adjustment to be even more conservative.

Exhibit__(NYCRP-4)

COST OF EQUITY SUMMARY

RFC Proxy Group (30 Companies)

		Weight	Low	High	Percentile			
					50.0% (Median)	70.0%	85.0%	100.0%
DCF (2/3 Weight)		66.7%	**6.63%**	**8.95%**	8.05%	**8.58%**	**8.61%**	**8.95%**
Constant Growth - Sustainable Growth	[A]		8.57%	8.60%				
Constant Growth - Option-Implied Growth	[B]		6.63%	6.95%				
Non-Constant Growth	[C]		7.86%	8.25%				
200-Yr. 2-Stage - Sustainable Growth	[D]		8.62%	8.95%				
200-Yr. 2-Stage - Option-Implied Growth	[E]		7.10%	7.12%				
CAPM (1/3 Weight)		33.3%	**5.89%**	**6.97%**	6.47%	**6.56%**	**6.91%**	**6.97%**
3-Mo. Weighted Average (Dec. 2025 to Feb. 2026)								
3-Month Treasury Bill Risk-Free Rate	[F]		5.97%	6.47%				
30-Year Treasury Bond Risk-Free Rate	[F]		6.57%	6.97%				
Spot (Feb. 28, 2026)								
3-Month Treasury Bill Risk-Free Rate	[G]		5.89%	6.47%				
30-Year Treasury Bond Risk-Free Rate	[G]		6.45%	6.92%				
Proxy Group Cost of Equity					7.52% Median of Overall Range of Results	**7.91%**	**8.04% Recommendation**	**8.29%**
						<---- Recommended Range ---->		

Sources:
[A] Exhibit__(NYCRP-5), page 1
[B] Exhibit__(NYCRP-5), page 2
[C] Exhibit__(NYCRP-5), page 3 and Exhibit__(NYCRP-5), page 4
[D] Exhibit__(NYCRP-5), page 6 and Exhibit__(NYCRP-5), page 7
[E] Exhibit__(NYCRP-5), page 8 and Exhibit__(NYCRP-5), page 9
[F] Exhibit__(NYCRP-6), page 1
[G] Exhibit__(NYCRP-6), page 5

Exhibit__(NYCRP-5)

CONSTANT GROWTH DISCOUNTED CASH FLOW (DCF) - INDICATED COST OF EQUITY
RFC Proxy Group (30 Companies)

		Based on Average Market Price For Year Ending 2/28/2026	Based On Market Price As Of 2/28/2026
1 Dividend Yield On Market Price	[A]	3.40%	3.06%
2 Retention Rate:			
a) Market-to-Book Ratio	[A]	2.01	2.17
b) Dividend Yield on Book	[B]	6.82%	6.63%
c) Expected Return on Equity	[C]	10.70%	10.70%
d) Retention Rate	[D]	36.30%	37.99%
3 Reinvestment Growth	[E]	3.88%	4.07%
4 New Financing Growth	[F]	1.20%	1.39%
5 Total Estimate of Investor Anticipated Growth	[G]	5.08%	5.46%
6 Increment to Dividend Yield for Growth to Next Year	[H]	0.09%	0.08%
7 Indicated Cost of Equity	**[I]**	**8.57%**	**8.60%**

Sources:
[A] Exhibit__(NYCRP-7), page 1
[B] Line 1 x Line 2a
[C] Some of the considerations for determining Future Expected Return on Equity:

	Median	Mean	From
Value Line Expectation	**11.00%**	**10.98%**	Exhibit__(NYCRP-7), page 2
Return on Equity to Achieve Zacks Growth	11.29%	10.99%	Exhibit__(NYCRP-7), page 3
Average Historical Growth	9.67%	10.14%	
Earned Return on Equity in 2025	10.10%	10.41%	Exhibit__(NYCRP-7), page 2
Earned Return on Equity in 2024	9.58%	9.96%	Exhibit__(NYCRP-7), page 2
Earned Return on Equity in 2023	9.33%	10.06%	Exhibit__(NYCRP-7), page 2

[D] 1 - Line 2b / Line 2c
[E] Line 2c x Line 2d — From
[F] S x V = (Ext. Fin Rate) x (Line 2a - 1) — Ext. Fin. Rate = 1.19% — Exhibit__(NYCRP-5), page 5
S = rate of continuous new stock financing
V = fraction of funds raised by sale of stock that increases the book value of existing shareholders' common equity
[G] Line 3 + Line 4
[H] Line 1 x one-half of Line 5
[I] Line 1 + Line 5 + Line 6

CONSTANT GROWTH DISCOUNTED CASH FLOW (DCF) - INDICATED COST OF EQUITY
RFC Proxy Group (30 Companies)

			Based On Weighted Averages As Of 2/28/2026	Based On Spot Market Values As Of 2/28/2026
1	Dividend Yield On Market Price	[A]	3.40%	3.06%
2	Total Estimate of Investor Anticipated Growth	[B]	3.49%	3.51%
3	Increment to Dividend Yield for Growth to Next Year	[C]	0.06%	0.05%
4	**Indicated Cost of Equity**	**[D]**	**6.95%**	**6.63%**

Sources:
[A] Exhibit__(NYCRP-7), page 1
[B] 6-Month Option-Implied Growth
[C] Line 1 x one-half of Line 2
[D] Line 1 + Line 2 + Line 3

NON-CONSTANT GROWTH DISCOUNTED CASH FLOW (DCF) - INDICATED COST OF EQUITY
(BASED ON VALUE LINE FORECASTS AND CLOSING STOCK PRICE)
RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
		Forecasted Dividends per Share					Growth	Book Value		Closing Stock Price		Cash Flow From Buying and Selling Stock (At Closing Price)					
		2026	2027	2027	2028	2029	2026-29	2/28/26	2/28/29	2/28/2026	2/28/2029		2026	2027	2028	2029	IRR / DCF
		[A]	[A]	[B]	[B]	[A]	[B]	[C]	[C]	[D]	[E]	[F]	[F]	[F]	[F]	[F]	[G]
ATMOS ENERGY CORP.	ATO	$4.00	NA	$4.32	$4.67	$5.05	8.08%	$84.52	$106.98	$186.79	$236.42		($182.79)	$4.32	$4.67	$236.42	10.54%
CHESAPEAKE UTIL.	CPK	$2.82	NA	$3.03	$3.26	$3.50	7.47%	$65.34	$83.66	$135.97	$174.07		($133.15)	$3.03	$3.26	$174.07	10.86%
NI SOURCE INC.	NI	$1.20	NA	$1.30	$1.40	$1.52	8.20%	$25.78	$31.64	$47.30	$58.05		($46.10)	$1.30	$1.40	$58.05	9.88%
N.W. NATURAL	NWN	$1.97	NA	$1.98	$1.99	$2.00	0.51%	$34.57	$37.57	$53.04	$57.65		($51.07)	$1.98	$1.99	$57.65	6.69%
ONE GAS, INC.	OGS	$2.72	NA	$2.79	$2.87	$2.95	2.74%	$53.79	$52.81	$87.44	$85.84		($84.72)	$2.79	$2.87	$85.84	NA [H]
SOUTHWEST GAS	SWX	$2.48	NA	$2.55	$2.62	$2.70	2.87%	$54.63	$62.64	$88.17	$101.11		($85.69)	$2.55	$2.62	$101.11	7.65%
SPIRE INC.	SR	$3.30	NA	$3.52	$3.75	$4.00	6.62%	$53.17	$54.70	$91.61	$94.24		($88.31)	$3.52	$3.75	$94.24	4.94%
ALLIANT ENERGY	LNT	$2.15	NA	$2.24	$2.33	$2.43	4.17%	$28.87	$31.76	$72.34	$79.57		($70.19)	$2.24	$2.33	$79.57	6.42%
AMEREN	AEE	$3.03	NA	$3.20	$3.38	$3.57	5.62%	$46.39	$50.15	$113.28	$122.47		($110.25)	$3.20	$3.38	$122.47	5.54%
AMERICAN ELEC. PWR.	AEP	$3.98	NA	$4.09	$4.20	$4.31	2.69%	$52.86	$57.95	$133.82	$146.71		($129.84)	$4.09	$4.20	$146.71	6.26%
AVISTA CORP.	AVA	$2.10	NA	$2.16	$2.23	$2.30	3.08%	$33.33	$34.30	$40.62	$41.81		($38.52)	$2.16	$2.23	$41.81	6.59%
CENTERPOINT EN'RGY	CNP	$0.95	NA	$0.98	$1.02	$1.05	3.39%	$18.12	$20.52	$43.50	$49.25		($42.55)	$0.98	$1.02	$49.25	6.53%
CMS ENERGY CORP.	CMS	$2.30	NA	$2.51	$2.75	$3.00	9.26%	$29.16	$31.55	$78.07	$84.47		($75.77)	$2.51	$2.75	$84.47	5.98%
DOMINION ENERGY	D	$2.67	NA	$2.71	$2.76	$2.80	1.60%	$31.88	$39.49	$63.14	$78.21		($60.47)	$2.71	$2.76	$78.21	11.88%
DTE ENERGY CO.	DTE	$4.71	NA	$4.85	$5.00	$5.15	3.02%	$58.70	$61.43	$148.24	$155.12		($143.53)	$4.85	$5.00	$155.12	4.91%
ENTERGY CORP.	ETR	$2.60	NA	$2.73	$2.86	$3.00	4.89%	$37.03	$42.19	$107.11	$122.04		($104.51)	$2.73	$2.86	$122.04	7.05%
EVERSOURCE ENERGY	ES	$3.15	NA	$3.38	$3.62	$3.88	7.19%	$43.66	$53.01	$75.41	$91.56		($72.26)	$3.38	$3.62	$91.56	11.35%
EXELON CORP.	EXC	$1.76	NA	$1.84	$1.92	$2.00	4.35%	$27.39	$29.48	$49.05	$52.80		($47.29)	$1.84	$1.92	$52.80	6.37%
FIRST ENERGY	FE	$1.86	NA	$1.98	$2.11	$2.24	6.39%	$22.33	$27.61	$51.16	$63.26		($49.30)	$1.98	$2.11	$63.26	11.35%
EVERGY, INC.	EVRG	$2.84	NA	$2.97	$3.11	$3.25	4.60%	$45.68	$47.33	$83.66	$86.67		($80.82)	$2.97	$3.11	$86.67	4.86%
IDA CORP, INC.	IDA	$3.65	NA	$3.82	$4.01	$4.20	4.79%	$64.72	$69.96	$143.97	$155.61		($140.32)	$3.82	$4.01	$155.61	5.35%
NEXTERA ENERGY	NEE	$2.50	NA	$2.79	$3.12	$3.48	11.66%	$26.53	$36.62	$93.77	$129.45		($91.27)	$2.79	$3.12	$129.45	14.41%
OGE ENERGY CORP.	OGE	$1.73	NA	$1.75	$1.77	$1.79	1.14%	$23.83	$25.80	$49.14	$53.19		($47.41)	$1.75	$1.77	$53.19	6.37%
PINNACLE WEST	PNW	$3.67	NA	$3.78	$3.89	$4.00	2.91%	$58.12	$69.45	$100.30	$119.85		($96.63)	$3.78	$3.89	$119.85	10.02%
PORTLAND GENERAL	POR	$2.20	NA	$2.32	$2.45	$2.58	5.45%	$36.24	$40.83	$53.96	$60.79		($51.76)	$2.32	$2.45	$60.79	8.54%
PPL CORPORATION	PPL	$1.16	NA	$1.25	$1.34	$1.44	7.47%	$20.65	$23.14	$38.98	$43.67		($37.82)	$1.25	$1.34	$43.67	7.16%
P.S. ENTERPRISE GP.	PEG	$2.68	NA	$2.92	$3.17	$3.45	8.78%	$35.11	$44.19	$86.07	$108.32		($83.39)	$2.92	$3.17	$108.32	11.46%
SOUTHERN COMPANY	SO	$3.04	NA	$3.17	$3.30	$3.44	4.21%	$31.77	$32.67	$97.38	$100.13		($94.34)	$3.17	$3.30	$100.13	4.29%
WEC ENERGY GROUP	WEC	$3.81	NA	$4.05	$4.31	$4.59	6.41%	$40.99	$45.09	$116.96	$128.66		($113.15)	$4.05	$4.31	$128.66	6.81%
XCEL ENERGY	XEL	$2.42	NA	$2.60	$2.79	$3.00	7.42%	$36.69	$41.90	$83.36	$95.19		($80.94)	$2.60	$2.79	$95.19	7.74%
Maximum		$4.71	$0.00	$4.85	$5.00	$5.15	11.66%	$84.52	$106.98	$186.79	$236.42	$0.00	($37.82)	$4.85	$5.00	$236.42	14.41%
Minimum		$0.95	$0.00	$0.98	$1.02	$1.05	0.51%	$18.12	$20.52	$38.98	$41.81	$0.00	($182.79)	$0.98	$1.02	$41.81	4.29%
Median		$2.64	#NUM!	$2.76	$2.87	$3.00	4.84%	$36.47	$42.04	$84.87	$92.90	#NUM!	($82.17)	$2.76	$2.87	$92.90	6.81%
Average		$2.65	#DIV/0!	$2.79	$2.93	$3.09	5.23%	$40.73	$46.21	$87.12	$99.21	#DIV/0!	($84.47)	$2.79	$2.93	$99.21	7.86%

Sources:
[A] Value Line: Most current data available at time of schedule preparation. 2029 data is VL forecast for 2028-30.
[B] Straight line interpolation based on Value Line data, assuming constant dividend growth for 2026-29.
[C] Straight line interpolation based on Value Line data, assuming constant book value growth for 2026-29.
[D] EOD Data: Market Data as of February 28, 2026.
[E] Stock Price projected assuming constant Market to Book Ratio (Exhibit__(NYCRP-7), page 1) and using VL projected Book Value.
[F] Cash Flow from purchasing stock on March 1, 2026, receiving dividends through 2029, and selling on February 28, 2029.
Negative number in 2026 reflects cash outflow required to purchase stock.
Cash flow sources are 1) dividends and 2) proceeds of stock sale.
4 of 4 dividends assumed received in 2026 and 0 of 4 in 2029 based on purchase and sale date.
[G] Total return on equity to investor who purchased, held, and sold stock as described above,
assuming Value Line projections of Dividends and Book Value are correct and
assuming Stock Price grows at same rate as Book Value.
DCF result is an Internal Rate of Return computation made using the "IRR" function built into Microsoft Excel
based on projected cash flows from 2026 to 2029.
[H] Excluded because of declining book value forecast.

NON-CONSTANT GROWTH DISCOUNTED CASH FLOW (DCF) - INDICATED COST OF EQUITY

(BASED ON VALUE LINE FORECASTS AND LTM AVERAGE STOCK PRICE)

RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
		Forecasted Dividends per Share					Growth	LTM Avg. Book Value		LTM Avg. Stock Price		Cash Flow From Buying and Selling Stock (At LTM Average Price)					
		2026	2027	2027	2028	2029	2026-29	2026	2029	2/28/26	2/28/29		2026	2027	2028	2029	IRR / DCF
		[A]	[A]	[B]	[B]	[A]	[B]	[C]	[C]	[D]	[E]	[F]	[F]	[F]	[F]	[F]	[G]
ATMOS ENERGY CORP.	ATO	$4.00	NA	$4.32	$4.67	$5.05	8.08%	$81.87	$103.62	$164.71	$208.46		($160.71)	$4.32	$4.67	$208.46	10.86%
CHESAPEAKE UTIL.	CPK	$2.82	NA	$3.03	$3.26	$3.50	7.47%	$63.32	$81.07	$127.92	$163.76		($125.10)	$3.03	$3.26	$163.76	11.01%
NI SOURCE INC.	NI	$1.20	NA	$1.30	$1.40	$1.52	8.20%	$22.72	$27.88	$41.50	$50.92		($40.30)	$1.30	$1.40	$50.92	10.28%
N.W. NATURAL	NWN	$1.97	NA	$1.98	$1.99	$2.00	0.51%	$34.49	$37.49	$46.21	$50.23		($44.24)	$1.98	$1.99	$50.23	7.29%
ONE GAS, INC.	OGS	$2.72	NA	$2.79	$2.87	$2.95	2.74%	$52.97	$52.00	$78.80	$77.35		($76.08)	$2.79	$2.87	$77.35	NA
SOUTHWEST GAS	SWX	$2.48	NA	$2.55	$2.62	$2.70	2.87%	$52.17	$59.83	$76.91	$88.20		($74.43)	$2.55	$2.62	$88.20	8.10%
SPIRE INC.	SR	$3.30	NA	$3.52	$3.75	$4.00	6.62%	$52.62	$54.13	$81.45	$83.78		($78.15)	$3.52	$3.75	$83.78	5.46%
ALLIANT ENERGY	LNT	$2.15	NA	$2.24	$2.33	$2.43	4.17%	$28.21	$31.03	$64.75	$71.22		($62.60)	$2.24	$2.33	$71.22	6.81%
AMEREN	AEE	$3.03	NA	$3.20	$3.38	$3.57	5.62%	$44.84	$48.48	$102.60	$110.92		($99.57)	$3.20	$3.38	$110.92	5.85%
AMERICAN ELEC. PWR.	AEP	$3.98	NA	$4.09	$4.20	$4.31	2.69%	$51.88	$56.88	$116.03	$127.20		($112.05)	$4.09	$4.20	$127.20	6.76%
AVISTA CORP.	AVA	$2.10	NA	$2.16	$2.23	$2.30	3.08%	$32.91	$33.87	$39.50	$40.65		($37.40)	$2.16	$2.23	$40.65	6.75%
CENTERPOINT EN'RGY	CNP	$0.95	NA	$0.98	$1.02	$1.05	3.39%	$17.37	$19.66	$38.41	$43.48		($37.46)	$0.98	$1.02	$43.48	6.85%
CMS ENERGY CORP.	CMS	$2.30	NA	$2.51	$2.75	$3.00	9.26%	$28.14	$30.45	$73.01	$78.99		($70.71)	$2.51	$2.75	$78.99	6.22%
DOMINION ENERGY	D	$2.67	NA	$2.71	$2.76	$2.80	1.60%	$31.42	$38.92	$57.82	$71.62		($55.15)	$2.71	$2.76	$71.62	12.31%
DTE ENERGY CO.	DTE	$4.71	NA	$4.85	$5.00	$5.15	3.02%	$57.47	$60.14	$139.16	$145.62		($134.45)	$4.85	$5.00	$145.62	5.13%
ENTERGY CORP.	ETR	$2.60	NA	$2.73	$2.86	$3.00	4.89%	$36.20	$41.24	$91.39	$104.13		($88.79)	$2.73	$2.86	$104.13	7.52%
EVERSOURCE ENERGY	ES	$3.15	NA	$3.38	$3.62	$3.88	7.19%	$42.53	$51.63	$64.35	$78.12		($61.20)	$3.38	$3.62	$78.12	12.20%
EXELON CORP.	EXC	$1.76	NA	$1.84	$1.92	$2.00	4.35%	$27.12	$29.20	$45.80	$49.30		($44.04)	$1.84	$1.92	$49.30	6.66%
FIRST ENERGY	FE	$1.86	NA	$1.98	$2.11	$2.24	6.39%	$22.01	$27.21	$44.46	$54.98		($42.60)	$1.98	$2.11	$54.98	11.98%
EVERGY, INC.	EVRG	$2.84	NA	$2.97	$3.11	$3.25	4.60%	$44.73	$46.34	$73.01	$75.64		($70.17)	$2.97	$3.11	$75.64	5.42%
IDA CORP, INC.	IDA	$3.65	NA	$3.82	$4.01	$4.20	4.79%	$63.42	$68.55	$127.05	$137.32		($123.40)	$3.82	$4.01	$137.32	5.73%
NEXTERA ENERGY	NEE	$2.50	NA	$2.79	$3.12	$3.48	11.66%	$25.59	$35.33	$78.82	$108.81		($76.32)	$2.79	$3.12	$108.81	15.01%
OGE ENERGY CORP.	OGE	$1.73	NA	$1.75	$1.77	$1.79	1.14%	$23.42	$25.35	$44.99	$48.70		($43.26)	$1.75	$1.77	$48.70	6.72%
PINNACLE WEST	PNW	$3.67	NA	$3.78	$3.89	$4.00	2.91%	$57.52	$68.73	$93.23	$111.39		($89.56)	$3.78	$3.89	$111.39	10.33%
PORTLAND GENERAL	POR	$2.20	NA	$2.32	$2.45	$2.58	5.45%	$35.57	$40.08	$46.97	$52.92		($44.77)	$2.32	$2.45	$52.92	9.24%
PPL CORPORATION	PPL	$1.16	NA	$1.25	$1.34	$1.44	7.47%	$19.98	$22.38	$35.77	$40.07		($34.61)	$1.25	$1.34	$40.07	7.46%
P.S. ENTERPRISE GP.	PEG	$2.68	NA	$2.92	$3.17	$3.45	8.78%	$33.93	$42.70	$82.97	$104.41		($80.29)	$2.92	$3.17	$104.41	11.60%
SOUTHERN COMPANY	SO	$3.04	NA	$3.17	$3.30	$3.44	4.21%	$30.96	$31.84	$91.97	$94.56		($88.93)	$3.17	$3.30	$94.56	4.50%
WEC ENERGY GROUP	WEC	$3.81	NA	$4.05	$4.31	$4.59	6.41%	$40.18	$44.19	$109.40	$120.34		($105.59)	$4.05	$4.31	$120.34	7.07%
XCEL ENERGY	XEL	$2.42	NA	$2.60	$2.79	$3.00	7.42%	$35.53	$40.57	$74.72	$85.33		($72.30)	$2.60	$2.79	$85.33	8.12%
Maximum		$4.71	$0.00	$4.85	$5.00	$5.15	11.66%	$81.87	$103.62	$164.71	$208.46	$0.00	($34.61)	$4.85	$5.00	$208.46	15.01%
Minimum		$0.95	$0.00	$0.98	$1.02	$1.05	0.51%	$17.37	$19.66	$35.77	$40.07	$0.00	($160.71)	$0.98	$1.02	$40.07	4.50%
Median		$2.64	#NUM!	$2.76	$2.87	$3.00	4.84%	$35.55	$40.90	$75.82	$81.39	#NUM!	($73.37)	$2.76	$2.87	$81.39	7.29%
Average		$2.65	#DIV/0!	$2.79	$2.93	$3.09	5.23%	$39.70	$45.03	$78.45	$89.28	#DIV/0!	($75.81)	$2.79	$2.93	$89.28	**8.25%**

Sources:

[A] Value Line: Most current data available at time of schedule preparation. 2029 data is VL forecast for 2028-30.

[B] Straight line interpolation based on Value Line data, assuming constant dividend growth for 2026-29.

[C] Straight line interpolation based on Value Line data, assuming constant book value growth for 2026-29.

[D] EOD Data: Market Data as of February 28, 2026.

[E] Stock Price projected assuming constant Market to Book Ratio (Exhibit__(NYCRP-7), page 1) and using VL projected Book Value.

[F] Cash Flow from purchasing stock on March 1, 2026, receiving dividends through 2029, and selling on February 28, 2029.
Negative number in 2026 reflects cash outflow required to purchase stock.
Cash flow sources are 1) dividends and 2) proceeds of stock sale.
4 of 4 dividends assumed received in 2026 and 0 of 4 in 2029 based on purchase and sale date.

[G] Total return on equity to investor who purchased, held, and sold stock as described above,
assuming Value Line projections of Dividends and Book Value are correct and
assuming Stock Price grows at same rate as Book Value.
DCF result is an Internal Rate of Return computation made using the "IRR" function built into Microsoft Excel
based on projected cash flows from 2026 to 2029.

COMMON SHARES OUTSTANDING AND EXTERNAL FINANCING RATE
RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
		Common Stock Outstanding (Millions of Shares)								**Annual Growth Rate**		
		2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2029**	**2020-24**	**2024-29**	**2020-29**
		[A]	[A]	[A]	[A]	[A]	[A]	[A]	[A]	[B]	[B]	[B]
ATMOS ENERGY CORP.	ATO	125.9	132.4	140.9	148.5	155.3	161.6	171.0	200.0	5.38%	5.19%	5.28%
CHESAPEAKE UTIL.	CPK	17.5	17.7	17.7	22.2	22.9	24.0	24.0	26.0	7.02%	2.57%	4.52%
NI SOURCE INC.	NI	391.8	405.3	412.1	447.4	469.8	478.4	500.0	525.0	4.65%	2.25%	3.31%
N.W. NATURAL	NWN	30.6	31.1	35.5	37.6	40.2	42.0	45.0	50.0	7.08%	4.45%	5.61%
ONE GAS, INC.	OGS	53.2	53.6	55.4	56.6	59.9	60.0	62.0	75.0	3.02%	4.61%	3.90%
SOUTHWEST GAS	SWX	57.2	60.4	67.1	71.6	71.8	73.0	74.0	77.0	5.85%	1.41%	3.36%
SPIRE INC.	SR	51.6	51.7	52.5	53.2	57.7	59.0	62.0	75.0	2.83%	5.38%	4.24%
ALLIANT ENERGY	LNT	249.9	250.5	251.1	256.1	256.7	257.1	257.5	259.0	0.68%	0.18%	0.40%
AMEREN	AEE	253.3	257.7	262.0	267.0	266.9	272.0	275.0	285.0	1.32%	1.32%	1.32%
AMERICAN ELEC. PWR.	AEP	496.6	504.2	513.9	526.2	532.9	535.0	540.0	550.0	1.78%	0.63%	1.14%
AVISTA CORP.	AVA	69.2	71.5	75.0	78.1	80.0	81.5	83.0	85.0	3.69%	1.21%	2.30%
CENTERPOINT EN'RGY	CNP	551.4	628.9	629.5	631.2	651.7	653.0	653.0	653.0	4.27%	0.04%	1.90%
CMS ENERGY CORP.	CMS	288.9	289.8	291.3	294.4	298.8	304.5	305.0	306.0	0.84%	0.48%	0.64%
DOMINION ENERGY	D	806.0	810.0	835.0	838.0	852.0	855.0	870.0	930.0	1.40%	1.77%	1.60%
DTE ENERGY CO.	DTE	193.8	193.8	205.7	206.4	207.2	205.5	205.5	206.0	1.69%	-0.11%	0.68%
ENTERGY CORP.	ETR	400.5	405.3	422.4	425.7	429.6	435.0	440.0	460.0	1.77%	1.38%	1.55%
EVERSOURCE ENERGY	ES	343.0	344.4	348.4	349.5	366.6	376.0	378.0	390.0	1.68%	1.24%	1.44%
EXELON CORP.	EXC	976.0	979.0	994.0	999.0	1,005.0	1,005.0	1,005.0	1,005.0	0.73%	0.00%	0.33%
FIRST ENERGY	FE	543.1	570.3	572.1	574.3	576.6	578.0	585.0	605.0	1.51%	0.97%	1.21%
EVERGY, INC.	EVRG	226.8	229.3	229.9	229.7	230.0	230.0	230.0	230.0	0.34%	0.00%	0.15%
IDA CORP, INC.	IDA	50.5	50.5	50.6	50.6	54.0	55.0	55.5	56.0	1.69%	0.74%	1.16%
NEXTERA ENERGY	NEE	1,960.0	1,963.0	1,987.0	2,052.0	2,057.0	2,085.0	2,110.0	2,220.0	1.21%	1.54%	1.39%
OGE ENERGY CORP.	OGE	200.1	200.1	200.2	200.3	200.9	200.2	200.2	200.2	0.10%	-0.07%	0.01%
PINNACLE WEST	PNW	112.8	113.0	113.2	113.4	119.1	120.0	121.0	125.0	1.38%	0.97%	1.15%
PORTLAND GENERAL	POR	89.5	89.4	89.3	101.2	109.3	112.5	114.0	120.0	5.12%	1.88%	3.31%
PPL CORPORATION	PPL	768.9	735.1	736.5	737.1	738.0	737.4	737.5	738.0	-1.02%	0.00%	-0.45%
P.S. ENTERPRISE GP.	PEG	504.0	504.0	497.0	498.0	498.0	499.2	500.0	504.0	-0.30%	0.24%	0.00%
SOUTHERN COMPANY	SO	1,056.5	1,060.0	1,089.0	1,091.0	1,096.0	1,105.0	1,110.0	1,120.0	0.92%	0.43%	0.65%
WEC ENERGY GROUP	WEC	315.4	315.4	315.4	315.4	317.7	315.4	315.4	315.4	0.18%	-0.14%	0.00%
XCEL ENERGY	XEL	537.4	544.0	549.6	554.9	574.4	591.6	593.5	600.0	1.68%	0.88%	1.23%
Maximum		1,960.0	1,963.0	1,987.0	2,052.0	2,057.0	2,085.0	2,110.0	2,220.0	7.08%	5.38%	5.61%
Minimum		17.5	17.7	17.7	22.2	22.9	24.0	24.0	26.0	-1.02%	-0.14%	-0.45%
Median		271.1	273.7	276.6	280.7	282.9	288.3	290.0	295.5	1.68%	0.97%	1.27%
Average		390.7	395.4	401.3	407.6	413.2	416.9	420.7	433.0	2.28%	1.38%	1.78%
									Sustainable Growth [C]			1.19%

Sources:
[A] Value Line: Most current data available at time of schedule preparation.
[B] Annualized Growth Rate calculation.
[C] Estimated Sustainable Growth in Common Stock based on analysis of historical and projected growth rates.

200-YEAR 2-STAGE DISCOUNTED CASH FLOW (DCF) - INDICATED COST OF EQUITY
(BASED ON AVERAGE STOCK PRICE, VALUE LINE DIVIDEND FORECASTS, AND MOST RECENT SUSTAINABLE GROWTH)
RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
		Stock Price	Dividends per Share					Sustainable	
		Dec '25-Feb '26 Avg.	2026	2027	2028	2029	Growth 26-29	Growth	Cost of Equity
		[A]	[B]	[C]	[C]	[B]	[D]	[E]	[F]
AMEREN	AEE	$103.07	$3.03	$3.21	$3.39	$3.57	5.62%	5.54%	8.47%
AMERICAN ELEC. PWR.	AEP	$119.31	$3.98	$4.09	$4.20	$4.31	2.69%	5.54%	8.62%
ATMOS ENERGY CORP.	ATO	$170.41	$4.00	$4.35	$4.70	$5.05	8.08%	5.54%	8.03%
AVISTA CORP.	AVA	$39.77	$2.10	$2.17	$2.23	$2.30	3.08%	5.54%	10.49%
CMS ENERGY CORP.	CMS	$71.64	$2.30	$2.53	$2.77	$3.00	9.26%	5.54%	9.08%
CENTERPOINT EN'RGY	CNP	$39.31	$0.95	$0.98	$1.02	$1.05	3.39%	5.54%	7.78%
CHESAPEAKE UTIL.	CPK	$128.93	$2.82	$3.05	$3.27	$3.50	7.47%	5.54%	7.81%
DOMINION ENERGY	D	$59.71	$2.67	$2.71	$2.76	$2.80	1.60%	5.54%	9.56%
DTE ENERGY CO.	DTE	$134.37	$4.71	$4.86	$5.00	$5.15	3.02%	5.54%	8.81%
EVERSOURCE ENERGY	ES	$68.24	$3.15	$3.39	$3.64	$3.88	7.19%	5.54%	10.36%
ENTERGY CORP.	ETR	$95.57	$2.60	$2.73	$2.87	$3.00	4.89%	5.54%	8.19%
EVERGY, INC.	EVRG	$76.16	$2.84	$2.98	$3.11	$3.25	4.60%	5.54%	9.17%
EXELON CORP.	EXC	$44.55	$1.76	$1.84	$1.92	$2.00	4.35%	5.54%	9.36%
FIRST ENERGY	FE	$46.32	$1.86	$1.99	$2.11	$2.24	6.39%	5.54%	9.64%
IDA CORP, INC.	IDA	$131.12	$3.65	$3.83	$4.02	$4.20	4.79%	5.54%	8.25%
ALLIANT ENERGY	LNT	$66.60	$2.15	$2.24	$2.34	$2.43	4.17%	5.54%	8.64%
NEXTERA ENERGY	NEE	$84.93	$2.50	$2.83	$3.15	$3.48	11.66%	5.54%	8.99%
NI SOURCE INC.	NI	$43.34	$1.20	$1.31	$1.41	$1.52	8.20%	5.54%	8.50%
N.W. NATURAL	NWN	$47.73	$1.97	$1.98	$1.99	$2.00	0.51%	5.54%	9.13%
OGE ENERGY CORP.	OGE	$44.12	$1.73	$1.75	$1.77	$1.79	1.14%	5.54%	9.01%
ONE GAS, INC.	OGS	$79.96	$2.72	$2.80	$2.87	$2.95	2.74%	5.54%	8.68%
P.S. ENTERPRISE GP.	PEG	$80.93	$2.68	$2.94	$3.19	$3.45	8.78%	5.54%	9.14%
PINNACLE WEST	PNW	$91.09	$3.67	$3.78	$3.89	$4.00	2.91%	5.54%	9.29%
PORTLAND GENERAL	POR	$49.93	$2.20	$2.33	$2.45	$2.58	5.45%	5.54%	9.93%
PPL CORPORATION	PPL	$35.75	$1.16	$1.25	$1.35	$1.44	7.47%	5.54%	8.95%
SOUTHERN COMPANY	SO	$88.48	$3.04	$3.17	$3.31	$3.44	4.21%	5.54%	8.85%
SPIRE INC.	SR	$84.95	$3.30	$3.53	$3.77	$4.00	6.62%	5.54%	9.53%
SOUTHWEST GAS	SWX	$82.50	$2.48	$2.55	$2.63	$2.70	2.87%	5.54%	8.32%
WEC ENERGY GROUP	WEC	$108.41	$3.81	$4.07	$4.33	$4.59	6.41%	5.54%	9.13%
XCEL ENERGY	XEL	$76.56	$2.42	$2.61	$2.81	$3.00	7.42%	5.54%	8.86%
Maximum		$170.41	$4.71	$4.86	$5.00	$5.15	11.66%	5.54%	10.49%
Minimum		$35.75	$0.95	$0.98	$1.02	$1.05	0.51%	5.54%	7.78%
Median		$78.26	$2.64	$2.77	$2.87	$3.00	4.84%	5.54%	8.97%
Average		$79.79	$2.65	$2.80	$2.94	$3.09	5.23%	5.54%	**8.95%**

Sources:
[A] EOD Data: Market Data as of February 28, 2026. Average stock price Dec '25-Feb '26.
[B] Value Line: Most current data available at time of schedule preparation. 2029 data is VL forecast for 2028-30.
[C] Straight line interpolation based on Value Line data, assuming constant growth.
[D] Compounded annual growth calculation.
[E] Most recent sustainable growth rate for RFC Proxy Group as of February 28, 2026.
[F] Internal Rate of Return (IRR) calculation for 200-year dividend flow using Value Line forecasts and sustainable growth rate.

NON-CONSTANT GROWTH DISCOUNTED CASH FLOW (DCF) - INDICATED COST OF EQUITY
(BASED ON AVERAGE STOCK PRICE, VALUE LINE DIVIDEND FORECASTS, AND 3-MONTH AVG. SUSTAINABLE GROWTH)
RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
		Stock Price	Dividends per Share					Sustainable	
		Dec '25-Feb '26 Avg.	2026	2027	2028	2029	Growth 26-29	Growth	Cost of Equity
		[A]	[B]	[C]	[C]	[B]	[D]	[E]	[F]
AMEREN	AEE	$103.07	$3.03	$3.21	$3.39	$3.57	5.62%	5.17%	8.14%
AMERICAN ELEC. PWR.	AEP	$119.31	$3.98	$4.09	$4.20	$4.31	2.69%	5.17%	8.28%
ATMOS ENERGY CORP.	ATO	$170.41	$4.00	$4.35	$4.70	$5.05	8.08%	5.17%	7.69%
AVISTA CORP.	AVA	$39.77	$2.10	$2.17	$2.23	$2.30	3.08%	5.17%	10.17%
CMS ENERGY CORP.	CMS	$71.64	$2.30	$2.53	$2.77	$3.00	9.26%	5.17%	8.74%
CENTERPOINT EN'RGY	CNP	$39.31	$0.95	$0.98	$1.02	$1.05	3.39%	5.17%	7.44%
CHESAPEAKE UTIL.	CPK	$128.93	$2.82	$3.05	$3.27	$3.50	7.47%	5.17%	7.47%
DOMINION ENERGY	D	$59.71	$2.67	$2.71	$2.76	$2.80	1.60%	5.17%	9.23%
DTE ENERGY CO.	DTE	$134.37	$4.71	$4.86	$5.00	$5.15	3.02%	5.17%	8.47%
EVERSOURCE ENERGY	ES	$68.24	$3.15	$3.39	$3.64	$3.88	7.19%	5.17%	10.04%
ENTERGY CORP.	ETR	$95.57	$2.60	$2.73	$2.87	$3.00	4.89%	5.17%	7.85%
EVERGY, INC.	EVRG	$76.16	$2.84	$2.98	$3.11	$3.25	4.60%	5.17%	8.84%
EXELON CORP.	EXC	$44.55	$1.76	$1.84	$1.92	$2.00	4.35%	5.17%	9.03%
FIRST ENERGY	FE	$46.32	$1.86	$1.99	$2.11	$2.24	6.39%	5.17%	9.32%
IDA CORP, INC.	IDA	$131.12	$3.65	$3.83	$4.02	$4.20	4.79%	5.17%	7.91%
ALLIANT ENERGY	LNT	$66.60	$2.15	$2.24	$2.34	$2.43	4.17%	5.17%	8.30%
NEXTERA ENERGY	NEE	$84.93	$2.50	$2.83	$3.15	$3.48	11.66%	5.17%	8.65%
NI SOURCE INC.	NI	$43.34	$1.20	$1.31	$1.41	$1.52	8.20%	5.17%	8.16%
N.W. NATURAL	NWN	$47.73	$1.97	$1.98	$1.99	$2.00	0.51%	5.17%	8.80%
OGE ENERGY CORP.	OGE	$44.12	$1.73	$1.75	$1.77	$1.79	1.14%	5.17%	8.68%
ONE GAS, INC.	OGS	$79.96	$2.72	$2.80	$2.87	$2.95	2.74%	5.17%	8.35%
P.S. ENTERPRISE GP.	PEG	$80.93	$2.68	$2.94	$3.19	$3.45	8.78%	5.17%	8.81%
PINNACLE WEST	PNW	$91.09	$3.67	$3.78	$3.89	$4.00	2.91%	5.17%	8.96%
PORTLAND GENERAL	POR	$49.93	$2.20	$2.33	$2.45	$2.58	5.45%	5.17%	9.61%
PPL CORPORATION	PPL	$35.75	$1.16	$1.25	$1.35	$1.44	7.47%	5.17%	8.62%
SOUTHERN COMPANY	SO	$88.48	$3.04	$3.17	$3.31	$3.44	4.21%	5.17%	8.51%
SPIRE INC.	SR	$84.95	$3.30	$3.53	$3.77	$4.00	6.62%	5.17%	9.21%
SOUTHWEST GAS	SWX	$82.50	$2.48	$2.55	$2.63	$2.70	2.87%	5.17%	7.98%
WEC ENERGY GROUP	WEC	$108.41	$3.81	$4.07	$4.33	$4.59	6.41%	5.17%	8.80%
XCEL ENERGY	XEL	$76.56	$2.42	$2.61	$2.81	$3.00	7.42%	5.17%	8.52%
Maximum		$170.41	$4.71	$4.86	$5.00	$5.15	11.66%	5.17%	10.17%
Minimum		$35.75	$0.95	$0.98	$1.02	$1.05	0.51%	5.17%	7.44%
Median		$78.26	$2.64	$2.77	$2.87	$3.00	4.84%	5.17%	8.63%
Average		$79.79	$2.65	$2.80	$2.94	$3.09	5.23%	5.17%	**8.62%**

Sources:
[A] EOD Data: Market Data as of February 28, 2026. Average stock price Dec '25-Feb '26.
[B] Value Line: Most current data available at time of schedule preparation. 2029 data is VL forecast for 2028-30.
[C] Straight line interpolation based on Value Line data, assuming constant growth.
[D] Compounded annual growth calculation.
[E] 3-month weighted average sustainable growth rate for RFC Proxy Group as of February 28, 2026.
[F] Internal Rate of Return (IRR) calculation for 200-year dividend flow using Value Line forecasts and sustainable growth rate.

NON-CONSTANT GROWTH DISCOUNTED CASH FLOW (DCF) - INDICATED COST OF EQUITY
(BASED ON AVERAGE STOCK PRICE, VALUE LINE DIVIDEND FORECASTS, AND MOST RECENT OPTION-IMPLIED GROWTH)
RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
		Stock Price	Dividends per Share					Option-Implied	
		Dec '25-Feb '26 Avg.	2026	2027	2028	2029	Growth 26-29	Growth	Cost of Equity
		[A]	[B]	[C]	[C]	[B]	[D]	[E]	[F]
AMEREN	AEE	$103.07	$3.03	$3.21	$3.39	$3.57	5.62%	3.51%	6.62%
AMERICAN ELEC. PWR.	AEP	$119.31	$3.98	$4.09	$4.20	$4.31	2.69%	3.51%	6.77%
ATMOS ENERGY CORP.	ATO	$170.41	$4.00	$4.35	$4.70	$5.05	8.08%	3.51%	6.15%
AVISTA CORP.	AVA	$39.77	$2.10	$2.17	$2.23	$2.30	3.08%	3.51%	8.73%
CMS ENERGY CORP.	CMS	$71.64	$2.30	$2.53	$2.77	$3.00	9.26%	3.51%	7.25%
CENTERPOINT EN'RGY	CNP	$39.31	$0.95	$0.98	$1.02	$1.05	3.39%	3.51%	5.90%
CHESAPEAKE UTIL.	CPK	$128.93	$2.82	$3.05	$3.27	$3.50	7.47%	3.51%	5.92%
DOMINION ENERGY	D	$59.71	$2.67	$2.71	$2.76	$2.80	1.60%	3.51%	7.76%
DTE ENERGY CO.	DTE	$134.37	$4.71	$4.86	$5.00	$5.15	3.02%	3.51%	6.97%
EVERSOURCE ENERGY	ES	$68.24	$3.15	$3.39	$3.64	$3.88	7.19%	3.51%	8.59%
ENTERGY CORP.	ETR	$95.57	$2.60	$2.73	$2.87	$3.00	4.89%	3.51%	6.32%
EVERGY, INC.	EVRG	$76.16	$2.84	$2.98	$3.11	$3.25	4.60%	3.51%	7.35%
EXELON CORP.	EXC	$44.55	$1.76	$1.84	$1.92	$2.00	4.35%	3.51%	7.55%
FIRST ENERGY	FE	$46.32	$1.86	$1.99	$2.11	$2.24	6.39%	3.51%	7.85%
IDA CORP, INC.	IDA	$131.12	$3.65	$3.83	$4.02	$4.20	4.79%	3.51%	6.38%
ALLIANT ENERGY	LNT	$66.60	$2.15	$2.24	$2.34	$2.43	4.17%	3.51%	6.79%
NEXTERA ENERGY	NEE	$84.93	$2.50	$2.83	$3.15	$3.48	11.66%	3.51%	7.16%
NI SOURCE INC.	NI	$43.34	$1.20	$1.31	$1.41	$1.52	8.20%	3.51%	6.65%
N.W. NATURAL	NWN	$47.73	$1.97	$1.98	$1.99	$2.00	0.51%	3.51%	7.31%
OGE ENERGY CORP.	OGE	$44.12	$1.73	$1.75	$1.77	$1.79	1.14%	3.51%	7.18%
ONE GAS, INC.	OGS	$79.96	$2.72	$2.80	$2.87	$2.95	2.74%	3.51%	6.84%
P.S. ENTERPRISE GP.	PEG	$80.93	$2.68	$2.94	$3.19	$3.45	8.78%	3.51%	7.32%
PINNACLE WEST	PNW	$91.09	$3.67	$3.78	$3.89	$4.00	2.91%	3.51%	7.48%
PORTLAND GENERAL	POR	$49.93	$2.20	$2.33	$2.45	$2.58	5.45%	3.51%	8.15%
PPL CORPORATION	PPL	$35.75	$1.16	$1.25	$1.35	$1.44	7.47%	3.51%	7.12%
SOUTHERN COMPANY	SO	$88.48	$3.04	$3.17	$3.31	$3.44	4.21%	3.51%	7.01%
SPIRE INC.	SR	$84.95	$3.30	$3.53	$3.77	$4.00	6.62%	3.51%	7.73%
SOUTHWEST GAS	SWX	$82.50	$2.48	$2.55	$2.63	$2.70	2.87%	3.51%	6.46%
WEC ENERGY GROUP	WEC	$108.41	$3.81	$4.07	$4.33	$4.59	6.41%	3.51%	7.31%
XCEL ENERGY	XEL	$76.56	$2.42	$2.61	$2.81	$3.00	7.42%	3.51%	7.02%
Maximum		$170.41	$4.71	$4.86	$5.00	$5.15	11.66%	3.51%	8.73%
Minimum		$35.75	$0.95	$0.98	$1.02	$1.05	0.51%	3.51%	5.90%
Median		$78.26	$2.64	$2.77	$2.87	$3.00	4.84%	3.51%	7.14%
Average		$79.79	$2.65	$2.80	$2.94	$3.09	5.23%	3.51%	**7.12%**

Sources:
[A] EOD Data: Market Data as of February 28, 2026. Average stock price Dec '25-Feb '26.
[B] Value Line: Most current data available at time of schedule preparation. 2029 data is VL forecast for 2028-30.
[C] Straight line interpolation based on Value Line data, assuming constant growth.
[D] Compounded annual growth calculation.
[E] Most recent option-implied growth rate for RFC Proxy Group as of February 28, 2026.
[F] Internal Rate of Return (IRR) calculation for 200-year dividend flow using Value Line forecasts and option-implied growth rate.

NON-CONSTANT GROWTH DISCOUNTED CASH FLOW (DCF) - INDICATED COST OF EQUITY
(BASED ON AVERAGE STOCK PRICE, VALUE LINE DIVIDEND FORECASTS, AND 3-MONTH AVG. OPTION-IMPLIED GROWTH)
RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
		Stock Price	Dividends per Share					Option-Implied	
		Dec '25-Feb '26 Avg.	2026	2027	2028	2029	Growth 26-29	Growth	Cost of Equity
		[A]	[B]	[C]	[C]	[B]	[D]	[E]	[F]
AMEREN	AEE	$103.07	$3.03	$3.21	$3.39	$3.57	5.62%	3.49%	6.60%
AMERICAN ELEC. PWR.	AEP	$119.31	$3.98	$4.09	$4.20	$4.31	2.69%	3.49%	6.75%
ATMOS ENERGY CORP.	ATO	$170.41	$4.00	$4.35	$4.70	$5.05	8.08%	3.49%	6.13%
AVISTA CORP.	AVA	$39.77	$2.10	$2.17	$2.23	$2.30	3.08%	3.49%	8.71%
CMS ENERGY CORP.	CMS	$71.64	$2.30	$2.53	$2.77	$3.00	9.26%	3.49%	7.23%
CENTERPOINT EN'RGY	CNP	$39.31	$0.95	$0.98	$1.02	$1.05	3.39%	3.49%	5.88%
CHESAPEAKE UTIL.	CPK	$128.93	$2.82	$3.05	$3.27	$3.50	7.47%	3.49%	5.90%
DOMINION ENERGY	D	$59.71	$2.67	$2.71	$2.76	$2.80	1.60%	3.49%	7.74%
DTE ENERGY CO.	DTE	$134.37	$4.71	$4.86	$5.00	$5.15	3.02%	3.49%	6.95%
EVERSOURCE ENERGY	ES	$68.24	$3.15	$3.39	$3.64	$3.88	7.19%	3.49%	8.58%
ENTERGY CORP.	ETR	$95.57	$2.60	$2.73	$2.87	$3.00	4.89%	3.49%	6.30%
EVERGY, INC.	EVRG	$76.16	$2.84	$2.98	$3.11	$3.25	4.60%	3.49%	7.33%
EXELON CORP.	EXC	$44.55	$1.76	$1.84	$1.92	$2.00	4.35%	3.49%	7.53%
FIRST ENERGY	FE	$46.32	$1.86	$1.99	$2.11	$2.24	6.39%	3.49%	7.83%
IDA CORP, INC.	IDA	$131.12	$3.65	$3.83	$4.02	$4.20	4.79%	3.49%	6.36%
ALLIANT ENERGY	LNT	$66.60	$2.15	$2.24	$2.34	$2.43	4.17%	3.49%	6.77%
NEXTERA ENERGY	NEE	$84.93	$2.50	$2.83	$3.15	$3.48	11.66%	3.49%	7.14%
NI SOURCE INC.	NI	$43.34	$1.20	$1.31	$1.41	$1.52	8.20%	3.49%	6.63%
N.W. NATURAL	NWN	$47.73	$1.97	$1.98	$1.99	$2.00	0.51%	3.49%	7.29%
OGE ENERGY CORP.	OGE	$44.12	$1.73	$1.75	$1.77	$1.79	1.14%	3.49%	7.17%
ONE GAS, INC.	OGS	$79.96	$2.72	$2.80	$2.87	$2.95	2.74%	3.49%	6.82%
P.S. ENTERPRISE GP.	PEG	$80.93	$2.68	$2.94	$3.19	$3.45	8.78%	3.49%	7.30%
PINNACLE WEST	PNW	$91.09	$3.67	$3.78	$3.89	$4.00	2.91%	3.49%	7.46%
PORTLAND GENERAL	POR	$49.93	$2.20	$2.33	$2.45	$2.58	5.45%	3.49%	8.13%
PPL CORPORATION	PPL	$35.75	$1.16	$1.25	$1.35	$1.44	7.47%	3.49%	7.10%
SOUTHERN COMPANY	SO	$88.48	$3.04	$3.17	$3.31	$3.44	4.21%	3.49%	6.99%
SPIRE INC.	SR	$84.95	$3.30	$3.53	$3.77	$4.00	6.62%	3.49%	7.71%
SOUTHWEST GAS	SWX	$82.50	$2.48	$2.55	$2.63	$2.70	2.87%	3.49%	6.44%
WEC ENERGY GROUP	WEC	$108.41	$3.81	$4.07	$4.33	$4.59	6.41%	3.49%	7.29%
XCEL ENERGY	XEL	$76.56	$2.42	$2.61	$2.81	$3.00	7.42%	3.49%	7.00%
Maximum		$170.41	$4.71	$4.86	$5.00	$5.15	11.66%	3.49%	8.71%
Minimum		$35.75	$0.95	$0.98	$1.02	$1.05	0.51%	3.49%	5.88%
Median		$78.26	$2.64	$2.77	$2.87	$3.00	4.84%	3.49%	7.12%
Average		$79.79	$2.65	$2.80	$2.94	$3.09	5.23%	3.49%	**7.10%**

Sources:
[A] EOD Data: Market Data as of February 28, 2026. Average stock price Dec '25-Feb '26.
[B] Value Line: Most current data available at time of schedule preparation. 2029 data is VL forecast for 2028-30.
[C] Straight line interpolation based on Value Line data, assuming constant growth.
[D] Compounded annual growth calculation.
[E] 3-month weighted average option-implied growth rate for RFC Proxy Group as of February 28, 2026.
[F] Internal Rate of Return (IRR) calculation for 200-year dividend flow using Value Line forecasts and option-implied growth rate.

Exhibit__(NYCRP-6)

CAPITAL ASSET PRICING MODEL (CAPM) - INDICATED COST OF EQUITY

WEIGHTED - All Inputs Weighted From December 2025 to February 2026

RFC Proxy Group

	3-Month Treasury Bill		30-Year Treasury Bond	
	Historical Blended Beta	Forward Beta	Historical Blended Beta	Forward Beta
Risk-Free Rate	3.67%	3.67%	4.77%	4.77%
Beta	0.45	0.55	0.45	0.55
Risk Premium	5.13%	5.13%	4.04%	4.04%
CAPM (Weighted)	5.97%	6.47%	6.57%	6.97%

CAPITAL ASSET PRICING MODEL (CAPM) - RISK-FREE RATE

Spot (Feb. 28, 2026)	
3-Month Treasury Bill	3.67%
30-Year Treasury Bond	4.64%
3-Mo. Weighted Average (Dec. 2025 to Feb. 2026)	
3-Month Treasury Bill	3.67%
30-Year Treasury Bond	4.77%

Source: www.treasury.gov

CAPITAL ASSET PRICING MODEL (CAPM) - BETAS
(BASED ON HISTORICAL AND OPTION-IMPLIED RETURNS)
RFC Proxy Group

Betas	11/25/2025	12/02/2025	12/09/2025	12/16/2025	12/23/2025	12/30/2025	01/06/2026	01/13/2026	01/20/2026	01/27/2026	02/03/2026	02/10/2026	02/17/2026	02/24/2026	Average	Time Avg.
Forward (6 months)	0.54	0.54	0.54	0.53	0.58	0.55	0.52	0.51	0.50	0.57	0.57	0.58	0.55	0.53	0.543	0.546
Historical (6 months)	0.41	0.43	0.42	0.41	0.39	0.39	0.39	0.36	0.35	0.37	0.36	0.34	0.31	0.30	0.374	0.353
Historical (2 yrs)	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.48	0.47	0.48	0.48	0.48	0.47	0.47	0.473	0.474
Historical (5 yrs)	0.65	0.65	0.65	0.65	0.64	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.64	0.64	0.645	0.645
Weighting																
Forward (6 months)	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%		
Historical (6 months)	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%		
Historical (2 yrs)	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%		
Historical (5 yrs)	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%		
Historical Blended Beta	**0.47**	**0.49**	**0.48**	**0.48**	**0.47**	**0.47**	**0.47**	**0.45**	**0.45**	**0.46**	**0.45**	**0.44**	**0.43**	**0.42**	0.458	0.448
Slope	15%															
Points	0.00	1.00	1.15	1.32	1.52	1.75	2.01	2.31	2.66	3.06	3.52	4.05	4.65	5.35		
Time Weight	0.0%	2.9%	3.3%	3.8%	4.4%	5.1%	5.9%	6.7%	7.7%	8.9%	10.2%	11.8%	13.5%	15.6%		

CAPM Betas	Spot (Feb 24, 2026)	Weighted (Dec 2025 - Feb 2026)
Forward	0.53	0.55
Historical Blended	0.42	0.45

Note: Historical betas are calculated on Tuesdays, following Value Line's methodology. Forward (option-implied) betas are also calculated on Tuesdays for the sake of compatibility.

CAPITAL ASSET PRICING MODEL (CAPM) - MARKET RISK PREMIUM

WEIGHTED - All Inputs Weighted From December 2025 to February 2026

Cumulative Probability	50.00%	
S&P 500 Option-Implied Growth Rate	7.65%	
S&P 500 Dividend Yield	1.15%	
S&P 500 Market Return	8.80%	
	3-Month Treasury Bill	**30-Year Treasury Bond**
Risk-Free Rate	3.67%	4.77%
Option-Implied Market Risk Premium (Weighted)	5.13%	4.04%

CAPITAL ASSET PRICING MODEL (CAPM) - INDICATED COST OF EQUITY

SPOT - All Inputs Based on Last Available Data as of February 28, 2026
RFC Proxy Group

	3-Month Treasury Bill		30-Year Treasury Bond	
	Historical Blended Beta	Forward Beta	Historical Blended Beta	Forward Beta
Risk-Free Rate	3.67%	3.67%	4.64%	4.64%
Beta	0.42	0.53	0.42	0.53
Risk Premium	5.29%	5.29%	4.32%	4.32%
CAPM (Spot)	5.89%	6.47%	6.45%	6.92%

CAPITAL ASSET PRICING MODEL (CAPM) - MARKET RISK PREMIUM

SPOT - All Inputs Based on Last Available Data as of February 28, 2026

Cumulative Probability	50.00%	
S&P 500 Option-Implied Growth Rate	7.82%	
S&P 500 Dividend Yield	1.14%	
S&P 500 Market Return	8.96%	
	3-Month Treasury Bill	**30-Year Treasury Bond**
Risk-Free Rate	3.67%	4.64%
Option-Implied Market Risk Premium (Spot)	5.29%	4.32%

Exhibit__(NYCRP-7)

MARKET TO BOOK RATIO AND DIVIDEND YIELD

RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]
		Book Value per Share															
		Actual				**Estimated**			**Market Price**			**Mkt. to Book Ratio**		**Dividend Rate**		**Dividend Yield**	
		12/31/22	**12/31/23**	**12/31/24**	**12/31/25**	**2/28/25**	**2/28/26**	**12/31/26**	**2/28/26**	**LTM High**	**LTM Low**	**2/28/26**	**LTM Avg.**	**MRQ**	**Annual**	**2/28/26**	**LTM Avg.**
		[A]	[A]	[A]	[A]	[B]	[B]	[A]	[C]	[C]	[C]	[D]	[D]	[A]	[E]	[F]	[F]
ATMOS ENERGY CORP.	ATO	$66.85	$73.20	$78.31	$83.92	$79.21	$84.52	$87.70	$186.79	$187.82	$141.59	2.21	2.01	$1.000	$4.000	2.14%	2.43%
CHESAPEAKE UTIL.	CPK	$46.94	$56.04	$60.71	$64.40	$61.30	$65.34	$70.30	$135.97	$140.59	$115.24	2.08	2.02	$0.685	$2.740	2.02%	2.14%
NI SOURCE INC.	NI	$14.63	$17.40	$18.48	$25.79	$19.65	$25.78	$25.75	$47.30	$47.35	$35.64	1.83	1.83	$0.300	$1.200	2.54%	2.89%
N.W. NATURAL	NWN	$33.09	$34.12	$34.44	$34.25	$34.41	$34.57	$36.25	$53.04	$53.48	$38.94	1.53	1.34	$0.493	$1.972	3.72%	4.27%
ONE GAS, INC.	OGS	$46.69	$48.91	$51.85	$53.65	$52.14	$53.79	$54.55	$87.44	$87.84	$69.75	1.63	1.49	$0.680	$2.720	3.11%	3.45%
SOUTHWEST GAS	SWX	$45.57	$46.25	$48.82	$54.45	$49.72	$54.63	$55.55	$88.17	$89.14	$64.69	1.61	1.47	$0.620	$2.480	2.81%	3.22%
SPIRE INC.	SR	$49.08	$50.29	$51.83	$53.35	$52.07	$53.17	$52.25	$91.61	$92.95	$69.94	1.72	1.55	$0.825	$3.300	3.60%	4.05%
ALLIANT ENERGY	LNT	$24.99	$26.46	$27.29	$28.85	$27.54	$28.87	$29.00	$72.34	$72.40	$57.09	2.51	2.30	$0.508	$2.032	2.81%	3.14%
AMEREN	AEE	$40.11	$40.26	$42.78	$45.95	$43.29	$46.39	$48.70	$113.28	$113.44	$91.77	2.44	2.29	$0.710	$2.840	2.51%	2.77%
AMERICAN ELEC. PWR.	AEP	$46.60	$48.46	$50.63	$52.35	$50.91	$52.86	$55.55	$133.82	$134.60	$97.46	2.53	2.24	$0.950	$3.800	2.84%	3.28%
AVISTA CORP.	AVA	$31.15	$31.83	$32.37	$33.15	$32.49	$33.33	$34.25	$40.62	$43.50	$35.50	1.22	1.20	$0.490	$1.960	4.83%	4.96%
CENTERPOINT EN'RGY	CNP	$14.68	$15.31	$16.37	$17.90	$16.61	$18.12	$19.30	$43.50	$43.58	$33.24	2.40	2.21	$0.220	$0.880	2.02%	2.29%
CMS ENERGY CORP.	CMS	$23.32	$24.86	$26.79	$28.90	$27.13	$29.16	$30.50	$78.07	$78.31	$67.71	2.68	2.59	$0.543	$2.170	2.78%	2.97%
DOMINION ENERGY	D	$31.26	$30.72	$30.82	$31.65	$30.95	$31.88	$33.10	$63.14	$67.57	$48.07	1.98	1.84	$0.668	$2.670	4.23%	4.62%
DTE ENERGY CO.	DTE	$46.35	$53.55	$55.82	$58.40	$56.23	$58.70	$60.30	$148.24	$154.63	$123.69	2.53	2.42	$1.090	$4.360	2.94%	3.13%
ENTERGY CORP.	ETR	$30.70	$34.35	$35.11	$36.70	$35.36	$37.03	$38.75	$107.11	$107.21	$75.57	2.89	2.52	$0.640	$2.560	2.39%	2.80%
EVERSOURCE ENERGY	ES	$44.41	$40.55	$41.02	$43.35	$41.39	$43.66	$45.30	$75.41	$76.41	$52.28	1.73	1.51	$0.788	$3.150	4.18%	4.90%
EXELON CORP.	EXC	$24.89	$25.78	$26.79	$27.25	$26.86	$27.39	$28.10	$49.05	$49.88	$41.71	1.79	1.69	$0.400	$1.600	3.26%	3.49%
FIRST ENERGY	FE	$17.77	$18.17	$21.60	$22.15	$21.69	$22.33	$23.25	$51.16	$51.34	$37.58	2.29	2.02	$0.445	$1.780	3.48%	4.00%
EVERGY, INC.	EVRG	$41.86	$42.06	$43.43	$45.65	$43.79	$45.68	$45.85	$83.66	$84.08	$61.94	1.83	1.63	$0.690	$2.760	3.30%	3.78%
IDA CORP, INC.	IDA	$55.52	$57.44	$61.73	$64.10	$62.11	$64.72	$68.00	$143.97	$145.94	$108.15	2.22	2.00	$0.880	$3.520	2.44%	2.77%
NEXTERA ENERGY	NEE	$19.74	$23.13	$24.36	$26.20	$24.65	$26.53	$28.25	$93.77	$95.91	$61.72	3.53	3.08	$0.567	$2.266	2.42%	2.88%
OGE ENERGY CORP.	OGE	$22.52	$22.17	$22.87	$23.75	$23.01	$23.83	$24.25	$49.14	$49.18	$40.80	2.06	1.92	$0.421	$1.685	3.43%	3.75%
PINNACLE WEST	PNW	$53.45	$54.47	$56.71	$58.00	$56.92	$58.12	$58.75	$100.30	$101.13	$85.32	1.73	1.62	$0.910	$3.640	3.63%	3.90%
PORTLAND GENERAL	POR	$31.13	$32.81	$34.70	$36.00	$34.91	$36.24	$37.50	$53.96	$54.39	$39.55	1.49	1.32	$0.525	$2.100	3.89%	4.47%
PPL CORPORATION	PPL	$18.89	$18.90	$19.07	$20.55	$19.31	$20.65	$21.20	$38.98	$39.04	$32.50	1.89	1.79	$0.273	$1.092	2.80%	3.05%
P.S. ENTERPRISE GP.	PEG	$27.62	$31.08	$32.36	$34.80	$32.75	$35.11	$36.75	$86.07	$91.26	$74.67	2.45	2.45	$0.630	$2.520	2.93%	3.04%
SOUTHERN COMPANY	SO	$27.93	$28.82	$29.85	$31.75	$30.15	$31.77	$31.90	$97.38	$100.84	$83.09	3.06	2.97	$0.740	$2.960	3.04%	3.22%
WEC ENERGY GROUP	WEC	$36.76	$37.25	$39.11	$40.70	$39.36	$40.99	$42.50	$116.96	$118.19	$100.61	2.85	2.72	$0.893	$3.570	3.05%	3.26%
XCEL ENERGY	XEL	$30.34	$31.74	$33.99	$36.30	$34.36	$36.69	$38.75	$83.36	$84.23	$65.21	2.27	2.10	$0.570	$2.280	2.74%	3.05%
Maximum		$66.85	$73.20	$78.31	$83.92	$79.21	$84.52	$87.70	$186.79	$187.82	$141.59	3.53	3.08	$1.090	$4.360	4.83%	4.96%
Minimum		$14.63	$15.31	$16.37	$17.90	$16.61	$18.12	$19.30	$38.98	$39.04	$32.50	1.22	1.20	$0.220	$0.880	2.02%	2.14%
Median		$31.21	$33.47	$34.57	$36.15	$34.66	$36.47	$38.13	$84.87	$86.04	$64.95	2.15	2.01	$0.635	$2.540	2.93%	3.22%
Average		$34.83	$36.55	$38.33	$40.47	$38.68	$40.73	$42.07	$87.12	$88.54	$68.37	2.17	2.01	$0.638	$2.554	3.06%	3.40%

Sources:
[A] Value Line: Most current data available at time of schedule preparation.
[B] Straight-line interpolation of Actual and Estimated VL year-end values.
[C] EOD Data: Market Data as of February 28, 2026.
[D] Market Price divided by Book Value per Share.
[E] Most Recent Quarterly Dividend multiplied by 4.
[F] Dividend Rate divided by Market Price.

EARNINGS PER SHARE AND RETURN ON EQUITY
RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
		Earnings per Share				**Return on Equity**			
		2022	**2023**	**2024**	**2025**	**2023**	**2024**	**2025**	**VL Future Exp.**
		[A]	[A]	[A]	[A]	[B]	[B]	[B]	[A]
ATMOS ENERGY CORP.	ATO	$5.60	$6.10	$6.83	$7.46	8.71%	9.02%	9.20%	9.50%
CHESAPEAKE UTIL.	CPK	$4.97	$4.73	$5.26	$5.80	9.19%	9.01%	9.27%	9.50%
NI SOURCE INC.	NI	$1.47	$1.60	$1.75	$1.95	9.99%	9.75%	8.81%	8.00%
N.W. NATURAL	NWN	$2.54	$2.59	$2.03	$2.90	7.71%	5.92%	8.44%	8.00%
ONE GAS, INC.	OGS	$4.08	$4.14	$3.91	$4.37	8.66%	7.76%	8.28%	11.00%
SOUTHWEST GAS	SWX	($3.10)	$2.13	$2.76	$3.65	4.64%	5.81%	7.07%	9.00%
SPIRE INC.	SR	$3.95	$3.85	$4.19	$4.44	7.75%	8.21%	8.44%	12.50%
ALLIANT ENERGY	LNT	$2.73	$2.78	$2.69	$3.25	10.81%	10.01%	11.58%	12.00%
AMEREN	AEE	$4.14	$4.37	$4.59	$5.00	10.87%	11.05%	11.27%	10.00%
AMERICAN ELEC. PWR.	AEP	$5.09	$5.24	$5.61	$5.90	11.02%	11.32%	11.46%	11.00%
AVISTA CORP.	AVA	$2.12	$2.24	$2.29	$2.55	7.11%	7.13%	7.78%	9.50%
CENTERPOINT EN'RGY	CNP	$1.59	$1.37	$1.58	$1.75	9.14%	9.97%	10.21%	11.00%
CMS ENERGY CORP.	CMS	$2.84	$3.01	$3.33	$3.60	12.49%	12.89%	12.93%	15.00%
DOMINION ENERGY	D	$4.11	$1.99	$2.77	$3.40	6.42%	9.00%	10.89%	11.00%
DTE ENERGY CO.	DTE	$5.52	$6.76	$6.77	$7.20	13.53%	12.38%	12.61%	12.50%
ENTERGY CORP.	ETR	$2.69	$5.55	$2.45	$4.10	17.06%	7.05%	11.42%	9.50%
EVERSOURCE ENERGY	ES	$4.09	$4.34	$4.57	$4.75	10.22%	11.21%	11.26%	11.50%
EXELON CORP.	EXC	$2.26	$2.38	$2.45	$2.70	9.39%	9.32%	9.99%	10.00%
FIRST ENERGY	FE	$2.41	$2.56	$2.63	$2.55	14.25%	13.23%	11.66%	12.50%
EVERGY, INC.	EVRG	$3.26	$3.17	$3.80	$4.00	7.55%	8.89%	8.98%	10.00%
IDA CORP, INC.	IDA	$5.11	$5.14	$5.50	$5.85	9.10%	9.23%	9.30%	10.00%
NEXTERA ENERGY	NEE	$2.90	$3.17	$3.43	$3.71	14.79%	14.45%	14.68%	14.00%
OGE ENERGY CORP.	OGE	$2.25	$2.07	$2.19	$2.30	9.26%	9.72%	9.87%	13.00%
PINNACLE WEST	PNW	$4.26	$4.41	$5.24	$4.95	8.17%	9.43%	8.63%	9.00%
PORTLAND GENERAL	POR	$2.74	$2.38	$3.14	$3.25	7.44%	9.30%	9.19%	9.50%
PPL CORPORATION	PPL	$1.41	$1.60	$1.68	$1.80	8.47%	8.85%	9.09%	9.50%
P.S. ENTERPRISE GP.	PEG	$3.47	$3.48	$3.68	$4.05	11.86%	11.60%	12.06%	12.50%
SOUTHERN COMPANY	SO	$3.61	$3.64	$4.06	$4.30	12.83%	13.84%	13.96%	14.50%
WEC ENERGY GROUP	WEC	$4.46	$4.63	$4.89	$5.25	12.51%	12.81%	13.16%	13.00%
XCEL ENERGY	XEL	$3.17	$3.35	$3.50	$3.80	10.79%	10.65%	10.81%	11.50%
Maximum		$5.60	$6.76	$6.83	$7.46	17.06%	14.45%	14.68%	15.00%
Minimum		($3.10)	$1.37	$1.58	$1.75	4.64%	5.81%	7.07%	8.00%
Median		$3.22	$3.26	$3.47	$3.90	9.33%	9.58%	10.10%	11.00%
Average		$3.19	$3.49	$3.65	$4.02	10.06%	9.96%	10.41%	10.98%

Sources:
[A] Value Line: Most current data available at time of schedule preparation.
[B] Earnings per Share divded by average Book Value. Book Values shown on Exhibit__(NYCRP-7), page 1.

RETURN ON EQUITY IMPLIED BY ZACKS GROWTH RATES

RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
				Annual	Analyst	Analyst-Implied		Analyst-Implied		Implied	Analyst-
		Book Value	EPS	Dividend	5 Year	Book Value before SV		Book Value Incl. SV		EPS	Implied
		12/31/25	2025	Rate	Growth Rate	12/31/2029	12/31/2030	12/31/2029	12/31/2030	2030	ROE
		[A]	[A]	[A]	[B]	[C]	[C]	[C]	[C]	[C]	[C]
ATMOS ENERGY CORP.	ATO	$83.92	$7.46	$4.000	7.00%	$100.36	$105.21	$157.05	$184.15	$10.46	6.13%
CHESAPEAKE UTIL.	CPK	$64.40	$5.80	$2.740	NA	NA	NA	NA	NA	NA	NA
NI SOURCE INC.	NI	$25.79	$1.95	$1.200	6.00%	$29.27	$30.27	$32.95	$35.11	$2.61	7.67%
N.W. NATURAL	NWN	$34.25	$2.90	$1.972	NA	NA	NA	NA	NA	NA	NA
ONE GAS, INC.	OGS	$53.65	$4.37	$2.720	8.10%	$61.70	$64.13	$92.48	$106.37	$6.45	6.49%
SOUTHWEST GAS	SWX	$54.45	$3.65	$2.480	9.20%	$60.31	$62.13	$65.67	$69.11	$5.67	8.41%
SPIRE INC.	SR	$53.35	$4.44	$3.300	12.00%	$59.45	$61.46	$91.19	$104.91	$7.82	7.98%
ALLIANT ENERGY	LNT	$28.85	$3.25	$2.032	7.20%	$34.66	$36.39	$35.34	$37.28	$4.60	12.67%
AMEREN	AEE	$45.95	$5.00	$2.840	9.30%	$56.79	$60.16	$63.74	$69.49	$7.80	11.71%
AMERICAN ELEC. PWR.	AEP	$52.35	$5.90	$3.800	6.70%	$62.25	$65.16	$66.21	$70.38	$8.16	11.95%
AVISTA CORP.	AVA	$33.15	$2.55	$1.960	7.10%	$35.96	$36.79	$37.38	$38.61	$3.59	9.46%
CENTERPOINT EN'RGY	CNP	$17.90	$1.75	$0.880	8.90%	$22.23	$23.56	$22.23	$23.56	$2.68	11.71%
CMS ENERGY CORP.	CMS	$28.90	$3.60	$2.170	7.30%	$35.74	$37.78	$36.16	$38.33	$5.12	13.75%
DOMINION ENERGY	D	$31.65	$3.40	$2.670	10.30%	$35.40	$36.60	$42.14	$45.50	$5.55	12.67%
DTE ENERGY CO.	DTE	$58.40	$7.20	$4.360	7.10%	$71.92	$75.93	$72.52	$76.71	$10.15	13.60%
ENTERGY CORP.	ETR	$36.70	$4.10	$2.560	11.50%	$44.85	$47.50	$53.11	$58.68	$7.07	12.64%
EVERSOURCE ENERGY	ES	$43.35	$4.75	$3.150	4.70%	$50.54	$52.55	$54.29	$57.48	$5.98	10.69%
EXELON CORP.	EXC	$27.25	$2.70	$1.600	6.00%	$32.35	$33.82	$32.35	$33.82	$3.61	10.92%
FIRST ENERGY	FE	$22.15	$2.55	$1.780	7.00%	$25.81	$26.89	$28.58	$30.54	$3.58	12.10%
EVERGY, INC.	EVRG	$45.65	$4.00	$2.760	5.90%	$51.39	$53.04	$51.39	$53.04	$5.33	10.20%
IDA CORP, INC.	IDA	$64.10	$5.85	$3.520	8.00%	$75.44	$78.86	$77.47	$81.52	$8.60	10.81%
NEXTERA ENERGY	NEE	$26.20	$3.71	$2.266	NA	NA	NA	NA	NA	NA	NA
OGE ENERGY CORP.	OGE	$23.75	$2.30	$1.685	5.80%	$26.59	$27.40	$26.59	$27.40	$3.05	11.29%
PINNACLE WEST	PNW	$58.00	$4.95	$3.640	5.80%	$64.05	$65.78	$69.00	$72.21	$6.56	9.29%
PORTLAND GENERAL	POR	$36.00	$3.25	$2.100	5.20%	$41.23	$42.71	$45.63	$48.48	$4.19	8.90%
PPL CORPORATION	PPL	$20.55	$1.80	$1.092	7.30%	$23.94	$24.94	$23.98	$25.00	$2.56	10.45%
P.S. ENTERPRISE GP.	PEG	$34.80	$4.05	$2.520	7.10%	$42.09	$44.24	$43.19	$45.70	$5.71	12.84%
SOUTHERN COMPANY	SO	$31.75	$4.30	$2.960	7.20%	$38.15	$40.04	$39.57	$41.92	$6.09	14.94%
WEC ENERGY GROUP	WEC	$40.70	$5.25	$3.570	7.40%	$48.76	$51.16	$48.76	$51.16	$7.50	15.02%
XCEL ENERGY	XEL	$36.30	$3.80	$2.280	8.90%	$43.86	$46.19	$45.33	$48.13	$5.82	12.46%
Maximum		$83.92	$7.46	$4.360	12.00%	$100.36	$105.21	$157.05	$184.15	$10.46	15.02%
Minimum		$17.90	$1.75	$0.880	4.70%	$22.23	$23.56	$22.23	$23.56	$2.56	6.13%
Median		$36.15	$3.90	$2.540	7.20%	$43.86	$46.19	$45.63	$48.48	$5.71	11.29%
Average		$40.47	$4.02	$2.554	7.56%	$47.23	$49.29	$53.86	$58.32	$5.79	10.99%

Sources:
[A] Value Line: Most current data available at time of schedule preparation.
[B] Zacks: Data as of March 08, 2026.
[C] Analyst-Implied Book Value and Return on Equity is obtained by escalating both Dividends and Earnings per Share by the stated Analyst Growth Rate and adding Earnings and subtracting Dividends for each projected year.
"SV" = S X V, where S = rate of continuous new stock financing and V = rate of return on common equity investment.

CAPITAL STRUCTURE WITH SHORT TERM DEBT
RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
		% Common Equity					($ millions)						Percentage			
		2021	**2022**	**2023**	**2024**	**2025**	**Total Debt**	**LT Debt**	**ST Debt**	**Pfd Stock**	**Equity**	**Total Capital**	**LT Debt**	**ST Debt**	**Pfd Stock**	**Equity Ratio**
		[A]	[A]	[A]	[A]	[A]	[A]	[A]	[A]	[A]	[A]	[A]	[B]	[B]	[B]	[B]
ATMOS ENERGY CORP.	ATO	61.6%	62.1%	62.1%	60.7%	60.2%	$ 9,632.8	$ 9,621.8	$ 11.0	$ -	$ 14,553.6	$ 24,186.4	39.8%	0.0%	0.0%	60.2%
CHESAPEAKE UTIL.	CPK	58.5%	59.0%	51.2%	52.4%	51.5%	$ 1,568.2	$ 1,437.9	$ 130.3	$ -	$ 1,526.8	$ 3,095.0	46.5%	4.2%	0.0%	49.3%
NI SOURCE INC.	NI	33.5%	35.3%	40.3%	41.8%	46.0%	$ 16,303.0	$ 15,547.0	$ 756.0	$ -	$ 13,243.7	$ 29,546.7	52.6%	2.6%	0.0%	44.8%
N.W. NATURAL	NWN	47.2%	48.5%	47.4%	45.2%	45.0%	$ 2,439.0	$ 2,128.0	$ 311.0	$ -	$ 1,741.1	$ 4,180.1	50.9%	7.4%	0.0%	41.7%
ONE GAS, INC.	OGS	38.9%	49.3%	56.1%	56.5%	57.5%	$ 3,400.2	$ 2,355.6	$ 1,044.6	$ -	$ 3,187.0	$ 6,587.2	35.8%	15.9%	0.0%	48.4%
SOUTHWEST GAS	SWX	41.8%	41.0%	41.8%	44.6%	45.0%	$ 3,507.1	$ 3,507.1	$ -	$ -	$ 2,869.4	$ 6,376.5	55.0%	0.0%	0.0%	45.0%
SPIRE INC.	SR	43.2%	44.6%	41.3%	43.1%	46.6%	$ 5,349.5	$ 4,449.4	$ 900.1	$ 242.0	$ 4,094.0	$ 9,685.5	45.9%	9.3%	2.5%	42.3%
ALLIANT ENERGY	LNT	47.1%	45.0%	45.2%	44.7%	44.5%	$ 11,924.0	$ 10,655.0	$ 1,269.0	$ -	$ 8,543.2	$ 20,467.2	52.1%	6.2%	0.0%	41.7%
AMEREN	AEE	43.3%	43.4%	43.8%	45.3%	47.0%	$ 20,075.0	$ 19,172.0	$ 903.0	$ 129.0	$ 17,116.0	$ 37,320.0	51.4%	2.4%	0.3%	45.9%
AMERICAN ELEC. PWR.	AEP	41.7%	42.0%	42.0%	42.4%	42.0%	$ 45,397.0	$ 44,239.0	$ 1,158.0	$ -	$ 32,035.1	$ 77,432.1	57.1%	1.5%	0.0%	41.4%
AVISTA CORP.	AVA	52.5%	49.6%	48.8%	49.0%	49.5%	$ 3,092.0	$ 2,805.0	$ 287.0	$ -	$ 2,749.5	$ 5,841.5	48.0%	4.9%	0.0%	47.1%
CENTERPOINT EN'RGY	CNP	34.5%	37.1%	35.5%	34.3%	37.5%	$ 21,802.0	$ 19,400.0	$ 2,402.0	$ -	$ 11,640.0	$ 33,442.0	58.0%	7.2%	0.0%	34.8%
CMS ENERGY CORP.	CMS	34.2%	33.6%	33.1%	34.0%	34.0%	$ 18,073.0	$ 16,911.0	$ 1,162.0	$ 224.0	$ 8,827.1	$ 27,124.1	62.3%	4.3%	0.8%	32.5%
DOMINION ENERGY	D	38.5%	39.1%	42.4%	40.5%	38.0%	$ 48,549.0	$ 43,291.0	$ 5,258.0	$ 991.0	$ 27,140.6	$ 76,680.6	56.5%	6.9%	1.3%	35.4%
DTE ENERGY CO.	DTE	37.5%	37.0%	38.0%	38.2%	38.5%	$ 22,750.0	$ 22,424.0	$ 326.0	$ -	$ 14,037.8	$ 36,787.8	61.0%	0.9%	0.0%	38.2%
ENTERGY CORP.	ETR	31.7%	35.2%	38.6%	36.0%	36.5%	$ 30,447.0	$ 27,058.0	$ 3,389.0	$ 219.4	$ 15,679.1	$ 46,345.5	58.4%	7.3%	0.5%	33.8%
EVERSOURCE ENERGY	ES	45.3%	43.3%	37.0%	36.5%	37.5%	$ 29,836.0	$ 27,135.0	$ 2,701.0	$ 155.6	$ 16,374.4	$ 46,366.0	58.5%	5.8%	0.3%	35.3%
EXELON CORP.	EXC	49.1%	40.2%	39.1%	39.5%	39.0%	$ 47,363.0	$ 46,283.0	$ 1,080.0	$ -	$ 29,590.8	$ 76,953.8	60.1%	1.4%	0.0%	38.5%
FIRST ENERGY	FE	28.1%	32.4%	31.3%	35.6%	33.5%	$ 27,470.0	$ 25,510.0	$ 1,960.0	$ -	$ 12,850.9	$ 40,320.9	63.3%	4.9%	0.0%	31.9%
EVERGY, INC.	EVRG	49.9%	48.0%	48.0%	48.5%	48.0%	$ 13,063.0	$ 12,446.0	$ 617.0	$ -	$ 11,488.6	$ 24,551.6	50.7%	2.5%	0.0%	46.8%
IDA CORP, INC.	IDA	57.2%	56.1%	51.2%	52.2%	51.5%	$ 3,330.7	$ 3,330.7	$ -	$ -	$ 3,536.7	$ 6,867.4	48.5%	0.0%	0.0%	51.5%
NEXTERA ENERGY	NEE	42.2%	41.5%	43.6%	40.9%	38.0%	$ 95,619.0	$ 89,556.0	$ 6,063.0	$ -	$ 54,889.2	$150,508.2	59.5%	4.0%	0.0%	36.5%
OGE ENERGY CORP.	OGE	47.4%	52.4%	49.6%	49.2%	48.5%	$ 5,834.5	$ 5,368.2	$ 466.3	$ -	$ 5,055.5	$ 10,890.0	49.3%	4.3%	0.0%	46.4%
PINNACLE WEST	PNW	46.1%	43.9%	45.0%	45.6%	44.5%	$ 10,480.0	$ 9,204.0	$ 1,276.0	$ -	$ 7,379.8	$ 17,859.8	51.5%	7.1%	0.0%	41.3%
PORTLAND GENERAL	POR	43.2%	43.0%	44.2%	45.0%	44.0%	$ 5,023.0	$ 4,928.0	$ 95.0	$ -	$ 3,872.0	$ 8,895.0	55.4%	1.1%	0.0%	43.5%
PPL CORPORATION	PPL	56.3%	51.9%	48.8%	49.1%	49.0%	$ 18,986.0	$ 16,936.0	$ 2,050.0	$ -	$ 16,271.8	$ 35,257.8	48.0%	5.8%	0.0%	46.2%
P.S. ENTERPRISE GP.	PEG	48.7%	45.4%	46.5%	45.9%	44.5%	$ 23,370.0	$ 21,666.0	$ 1,704.0	$ -	$ 17,371.8	$ 40,741.8	53.2%	4.2%	0.0%	42.6%
SOUTHERN COMPANY	SO	35.6%	36.5%	37.6%	36.8%	36.0%	$ 72,162.0	$ 64,621.0	$ 7,541.0	$ 242.0	$ 36,485.4	$108,889.4	59.3%	6.9%	0.2%	33.5%
WEC ENERGY GROUP	WEC	44.6%	44.4%	44.1%	44.3%	44.5%	$ 20,825.3	$ 19,564.7	$ 1,260.6	$ -	$ 15,687.0	$ 36,512.3	53.6%	3.5%	0.0%	43.0%
XCEL ENERGY	XEL	41.8%	42.2%	41.4%	41.7%	40.0%	$ 34,637.0	$ 33,306.0	$ 1,331.0	$ -	$ 22,204.0	$ 56,841.0	58.6%	2.3%	0.0%	39.1%
Maximum		61.6%	62.1%	62.1%	60.7%	60.2%	$ 95,619.0	$ 89,556.0	$ 7,541.0	$ 991.0	$ 54,889.2	$150,508.2	63.3%	15.9%	2.5%	60.2%
Minimum		28.1%	32.4%	31.3%	34.0%	33.5%	$ 1,568.2	$ 1,437.9	$ -	$ -	$ 1,526.8	$ 3,095.0	35.8%	0.0%	0.0%	31.9%
Median		43.3%	43.4%	43.7%	44.5%	44.5%	$ 18,529.5	$ 16,923.5	$ 1,119.0	$ -	$ 13,047.3	$ 31,494.4	53.4%	4.2%	0.0%	42.0%
Average		44.0%	44.1%	43.8%	44.0%	43.9%	$ 22,410.3	$ 20,828.5	$ 1,581.7	$ 73.4	$ 14,401.4	$ 36,885.1	53.4%	4.5%	0.2%	**41.9%**

Sources:
[A] Value Line: Most current data available at time of schedule preparation.
[B] Percentage calculated on Total Capital including Short Term Debt.

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CAPITAL STRUCTURE WITHOUT SHORT TERM DEBT
RFC Proxy Group

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
		% Common Equity					($ millions)		
		2021	2022	2023	2024	2025	Total Debt	LT Debt	ST Debt
		[A]	[A]	[A]	[A]	[A]	[A]	[A]	[B]
ATMOS ENERGY CORP.	ATO	61.6%	62.1%	62.1%	60.7%	60.2%	$ 9,632.8	$ 9,621.8	
CHESAPEAKE UTIL.	CPK	58.5%	59.0%	51.2%	52.4%	51.5%	$ 1,568.2	$ 1,437.9	
NI SOURCE INC.	NI	33.5%	35.3%	40.3%	41.8%	46.0%	$ 16,303.0	$ 15,547.0	
N.W. NATURAL	NWN	47.2%	48.5%	47.4%	45.2%	45.0%	$ 2,439.0	$ 2,128.0	
ONE GAS, INC.	OGS	38.9%	49.3%	56.1%	56.5%	57.5%	$ 3,400.2	$ 2,355.6	
SOUTHWEST GAS	SWX	41.8%	41.0%	41.8%	44.6%	45.0%	$ 3,507.1	$ 3,507.1	
SPIRE INC.	SR	43.2%	44.6%	41.3%	43.1%	46.6%	$ 5,349.5	$ 4,449.4	
ALLIANT ENERGY	LNT	47.1%	45.0%	45.2%	44.7%	44.5%	$ 11,924.0	$ 10,655.0	
AMEREN	AEE	43.3%	43.4%	43.8%	45.3%	47.0%	$ 20,075.0	$ 19,172.0	
AMERICAN ELEC. PWR.	AEP	41.7%	42.0%	42.0%	42.4%	42.0%	$ 45,397.0	$ 44,239.0	
AVISTA CORP.	AVA	52.5%	49.6%	48.8%	49.0%	49.5%	$ 3,092.0	$ 2,805.0	
CENTERPOINT EN'RGY	CNP	34.5%	37.1%	35.5%	34.3%	37.5%	$ 21,802.0	$ 19,400.0	
CMS ENERGY CORP.	CMS	34.2%	33.6%	33.1%	34.0%	34.0%	$ 18,073.0	$ 16,911.0	
DOMINION ENERGY	D	38.5%	39.1%	42.4%	40.5%	38.0%	$ 48,549.0	$ 43,291.0	
DTE ENERGY CO.	DTE	37.5%	37.0%	38.0%	38.2%	38.5%	$ 22,750.0	$ 22,424.0	
ENTERGY CORP.	ETR	31.7%	35.2%	38.6%	36.0%	36.5%	$ 30,447.0	$ 27,058.0	
EVERSOURCE ENERGY	ES	45.3%	43.3%	37.0%	36.5%	37.5%	$ 29,836.0	$ 27,135.0	
EXELON CORP.	EXC	49.1%	40.2%	39.1%	39.5%	39.0%	$ 47,363.0	$ 46,283.0	
FIRST ENERGY	FE	28.1%	32.4%	31.3%	35.6%	33.5%	$ 27,470.0	$ 25,510.0	
EVERGY, INC.	EVRG	49.9%	48.0%	48.0%	48.5%	48.0%	$ 13,063.0	$ 12,446.0	
IDA CORP, INC.	IDA	57.2%	56.1%	51.2%	52.2%	51.5%	$ 3,330.7	$ 3,330.7	
NEXTERA ENERGY	NEE	42.2%	41.5%	43.6%	40.9%	38.0%	$ 95,619.0	$ 89,556.0	
OGE ENERGY CORP.	OGE	47.4%	52.4%	49.6%	49.2%	48.5%	$ 5,834.5	$ 5,368.2	
PINNACLE WEST	PNW	46.1%	43.9%	45.0%	45.6%	44.5%	$ 10,480.0	$ 9,204.0	
PORTLAND GENERAL	POR	43.2%	43.0%	44.2%	45.0%	44.0%	$ 5,023.0	$ 4,928.0	
PPL CORPORATION	PPL	56.3%	51.9%	48.8%	49.1%	49.0%	$ 18,986.0	$ 16,936.0	
P.S. ENTERPRISE GP.	PEG	48.7%	45.4%	46.5%	45.9%	44.5%	$ 23,370.0	$ 21,666.0	
SOUTHERN COMPANY	SO	35.6%	36.5%	37.6%	36.8%	36.0%	$ 72,162.0	$ 64,621.0	
WEC ENERGY GROUP	WEC	44.6%	44.4%	44.1%	44.3%	44.5%	$ 20,825.3	$ 19,564.7	
XCEL ENERGY	XEL	41.8%	42.2%	41.4%	41.7%	40.0%	$ 34,637.0	$ 33,306.0	
Maximum		61.6%	62.1%	62.1%	60.7%	60.2%	$ 95,619.0	$ 89,556.0	
Minimum		28.1%	32.4%	31.3%	34.0%	33.5%	$ 1,568.2	$ 1,437.9	
Median		43.3%	43.4%	43.7%	44.5%	44.5%	$ 18,529.5	$ 16,923.5	
Average		44.0%	44.1%	43.8%	44.0%	43.9%	$ 22,410.3	$ 20,828.5	

		[9]	[10]	[11]	[12]	[13]	[14]	[15]
		($ millions)			Percentage			
		Pfd Stock	Equity	Total Capital	LT Debt	ST Debt	Pfd Stock	Equity Ratio
		[A]	[A]	[A]	[B]	[B]	[B]	[B]
ATMOS ENERGY CORP.	ATO	$ -	$ 14,553.6	$ 24,175.4	39.8%	0.0%	0.0%	60.2%
CHESAPEAKE UTIL.	CPK	$ -	$ 1,526.8	$ 2,964.7	48.5%	0.0%	0.0%	51.5%
NI SOURCE INC.	NI	$ -	$ 13,243.7	$ 28,790.7	54.0%	0.0%	0.0%	46.0%
N.W. NATURAL	NWN	$ -	$ 1,741.1	$ 3,869.1	55.0%	0.0%	0.0%	45.0%
ONE GAS, INC.	OGS	$ -	$ 3,187.0	$ 5,542.6	42.5%	0.0%	0.0%	57.5%
SOUTHWEST GAS	SWX	$ -	$ 2,869.4	$ 6,376.5	55.0%	0.0%	0.0%	45.0%
SPIRE INC.	SR	$ 242.0	$ 4,094.0	$ 8,785.4	50.6%	0.0%	2.8%	46.6%
ALLIANT ENERGY	LNT	$ -	$ 8,543.2	$ 19,198.2	55.5%	0.0%	0.0%	44.5%
AMEREN	AEE	$ 129.0	$ 17,116.0	$ 36,417.0	52.6%	0.0%	0.4%	47.0%
AMERICAN ELEC. PWR.	AEP	$ -	$ 32,035.1	$ 76,274.1	58.0%	0.0%	0.0%	42.0%
AVISTA CORP.	AVA	$ -	$ 2,749.5	$ 5,554.5	50.5%	0.0%	0.0%	49.5%
CENTERPOINT EN'RGY	CNP	$ -	$ 11,640.0	$ 31,040.0	62.5%	0.0%	0.0%	37.5%
CMS ENERGY CORP.	CMS	$ 224.0	$ 8,827.1	$ 25,962.1	65.1%	0.0%	0.9%	34.0%
DOMINION ENERGY	D	$ 991.0	$ 27,140.6	$ 71,422.6	60.6%	0.0%	1.4%	38.0%
DTE ENERGY CO.	DTE	$ -	$ 14,037.8	$ 36,461.8	61.5%	0.0%	0.0%	38.5%
ENTERGY CORP.	ETR	$ 219.4	$ 15,679.1	$ 42,956.5	63.0%	0.0%	0.5%	36.5%
EVERSOURCE ENERGY	ES	$ 155.6	$ 16,374.4	$ 43,665.0	62.1%	0.0%	0.4%	37.5%
EXELON CORP.	EXC	$ -	$ 29,590.8	$ 75,873.8	61.0%	0.0%	0.0%	39.0%
FIRST ENERGY	FE	$ -	$ 12,850.9	$ 38,360.9	66.5%	0.0%	0.0%	33.5%
EVERGY, INC.	EVRG	$ -	$ 11,488.6	$ 23,934.6	52.0%	0.0%	0.0%	48.0%
IDA CORP, INC.	IDA	$ -	$ 3,536.7	$ 6,867.4	48.5%	0.0%	0.0%	51.5%
NEXTERA ENERGY	NEE	$ -	$ 54,889.2	$ 144,445.2	62.0%	0.0%	0.0%	38.0%
OGE ENERGY CORP.	OGE	$ -	$ 5,055.5	$ 10,423.7	51.5%	0.0%	0.0%	48.5%
PINNACLE WEST	PNW	$ -	$ 7,379.8	$ 16,583.8	55.5%	0.0%	0.0%	44.5%
PORTLAND GENERAL	POR	$ -	$ 3,872.0	$ 8,800.0	56.0%	0.0%	0.0%	44.0%
PPL CORPORATION	PPL	$ -	$ 16,271.8	$ 33,207.8	51.0%	0.0%	0.0%	49.0%
P.S. ENTERPRISE GP.	PEG	$ -	$ 17,371.8	$ 39,037.8	55.5%	0.0%	0.0%	44.5%
SOUTHERN COMPANY	SO	$ 242.0	$ 36,485.4	$ 101,348.4	63.8%	0.0%	0.2%	36.0%
WEC ENERGY GROUP	WEC	$ -	$ 15,687.0	$ 35,251.7	55.5%	0.0%	0.0%	44.5%
XCEL ENERGY	XEL	$ -	$ 22,204.0	$ 55,510.0	60.0%	0.0%	0.0%	40.0%
Maximum		$ 991.0	$ 54,889.2	$ 144,445.2	66.5%	0.0%	2.8%	60.2%
Minimum		$ -	$ 1,526.8	$ 2,964.7	39.8%	0.0%	0.0%	33.5%
Median		$ -	$ 13,047.3	$ 29,915.4	55.5%	0.0%	0.0%	44.5%
Average		$ 73.4	$ 14,401.4	$ 35,303.4	55.9%	0.0%	0.2%	**43.9%**

Sources:
[A] Value Line: Most current data available at time of schedule preparation.
[B] Percentage calculated on Total Capital excluding Short Term Debt.

Exhibit__(NYCRP-8)

Cboe

VIX®

White Paper
Cboe Volatility Index®

Contents

Introduction

In 1993, Cboe Global Markets, Incorporated® (Cboe®) introduced the Cboe Volatility Index® (VIX® Index), which was originally designed to measure the market's expectation of 30-day volatility implied by at-the-money S&P 100® Index (OEX® Index) option prices. The VIX Index soon became the premier benchmark for U.S. stock market volatility. It is regularly featured in the Wall Street Journal, Barron's and other leading financial publications, as well as business news shows on CNBC, Bloomberg TV and CNN/Money, where the VIX Index is often referred to as the "fear gauge."

Ten years later in 2003, Cboe together with Goldman Sachs, updated the VIX Index to reflect a new way to measure expected volatility, one that continues to be widely used by financial theorists, risk managers and volatility traders alike. The new VIX Index is based on the S&P 500® Index (SPX℠), the core index for U.S. equities, and estimates expected volatility by aggregating the weighted prices of SPX puts and calls over a wide range of strike prices. By supplying a script for replicating volatility exposure with a portfolio of SPX options, this new methodology transformed the VIX Index from an abstract concept into a practical standard for trading and hedging volatility.

In 2014, Cboe enhanced the VIX Index to include series of SPX Weeklys℠. First introduced by Cboe in 2005, weekly options are now available on hundreds of indexes, equities, ETFs and ETNs and have become a very popular and actively-traded risk management tool. Today, SPX Weeklys account for one-third of all SPX options traded, and average close to 350,000 contracts traded per day[1].

The inclusion of SPX Weeklys allows the VIX Index to be calculated with S&P 500 Index option series that most precisely match the 30-day target timeframe for expected volatility that the VIX Index is intended to represent. Using SPX options with more than 23 days and less than 37 days to expiration ensures that the VIX Index will always reflect an interpolation of two points along the S&P 500 volatility term structure.

Cboe began dissemination of the VIX Index outside of U.S. trading hours in April 2016. The VIX index is now available during "extended trading hours" between 2 a.m. and 8:15 a.m CT, as well as during regular trading hours between 8:30 a.m. and 3:15 p.m. CT. As part of the VIX Index expansion, Cboe implemented a smoothing algorithm for VIX values disseminated during both extended and regular market hours.

Volatility as a tradable asset: VIX Futures & Options

On March 24, 2004, Cboe introduced the first exchange-traded VIX futures contract on its new, all-electronic Cboe Futures Exchange℠ (CFE®). Two years later in February 2006, Cboe launched VIX options, the most successful new product in Cboe history. In 2015, combined trading activity in VIX options and futures grew to nearly 800,000 contracts per day.

The negative correlation of volatility to stock market returns is well documented and suggests a diversification benefit to including volatility in an investment portfolio. VIX futures and options are designed to deliver pure volatility exposure in a single, efficient package. Cboe/CFE provides a continuous, liquid and transparent market for VIX products that are available to all investors from the smallest retail trader to the largest institutional money managers and hedge funds.

[1] *Based on 2015 Volume.*

Beyond the VIX Index

In addition to the VIX Index, Cboe calculates several other broad market volatility indexes including the Cboe Short-Term Volatility Index (VXST[SM]) - which reflects 9-day expected volatility of the S&P 500 Index, the Cboe S&P 500® 3-Month Volatility Index (VXV[SM]) and the Cboe S&P 500® 6-Month Volatility Index (VXMT[SM]). Cboe also calculates the Nasdaq-100® Volatility Index (VXN[SM]), Cboe DJIA® Volatility Index (VXD[SM]) and the Cboe Russell 2000® Volatility Index (RVX[SM]). Currently, RVX futures are listed on CFE and RVX options trade on Cboe.

Historical Prices: The VIX Index and Other Volatility Indexes

Perhaps one of the most valuable features of the VIX Index is the existence of more than 25 years of historical prices. This extensive data set provides investors with a useful perspective of how option prices have behaved in response to a variety of market conditions. Price history for the original Cboe Volatility Index (VXO) based on OEX options is available from 1986 to the present. Cboe has created a similar historical record for the new VIX Index dating back to 1990 so that investors can compare the new VIX Index with VXO, which reflects information about the volatility "skew" or "smile." Historical prices for the VIX Index, VXO and Cboe's other volatility indexes may be found on the Cboe website at http://www.cboe.com/micro/IndexSites.aspx under Cboe Volatility Indexes.

The VIX Index Calculation: Step-by-Step

Stock indexes, such as the S&P 500, are calculated using the prices of their component stocks. Each index employs rules that govern the selection of component securities and a formula to calculate index values.

The VIX Index is a volatility index comprised of options rather than stocks, with the price of each option reflecting the market's expectation of future volatility. Like conventional indexes, the VIX Index calculation employs rules for selecting component options and a formula to calculate index values.

The generalized formula used in the VIX Index calculation[§] is:

$$\sigma^2 = \frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i) - \frac{1}{T}\left[\frac{F}{K_0} - 1\right]^2 \quad (1)$$

Where

σ	$VIX/100 \Rightarrow$ **VIX = σ × 100**	ΔK_i	Interval between strike prices – half the difference between the strike on either side of K_i: $\Delta K_i = \frac{K_{i+1} - K_{i-1}}{2}$
T	Time to expiration	R	Risk-free interest rate to expiration
F	Forward index level derived from index option prices	$Q(K_i)$	The midpoint of the bid-ask spread for each option with strike K_i.
K_0	First strike below the forward index level, F		
K_i	Strike price of i^{th} out-of-the-money option; a call if $K_i > K_0$ and a put if $K_i < K_0$; both put and call if $K_i = K_0$.		

§ *Please see "More than you ever wanted to know about volatility swaps" by Kresimir Demeterfi, Emanuel Derman, Michael Kamal and Joseph Zou, Goldman Sachs Quantitative Strategies Research Notes, March 1999.*

Getting Started

The VIX Index measures 30-day expected volatility of the S&P 500 Index. The components of the VIX Index are near- and next-term put and call options with more than 23 days and less than 37 days to expiration. These include SPX options with "standard" 3rd Friday expiration dates and "weekly" SPX options that expire every Friday, except the 3rd Friday of each month. Once each week, the SPX options used to calculate the VIX Index "roll" to new contract maturities. For example, on the second Tuesday in October, the VIX Index would be calculated using SPX options expiring 24 days later (i.e., "near-term") and 31 days later (i.e., "next-term"). On the following day, the SPX options that expire in 30 calendar days would become the "near-term" options and SPX options that expire in 37 calendar days would be the "next-term" options.

In this hypothetical example, the near-term options are "standard" SPX options with 25 days to expiration, the next-term options are P.M.-settled SPX Weeklys with 32 days to expiration; and the calculation reflects prices observed at 9:46 a.m. Chicago time. For the purpose of calculating time to expiration, "standard" SPX options are deemed to expire at the open of trading on SPX settlement day - the third Friday of the month , and "weekly" SPX options are deemed to expire at the close of trading (i.e., 3:00 p.m. CT).

The VIX Index calculation measures time to expiration, T, in calendar days and divides each day into minutes in order to replicate the precision that is commonly used by professional option and volatility traders. The time to expiration is given by the following expression:

$$T = \{ M_{\text{Current day}} + M_{\text{Settlement day}} + M_{\text{Other days}} \} / \text{Minutes in a year}$$

Where

$M_{\text{Current day}}$	minutes remaining until midnight of the current day
$M_{\text{Settlement day}}$	minutes from midnight until 8:30 a.m. for "standard" SPX expirations; or minutes from midnight until 3:00 p.m. for "weekly" SPX expirations
$M_{\text{Other days}}$	total minutes in the days between current day and expiration day

Using 9:46 a.m. as the time of the calculation, T for the near-term and next-term options, T_1 and T_2, respectively, is:

$$T_1 = \{854 + 510 + 34{,}560\} / 525{,}600 = 0.0683486$$

$$T_2 = \{854 + 900 + 44{,}640\} / 525{,}600 = 0.0882686$$

The risk-free interest rates, R_1 and R_2, are yields based on U.S. Treasury yield curve rates (commonly referred to as "Constant Maturity Treasury" rates or CMTs), to which a cubic spline is applied to derive yields on the expiration dates of relevant SPX options. As such, the VIX Index calculation may use different risk-free interest rates for near- and next-term options. In this example, assume that $R_1 = 0.0305\%$ for the near-term options and that $R_2 = 0.0286\%$ for the next-term options. Note in this example, T_2 uses a value of 900 for $M_{\text{Settlement day}}$, which reflects the 3:00 p.m. expiration time of the next-term SPX Weeklys options. Since many of the interim calculations are repetitive, only representative samples appear below. The complete set of SPX option data and calculations may be found in *Appendix 1*.

Step 1: Select the options to be used in the VIX Index calculation

The selected options are out-of-the-money SPX calls and out-of-the-money SPX puts centered around an at-the-money strike price, K_0. Only SPX options quoted with non-zero bid prices are used in the VIX Index calculation.

One important note: as volatility rises and falls, the strike price range of options with non-zero bids tends to expand and contract. As a result, the number of options used in the VIX Index calculation may vary from month-to-month, day-to-day and possibly, even minute-to-minute.

For each contract month:

- Determine the forward SPX level, F, by identifying the strike price at which the absolute difference between the call and put prices is smallest. The call and put prices in the following table reflect the average of each option's bid / ask quotation. As shown below, the difference between the call and put prices is smallest at the 1965 strike for the near- and the 1960 strike for the next-term options.

Near Term Options			
Strike Price	Call	Put	Difference
1940	38.45	15.25	23.20
1945	34.70	16.55	18.15
1950	31.10	18.25	12.85
1955	27.60	19.75	7.85
1960	24.25	21.30	2.95
1965	**21.05**	**23.15**	**2.10**
1970	18.10	25.05	6.95
1975	15.25	27.30	12.05
1980	12.75	29.75	17.00

Next Term Options			
Strike Price	Call	Put	Difference
1940	41.05	18.80	22.25
1945	37.45	20.20	17.25
1950	34.05	21.60	12.45
1955	30.60	23.20	7.40
1960	**27.30**	**24.90**	**2.40**
1965	24.15	26.90	2.75
1970	21.10	28.95	7.85
1975	18.30	31.05	12.75
1980	15.70	33.50	17.80

Using the **1965** call and put in the near-term, and the **1960** call and put in the next-term contract applied to the formula:

$$F = \text{Strike Price} + e^{RT} \times (\text{Call Price} - \text{Put Price})$$

the forward index prices, F_1 and F_2, for the near- and next-term options, respectively, are:

$$F_1 = 1965 + e^{(0.000305 \times 0.0683486)} \times (21.05 - 23.15) = 1962.89996$$

$$F_2 = 1960 + e^{(0.000286 \times 0.0882686)} \times (27.30 - 24.90) = 1962.40006$$

- Next, determine K_0 - the strike price immediately below the forward index level, F - for the near- and next-term options. In this example, $\mathbf{K_{0,1} = 1960}$ **and** $\mathbf{K_{0,2} = 1960}$**.**
- Select out-of-the-money put options with strike prices < K_0. Start with the put strike immediately lower than K0 and move to successively lower strike prices. Exclude any put option that has a bid price equal to zero (i.e., no bid). As shown below, once two puts with consecutive strike prices are found to have zero bid prices, no puts with lower strikes are considered for inclusion. (Note that the 1350 and 1355 put options are not included despite having non-zero bid prices.)

Put Strike	Bid	Ask	Include?
1345	0	0.15	Not considered following two zero bids
1350	**0.05**	**0.15**	
1355	**0.05**	**0.35**	
1360	0	0.35	No
1365	0	0.35	No
1370	0.05	0.35	Yes
1375	0.1	0.15	Yes
1380	0.1	0.2	Yes

- Next, select out-of-the-money call options with strike prices > K_0. Start with the call strike immediately higher than K_0 and move to successively higher strike prices, excluding call options that have a bid price of zero. As with the puts, once two consecutive call options are found to have zero bid prices, no calls with higher strikes are considered. (Note that the 2225 call option is not included despite having a non-zero bid price.)

Call Strike	Bid	Ask	Include?
2095	0.05	0.35	Yes
2100	0.05	0.15	Yes
2120	0	0.15	No
2125	0.05	0.15	Yes
2150	0	0.1	No
2175	0	0.05	No
2200	0	0.05	Not considered following two zero bids
2225	**0.05**	**0.1**	
2250	0	0.05	

- Finally, select **both** the put and call with strike price K_0. Notice that two options are selected at K_0, while a single option, either a put or a call, is used for every other strike price.
- The following table contains the options used to calculate the VIX Index in this example. The VIX Index uses the average of quoted bid and ask, or mid-quote, prices for each option selected. The K_0 put and call prices are averaged to produce a single value. The price used for the 1960 strike in the near-term is, therefore, (24.25 + 21.30)/2 = 22.775; and the price used in the next-term is (27.30 + 24.90)/2 = 26.10.

Near term Strike	Option Type	Mid-quote Price
1370	Put	0.2
1375	Put	0.125
1380	Put	0.15
.	.	.
1950	Put	18.25
1955	Put	19.75
1960	**Put/Call Average**	**22.775**
1965	Call	21.05
1970	Call	18.1
.	.	.
2095	Call	0.2
2100	Call	0.1
2125	Call	0.1

Next term Strike	Option Type	Mid-quote Price
1275	Put	0.075
1325	Put	0.15
1350	Put	0.15
.	.	.
1950	Put	21.60
1955	Put	23.20
1960	**Put/Call Average**	**26.10**
1965	Call	24.15
1970	Call	21.10
.	.	.
2125	Call	0.1
2150	Call	0.1
2200	Call	0.08

Step 2: Calculate volatility for both near-term and next-term options

Applying the VIX formula (1) to the near-term and next-term options with time to expiration of T_1 and T_2, respectively, yields:

$$\sigma^2_1 = \frac{2}{T_1}\sum_i \frac{\Delta K_i}{K_i^2} e^{R_1T_1} Q(K_i) - \frac{1}{T_1}\left[\frac{F_1}{K_0} - 1\right]^2$$

$$\sigma^2_2 = \frac{2}{T_2}\sum_i \frac{\Delta K_i}{K_i^2} e^{R_2T_2} Q(K_i) - \frac{1}{T_2}\left[\frac{F_2}{K_0} - 1\right]^2$$

The VIX Index is an amalgam of the information reflected in the prices of all of the selected options. The contribution of a single option to the VIX value is proportional to ΔK and the price of that option, and inversely proportional to the square of the option's strike price.

Generally, ΔK_i is half the difference between the strike prices on either side of K_i. For example, the ΔK for the next-term 1325 Put is 37.5: $\Delta K_{1325\ Put}$ = (1350 – 1275)/2. At the upper and lower edges of any given strip of options, ΔK_i is simply the difference between K_i and the adjacent strike price. In this example, the 1370 Put is the lowest strike in the strip of near-term options and 1375 is the adjacent strike. Therefore, $\Delta K_{1370\ Put}$ = 5 (i.e., 1375 – 1370).

The contribution of the near-term 1370 Put is given by:

$$\frac{\Delta K_{1370\,Put}}{K^2_{1370\,Put}} e^{R_1T_1} Q(1370\,Put)$$

$$\frac{\Delta K_{1370\,Put}}{K^2_{1370\,Put}} e^{R_1T_1} Q(1370\,Put) = \frac{5}{1370^2} e^{.000305\ (0.0683486)} (0.20) = 0.0000005328$$

A similar calculation is performed for each option. The resulting values for the near-term options are then summed and multiplied by $2/T_1$. Likewise, the resulting values for the next-term options are summed and multiplied by $2/T_2$. The table below summarizes the results for each strip of options.

Near term Strike	Option Type	Mid-quote Price	Contribution by Strike
1370	Put	0.2	0.0000005328
1375	Put	0.125	0.0000003306
1380	Put	0.15	0.0000003938
.	.	.	.
1950	Put	18.25	0.0000239979
1955	Put	19.75	0.0000258376
1960	**Put/Call Average**	**22.775**	**0.0000296432**
1965	Call	21.05	0.0000272588
1970	Call	18.1	0.0000233198
.	.	.	.
2095	Call	0.2	0.0000002278
2100	Call	0.1	0.0000003401
2125	Call	0.1	0.0000005536
$\frac{2}{T_1}\sum_i \frac{\Delta K_i}{K_i^2} e^{R_1T_1} Q(K_i)$			**0.018495**

Near term Strike	Option Type	Mid-quote Price	Contribution by Strike
1275	Put	0.075	0.0000023069
1325	Put	0.15	0.0000032041
1350	Put	0.15	0.0000020577
.	.	.	.
1950	Put	21.6	0.0000284031
1955	Put	23.2	0.0000303512
1960	**Put/Call Average**	**26.1**	**0.0000339711**
1965	Call	24.15	0.0000312732
1970	Call	21.1	0.0000271851
.	.	.	.
2125	Call	0.1	0.0000005536
2150	Call	0.1	0.0000008113
2200	Call	0.075	0.0000007748
$\frac{2}{T_2}\sum_i \frac{\Delta K_i}{K_i^2} e^{R_2T_2} Q(K_i)$			**0.018838**

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Next, calculate $\frac{1}{T}\left[\frac{F}{K_0}-1\right]^2$ for the near-term (T_1) and next-term (T_2):

$$\frac{1}{T_1}\left[\frac{F_1}{K_0}-1\right]^2 = \frac{1}{0.0683486}\left[\frac{1962.89996}{1960}-1\right]^2 = 0.00003203$$

$$\frac{1}{T_2}\left[\frac{F_2}{K_0}-1\right]^2 = \frac{1}{0.0882686}\left[\frac{1962.40006}{1960}-1\right]^2 = 0.00001699$$

Now calculate σ^2_1 and σ^2_2:

$$\sigma^2_1 = \frac{2}{T_1}\sum_i \frac{\Delta K_i}{K_i^2} e^{R_1 T_1} Q(K_i) - \frac{1}{T_1}\left[\frac{F_1}{K_0}-1\right]^2 = 0.018495 - 0.00003203 = \mathbf{0.01846292}$$

$$\sigma^2_2 = \frac{2}{T_2}\sum_i \frac{\Delta K_i}{K_i^2} e^{R_2 T_2} Q(K_i) - \frac{1}{T_2}\left[\frac{F_2}{K_0}-1\right]^2 = 0.018838 - 0.00001699 = \mathbf{0.01882101}$$

Step 3

Calculate the 30-day weighted average of σ^2_1 and σ^2_2. Then take the square root of that value and multiply by 100 to get the VIX value.

$$\text{VIX} = 100 \times \sqrt{\left\{T_1\sigma_1^2\left[\frac{N_{T_2}-N_{30}}{N_{T_2}-N_{T_1}}\right] + T_2\sigma_2^2\left[\frac{N_{30}-N_{T_1}}{N_{T_2}-N_{T_1}}\right]\right\} \times \frac{N_{365}}{N_{30}}}$$

The inclusion of SPX Weeklys in the VIX Index calculation means that the near-term options will always have more than 23 days to expiration and the next-term options always have less than 37 days to expiration, so the resulting VIX value will always reflect an interpolation of σ^2_1 and σ^2_2 ; i.e., each individual weight is less than or equal to 1 and the sum of the weights equals 1.

Returning to the example…

N_{T1} = number of minutes to settlement of the near-term options (35,924)
N_{T2} = number of minutes to settlement of the next-term options (46,394)
N_{30} = number of minutes in 30 days (30 x 1,440 = 43,200)
N_{365} = number of minutes in a 365-day year (365 x 1,440 = 525,600)

$$\text{VIX} = 100 \times \sqrt{\left\{0.0683486 \times 0.0184629 \times \left[\frac{46{,}394-43{,}200}{46{,}394-12{,}960}\right] + 0.0882686 \times 0.018821 \times \left[\frac{43{,}200-35{,}924}{53{,}280-35{,}924}\right]\right\} \times \frac{525{,}600}{43{,}200}}$$

VIX = 100 × 0.13685821 = 13.69

Related VIX Values

In addition to the VIX Index, Cboe publishes the Cboe VIX Indicative Bid Index ("VWB"), a VIX value based on SPX bid quotations, and the Cboe VIX Indicative Ask Index ("VWA"), a VIX value based on SPX option ask quotations. These values provide a market estimate of SPX option bid-ask "spreads" expressed in volatility terms. Cboe also publishes volatility information related to the near-term and next-term VIX "components", σ_1 and σ_2, under ticker symbols "VIN" (Cboe Near-Term VIX Index) and "VIF" (Cboe Far-Term VIX Index) every 15 seconds during each Cboe trading day.

Appendix 1: Complete SPX Option Data Used in Sample VIX Index Calculation

Option Series included in the VIX Index calculation are highlighted.

Near-Term Options

Strike	Calls		Puts	
	Bid	Ask	Bid	Ask
800	1160.90	1164.40	0.00	0.10
900	1060.90	1064.50	0.00	0.10
1000	961.00	964.50	0.00	0.10
1050	911.00	914.50	0.00	0.10
1100	861.00	864.60	0.00	0.05
1125	836.00	839.60	0.00	0.05
1150	811.00	814.60	0.00	0.05
1175	786.10	789.60	0.00	0.05
1200	761.10	764.60	0.00	0.05
1220	741.10	744.60	0.00	0.10
1225	736.10	739.60	0.00	0.05
1240	721.10	724.60	0.00	0.10
1250	711.10	714.60	0.00	0.05
1260	701.10	704.60	0.00	0.10
1270	691.10	694.60	0.00	0.10
1275	686.10	689.60	0.00	0.10
1280	681.10	684.60	0.00	0.10
1290	671.10	674.70	0.00	0.10
1300	661.10	664.70	0.05	0.10
1305	656.10	659.70	0.00	0.10
1310	651.10	654.70	0.00	0.10
1315	646.10	649.70	0.00	0.10
1320	641.20	644.70	0.00	0.10
1325	636.20	639.70	0.05	0.10
1330	631.20	634.70	0.00	0.10
1335	626.20	629.70	0.00	0.15
1340	621.20	624.70	0.00	0.15
1345	616.20	619.70	0.00	0.15
1350	611.20	614.70	0.05	0.15
1355	606.20	609.70	0.05	0.35
1360	601.20	604.70	0.00	0.35
1365	596.20	599.70	0.00	0.35
1370	591.20	594.70	0.05	0.35
1375	586.20	589.70	0.10	0.15
1380	581.20	584.70	0.10	0.20
1385	576.20	579.70	0.10	0.35
1390	571.20	574.70	0.10	0.35
1395	566.20	569.70	0.10	0.15
1400	561.20	564.80	0.10	0.15
1405	556.20	559.80	0.00	0.35
1410	551.20	554.80	0.05	0.40
1415	546.20	549.80	0.00	0.40
1420	541.20	544.80	0.05	0.40
1425	536.30	539.80	0.15	0.20

Next-Term Options

Strike	Calls		Puts	
	Bid	Ask	Bid	Ask
1225	735.90	738.80	0.00	0.10
1250	710.80	713.80	0.00	0.10
1275	686.00	688.70	0.05	0.10
1300	660.90	663.80	0.00	0.10
1325	635.90	638.60	0.10	0.20
1350	610.90	613.60	0.10	0.20
1375	585.90	588.70	0.10	0.25
1400	561.00	563.70	0.15	0.25
1425	536.00	538.80	0.20	0.30
1450	511.10	513.80	0.25	0.35
1475	486.10	488.90	0.30	0.40
1500	461.20	464.00	0.35	0.45
1510	451.30	454.00	0.35	0.50
1520	441.30	444.00	0.40	0.50
1525	436.30	439.10	0.40	0.55
1530	431.30	434.10	0.45	0.55
1540	421.40	424.10	0.45	0.60
1550	411.40	414.20	0.50	0.60
1555	406.40	409.20	0.50	0.65
1560	401.40	404.20	0.55	0.65
1565	396.50	399.20	0.55	0.70
1570	391.20	394.00	0.60	0.70
1575	386.50	389.30	0.60	0.75
1580	381.50	384.30	0.60	0.75
1585	376.60	379.30	0.65	0.75
1590	371.30	374.10	0.65	0.80
1595	366.60	369.40	0.70	0.80
1600	361.60	364.40	0.70	0.85
1605	356.70	359.40	0.75	0.85
1610	351.70	354.50	0.75	0.90
1615	346.70	349.50	0.80	0.90
1620	341.80	344.50	0.80	0.95
1625	336.80	339.50	0.85	0.95
1630	331.80	334.60	0.90	1.00

Near-Term Options (cont.)				
Strike	Calls		Puts	
	Bid	Ask	Bid	Ask
1430	531.30	534.80	0.05	0.40
1435	526.30	529.80	0.15	0.40
1440	521.30	524.80	0.05	0.30
1445	516.30	519.80	0.05	0.40
1450	511.30	514.80	0.15	0.25
1455	506.30	509.80	0.05	0.45
1460	501.30	504.80	0.05	0.45
1465	496.30	499.80	0.05	0.45
1470	491.30	494.80	0.05	0.45
1475	486.30	489.90	0.15	0.25
1480	481.30	484.90	0.05	0.45
1485	476.30	479.90	0.20	0.50
1490	471.30	474.90	0.05	0.30
1495	466.40	469.90	0.05	0.50
1500	461.40	464.90	0.25	0.40
1505	456.40	459.90	0.30	0.35
1510	451.40	454.90	0.05	0.55
1515	446.40	449.90	0.05	0.55
1520	441.40	445.00	0.10	0.60
1525	436.40	440.00	0.30	0.40
1530	431.40	435.00	0.05	0.60
1535	426.40	430.00	0.10	0.65
1540	421.40	425.00	0.10	0.65
1545	416.50	420.00	0.10	0.65
1550	411.50	415.00	0.30	0.70
1555	406.50	410.10	0.15	0.70
1560	401.50	405.10	0.15	0.70
1565	396.50	400.10	0.15	0.70
1570	391.50	395.10	0.20	0.75
1575	386.50	390.10	0.35	0.75
1580	381.50	385.10	0.25	0.80
1585	376.60	380.20	0.25	0.80
1590	371.60	375.20	0.25	0.80
1595	366.60	370.20	0.25	0.80
1600	361.60	365.20	0.50	0.85
1605	356.60	360.30	0.30	0.85
1610	351.60	355.30	0.35	0.90
1615	346.70	350.30	0.35	0.90
1620	341.70	345.30	0.35	0.90
1625	336.70	340.40	0.40	0.95
1630	331.70	335.40	0.40	0.95
1635	326.70	330.40	0.45	1.00
1640	321.80	325.40	0.45	1.00
1645	316.80	320.50	0.50	1.05
1650	311.80	315.50	0.50	0.85
1655	306.80	310.50	0.55	1.10
1660	301.90	305.60	0.55	1.10
1665	296.90	300.60	0.60	1.15

Next-Term Options (cont.)				
Strike	Calls		Puts	
	Bid	Ask	Bid	Ask
1635	326.90	329.60	0.90	1.05
1640	321.90	324.70	0.95	1.05
1645	316.90	319.70	0.95	1.10
1650	312.00	314.70	1.00	1.15
1655	307.00	309.80	1.05	1.15
1660	302.10	304.80	1.10	1.20
1665	297.10	299.90	1.15	1.25
1670	292.20	294.90	1.15	1.30
1675	287.20	289.90	1.20	1.35
1680	282.30	285.00	1.25	1.40
1685	277.30	280.10	1.30	1.45
1690	272.40	275.10	1.35	1.50
1695	267.40	270.20	1.40	1.55
1700	262.50	265.20	1.45	1.60
1705	257.50	260.30	1.50	1.70
1710	252.60	255.30	1.60	1.75
1715	247.70	250.40	1.65	1.80
1720	242.70	245.50	1.70	1.90
1725	237.80	240.60	1.75	1.95
1730	232.90	235.60	1.85	2.00
1735	228.00	230.70	1.90	2.10
1740	223.40	225.30	2.00	2.20
1745	218.50	220.40	2.10	2.25
1750	213.60	215.50	2.20	2.35
1755	208.70	210.60	2.30	2.45
1760	203.80	205.70	2.40	2.55
1765	198.90	200.80	2.50	2.65
1770	194.00	195.90	2.65	2.80
1775	189.20	191.10	2.75	2.90
1780	184.30	185.80	2.90	3.10
1785	179.40	180.90	3.00	3.20
1790	174.60	176.10	3.10	3.40
1795	169.70	171.20	3.30	3.60
1800	164.90	166.40	3.50	3.70
1805	160.10	161.60	3.70	3.90
1810	155.30	156.70	3.80	4.10
1815	150.50	152.00	4.10	4.30
1820	145.70	147.20	4.30	4.50
1825	140.90	142.40	4.50	4.80
1830	136.20	137.70	4.80	5.00
1835	131.50	132.90	5.00	5.30
1840	126.80	128.20	5.30	5.60
1845	122.10	123.50	5.60	5.90
1850	117.40	118.80	5.90	6.20
1855	112.80	114.20	6.30	6.60
1860	108.20	109.60	6.60	6.90
1865	103.60	105.00	7.00	7.30
1870	99.00	100.40	7.50	7.80

Near-Term Options (cont.)				
Strike	Calls		Puts	
	Bid	Ask	Bid	Ask
1670	291.90	295.70	0.60	1.15
1675	287.00	290.70	0.65	1.20
1680	282.00	285.70	0.70	1.25
1685	277.00	280.80	0.75	1.30
1690	272.10	275.80	0.75	1.30
1695	267.10	270.90	0.80	1.35
1700	262.10	265.90	0.85	1.40
1705	257.20	261.00	0.85	1.40
1710	252.20	256.00	0.90	1.45
1715	247.30	251.10	0.95	1.50
1720	242.30	246.10	1.00	1.55
1725	237.40	241.20	1.05	1.60
1730	232.40	236.30	1.10	1.65
1735	227.50	231.30	1.15	1.70
1740	222.50	226.40	1.20	1.75
1745	217.60	221.50	1.25	1.85
1750	212.60	216.60	1.30	1.90
1755	207.70	211.60	1.40	1.95
1760	202.80	206.70	1.45	2.05
1765	197.80	201.80	1.50	2.15
1770	192.90	196.90	1.60	2.20
1775	188.00	192.00	1.65	2.35
1780	183.10	187.10	1.75	2.40
1785	178.20	182.20	1.85	2.50
1790	173.30	177.30	1.90	2.60
1795	168.40	172.40	2.00	2.75
1800	163.50	167.50	2.15	2.90
1805	158.60	162.60	2.25	3.00
1810	153.80	157.80	2.35	3.20
1815	148.90	152.90	2.50	3.40
1820	144.10	148.10	2.65	3.50
1825	139.20	143.30	3.00	3.60
1830	134.40	138.40	3.00	3.90
1835	129.60	133.60	3.20	4.10
1840	124.80	128.80	3.40	4.40
1845	120.10	124.10	3.60	4.60
1850	115.40	119.30	3.80	4.90
1855	110.60	114.60	4.10	5.20
1860	105.90	109.90	4.40	5.50
1865	101.30	105.20	4.70	5.80
1870	96.60	100.50	5.00	6.20
1875	92.00	95.90	5.40	6.60
1880	87.40	91.30	5.80	7.00
1885	82.90	86.70	6.20	7.50
1890	78.40	82.20	6.70	8.00
1895	74.00	77.70	7.20	8.60
1900	69.60	73.20	7.80	8.80
1905	66.00	68.50	8.50	9.50

Next-Term Options (cont.)				
Strike	Calls		Puts	
	Bid	Ask	Bid	Ask
1875	94.50	95.90	8.00	8.30
1880	90.00	91.40	8.40	8.80
1885	85.50	86.90	9.00	9.40
1890	81.10	82.50	9.50	10.00
1895	76.80	78.10	10.20	10.60
1900	72.40	73.70	10.90	11.30
1905	68.20	69.40	11.60	12.00
1910	64.00	65.20	12.40	12.80
1915	59.80	61.10	13.20	13.70
1920	55.70	57.00	14.20	14.60
1925	51.70	53.00	15.20	15.60
1930	47.80	49.10	16.20	16.60
1935	44.60	45.10	17.40	17.80
1940	40.80	41.30	18.60	19.00
1945	37.20	37.70	20.00	20.40
1950	33.70	34.40	21.40	21.80
1955	30.30	30.90	23.00	23.40
1960	27.00	27.60	24.70	25.10
1965	23.80	24.50	26.50	27.30
1970	20.80	21.40	28.50	29.40
1975	18.00	18.60	30.50	31.60
1980	15.50	15.90	33.00	34.00
1985	13.10	13.50	35.50	36.60
1990	10.90	11.30	38.40	39.50
1995	9.00	9.30	41.30	42.50
2000	7.20	7.60	44.50	45.80
2005	5.70	6.00	48.10	49.30
2010	4.50	4.80	51.70	53.00
2015	3.40	3.70	55.80	57.00
2020	2.60	2.80	59.90	61.70
2025	1.95	2.15	64.10	66.10
2030	1.45	1.65	68.60	70.60
2035	1.05	1.25	73.30	75.20
2040	0.80	0.95	78.00	80.00
2045	0.60	0.75	82.00	84.80
2050	0.50	0.65	86.90	89.60
2060	0.30	0.40	96.60	99.40
2070	0.20	0.30	106.70	109.50
2075	0.15	0.25	111.70	114.50
2100	0.10	0.20	136.30	139.10
2125	0.05	0.15	161.50	164.30
2150	0.05	0.15	186.30	189.00
2175	0.00	0.10	211.30	214.00
2200	0.05	0.10	236.30	239.00
2225	0.00	0.10	261.30	264.00
2250	0.00	0.10	286.30	289.00

Near-Term Options (cont.)				
Strike	Calls		Puts	
	Bid	Ask	Bid	Ask
1910	61.60	64.10	9.10	10.20
1915	57.40	59.80	9.90	11.30
1920	53.30	55.60	10.70	12.10
1925	49.10	51.20	11.60	12.60
1930	45.20	47.30	12.50	14.00
1935	41.20	43.40	13.60	14.70
1940	37.40	39.50	14.70	15.80
1945	33.70	35.70	15.90	17.20
1950	30.10	32.10	17.70	18.80
1955	26.70	28.50	19.00	20.50
1960	23.40	25.10	20.60	22.00
1965	20.30	21.80	22.30	24.00
1970	17.40	18.80	24.30	25.80
1975	14.60	15.90	26.50	28.10
1980	12.20	13.30	28.90	30.60
1985	9.90	11.00	31.40	33.20
1990	7.90	9.00	34.30	36.50
1995	6.20	7.10	37.40	39.70
2000	4.70	5.20	40.70	43.20
2005	3.40	4.20	44.00	47.70
2010	2.65	3.10	48.00	51.40
2015	1.75	2.30	52.20	56.00
2020	1.20	1.70	56.60	60.40
2025	1.00	1.25	61.20	65.00
2030	0.45	1.00	65.90	69.70
2035	0.25	0.80	70.70	74.40
2040	0.35	0.65	75.60	79.30
2045	0.20	0.60	80.50	84.10
2050	0.20	0.30	85.40	89.00
2055	0.15	0.50	90.40	94.00
2060	0.15	0.30	95.30	98.90
2065	0.15	0.20	100.30	103.90
2070	0.10	0.20	105.30	108.90
2075	0.10	0.20	110.30	113.80
2080	0.05	0.45	115.30	118.80
2085	0.05	0.40	120.30	123.80
2090	0.05	0.15	125.30	128.80
2095	0.05	0.35	130.30	133.80
2100	0.05	0.15	135.30	138.80
2120	0.00	0.15	155.30	158.80
2125	0.05	0.15	160.30	163.80
2150	0.00	0.10	185.20	188.80
2175	0.00	0.05	210.20	213.70
2200	0.00	0.05	235.20	238.70
2225	0.05	0.10	260.20	263.70
2250	0.00	0.05	285.20	288.70

Appendix 2: Individual Contributions — K_0 = 1960

Near term Strike	Option Type	Mid-quote Price	Delta-K	Contribution by Strike
1370	Put	0.200	5	0.0000005328
1375	Put	0.125	5	0.0000003306
1380	Put	0.150	5	0.0000003938
1385	Put	0.225	5	0.0000005865
1390	Put	0.225	5	0.0000005823
1395	Put	0.125	5	0.0000003212
1400	Put	0.125	7.5	0.0000004783
1410	Put	0.225	10	0.0000011318
1420	Put	0.225	7.5	0.0000008369
1425	Put	0.175	5	0.0000004309
1430	Put	0.225	5	0.0000005502
1435	Put	0.275	5	0.0000006677
1440	Put	0.175	5	0.0000004220
1445	Put	0.225	5	0.0000005388
1450	Put	0.200	5	0.0000004756
1455	Put	0.250	5	0.0000005905
1460	Put	0.250	5	0.0000005864
1465	Put	0.250	5	0.0000005824
1470	Put	0.250	5	0.0000005785
1475	Put	0.200	5	0.0000004596
1480	Put	0.250	5	0.0000005707
1485	Put	0.350	5	0.0000007936
1490	Put	0.175	5	0.0000003941
1495	Put	0.275	5	0.0000006152
1500	Put	0.325	5	0.0000007222
1505	Put	0.325	5	0.0000007174
1510	Put	0.300	5	0.0000006579
1515	Put	0.300	5	0.0000006535
1520	Put	0.350	5	0.0000007575
1525	Put	0.350	5	0.0000007525
1530	Put	0.325	5	0.0000006942
1535	Put	0.375	5	0.0000007958
1540	Put	0.375	5	0.0000007906
1545	Put	0.375	5	0.0000007855
1550	Put	0.500	5	0.0000010406
1555	Put	0.425	5	0.0000008788
1560	Put	0.425	5	0.0000008732
1565	Put	0.425	5	0.0000008676
1570	Put	0.475	5	0.0000009635
1575	Put	0.550	5	0.0000011086
1580	Put	0.525	5	0.0000010515
1585	Put	0.525	5	0.0000010449
1590	Put	0.525	5	0.0000010384
1595	Put	0.525	5	0.0000010319
1600	Put	0.675	5	0.0000013184
1605	Put	0.575	5	0.0000011161
1610	Put	0.625	5	0.0000012056
1615	Put	0.625	5	0.0000011982

Near term Strike	Option Type	Mid-quote Price	Delta-K	Contribution by Strike
1275	Put	0.075	50	0.0000023069
1325	Put	0.150	37.5	0.0000032041
1350	Put	0.150	25	0.0000020577
1375	Put	0.175	25	0.0000023141
1400	Put	0.200	25	0.0000025511
1425	Put	0.250	25	0.0000030779
1450	Put	0.300	25	0.0000035673
1475	Put	0.350	25	0.0000040219
1500	Put	0.400	17.5	0.0000031112
1510	Put	0.425	10	0.0000018640
1520	Put	0.450	7.5	0.0000014608
1525	Put	0.475	5	0.0000010213
1530	Put	0.500	7.5	0.0000016020
1540	Put	0.525	10	0.0000022138
1550	Put	0.550	7.5	0.0000017170
1555	Put	0.575	5	0.0000011890
1560	Put	0.600	5	0.0000012328
1565	Put	0.625	5	0.0000012759
1570	Put	0.650	5	0.0000013185
1575	Put	0.675	5	0.0000013606
1580	Put	0.675	5	0.0000013520
1585	Put	0.700	5	0.0000013932
1590	Put	0.725	5	0.0000014339
1595	Put	0.750	5	0.0000014741
1600	Put	0.775	5	0.0000015137
1605	Put	0.800	5	0.0000015528
1610	Put	0.825	5	0.0000015914
1615	Put	0.850	5	0.0000016295
1620	Put	0.875	5	0.0000016671
1625	Put	0.900	5	0.0000017042
1630	Put	0.950	5	0.0000017878
1635	Put	0.975	5	0.0000018237
1640	Put	1.000	5	0.0000018591
1645	Put	1.025	5	0.0000018940
1650	Put	1.075	5	0.0000019743
1655	Put	1.100	5	0.0000020081
1660	Put	1.150	5	0.0000020867
1665	Put	1.200	5	0.0000021644
1670	Put	1.225	5	0.0000021963
1675	Put	1.275	5	0.0000022723
1680	Put	1.325	5	0.0000023474
1685	Put	1.375	5	0.0000024215
1690	Put	1.425	5	0.0000024947
1695	Put	1.475	5	0.0000025670
1700	Put	1.525	5	0.0000026385
1705	Put	1.600	5	0.0000027520
1710	Put	1.675	5	0.0000028642
1715	Put	1.725	5	0.0000029325

Individual Contributions (Cont.)				
Near term Strike	Option Type	Mid-quote Price	Delta-K	Contribution by Strike
1620	Put	0.625	5	0.0000011908
1625	Put	0.675	5	0.0000012781
1630	Put	0.675	5	0.0000012703
1635	Put	0.725	5	0.0000013561
1640	Put	0.725	5	0.0000013478
1645	Put	0.775	5	0.0000014320
1650	Put	0.675	5	0.0000012397
1655	Put	0.825	5	0.0000015060
1660	Put	0.825	5	0.0000014970
1665	Put	0.875	5	0.0000015782
1670	Put	0.875	5	0.0000015688
1675	Put	0.925	5	0.0000016485
1680	Put	0.975	5	0.0000017273
1685	Put	1.025	5	0.0000018051
1690	Put	1.025	5	0.0000017944
1695	Put	1.075	5	0.0000018709
1700	Put	1.125	5	0.0000019464
1705	Put	1.125	5	0.0000019350
1710	Put	1.175	5	0.0000020092
1715	Put	1.225	5	0.0000020825
1720	Put	1.275	5	0.0000021549
1725	Put	1.325	5	0.0000022265
1730	Put	1.375	5	0.0000022972
1735	Put	1.425	5	0.0000023670
1740	Put	1.475	5	0.0000024360
1745	Put	1.550	5	0.0000025452
1750	Put	1.600	5	0.0000026123
1755	Put	1.675	5	0.0000027192
1760	Put	1.750	5	0.0000028248
1765	Put	1.825	5	0.0000029292
1770	Put	1.900	5	0.0000030324
1775	Put	2.000	5	0.0000031740
1780	Put	2.075	5	0.0000032746
1785	Put	2.175	5	0.0000034132
1790	Put	2.250	5	0.0000035112
1795	Put	2.375	5	0.0000036856
1800	Put	2.525	5	0.0000038967
1805	Put	2.625	5	0.0000040286
1810	Put	2.775	5	0.0000042353
1815	Put	2.950	5	0.0000044776
1820	Put	3.075	5	0.0000046417
1825	Put	3.300	5	0.0000049541
1830	Put	3.450	5	0.0000051511
1835	Put	3.650	5	0.0000054200
1840	Put	3.900	5	0.0000057598
1845	Put	4.100	5	0.0000060224
1850	Put	4.350	5	0.0000063551
1855	Put	4.650	5	0.0000067568
1860	Put	4.950	5	0.0000071542

Individual Contributions (Cont.)				
Near term Strike	Option Type	Mid-quote Price	Delta-K	Contribution by Strike
1720	Put	1.800	5	0.0000030423
1725	Put	1.850	5	0.0000031087
1730	Put	1.925	5	0.0000032160
1735	Put	2.000	5	0.0000033221
1740	Put	2.100	5	0.0000034682
1745	Put	2.175	5	0.0000035715
1750	Put	2.275	5	0.0000037144
1755	Put	2.375	5	0.0000038556
1760	Put	2.475	5	0.0000039951
1765	Put	2.575	5	0.0000041330
1770	Put	2.725	5	0.0000043491
1775	Put	2.825	5	0.0000044834
1780	Put	3.000	5	0.0000047344
1785	Put	3.100	5	0.0000048648
1790	Put	3.250	5	0.0000050718
1795	Put	3.450	5	0.0000053539
1800	Put	3.600	5	0.0000055557
1805	Put	3.800	5	0.0000058319
1810	Put	3.950	5	0.0000060287
1815	Put	4.200	5	0.0000063750
1820	Put	4.400	5	0.0000066419
1825	Put	4.650	5	0.0000069808
1830	Put	4.900	5	0.0000073160
1835	Put	5.150	5	0.0000076474
1840	Put	5.450	5	0.0000080490
1845	Put	5.750	5	0.0000084461
1850	Put	6.050	5	0.0000088388
1855	Put	6.450	5	0.0000093724
1860	Put	6.750	5	0.0000097557
1865	Put	7.150	5	0.0000102785
1870	Put	7.650	5	0.0000109385
1875	Put	8.150	5	0.0000115914
1880	Put	8.600	5	0.0000121664
1885	Put	9.200	5	0.0000129463
1890	Put	9.750	5	0.0000136478
1895	Put	10.400	5	0.0000144809
1900	Put	11.100	5	0.0000153743
1905	Put	11.800	5	0.0000162582
1910	Put	12.600	5	0.0000172697
1915	Put	13.450	5	0.0000183386
1920	Put	14.400	5	0.0000195317
1925	Put	15.400	5	0.0000207797
1930	Put	16.400	5	0.0000220146
1935	Put	17.600	5	0.0000235035
1940	Put	18.800	5	0.0000249767
1945	Put	20.200	5	0.0000266989
1950	Put	21.600	5	0.0000284031
1955	Put	23.200	5	0.0000303512
1960	Put/Call Average	26.100	5	0.0000339711

Individual Contributions (Cont.)				
Near term Strike	**Option Type**	**Mid-quote Price**	**Delta-K**	**Contribution by Strike**
1865	Put	5.250	5	0.0000075471
1870	Put	5.600	5	0.0000080073
1875	Put	6.000	5	0.0000085335
1880	Put	6.400	5	0.0000090541
1885	Put	6.850	5	0.0000096393
1890	Put	7.350	5	0.0000102883
1895	Put	7.900	5	0.0000109999
1900	Put	8.300	5	0.0000114961
1905	Put	9.000	5	0.0000124003
1910	Put	9.650	5	0.0000132263
1915	Put	10.600	5	0.0000144526
1920	Put	11.400	5	0.0000154626
1925	Put	12.100	5	0.0000163269
1930	Put	13.250	5	0.0000177861
1935	Put	14.150	5	0.0000188962
1940	Put	15.250	5	0.0000202603
1945	Put	16.550	5	0.0000218745
1950	Put	18.250	5	0.0000239979
1955	Put	19.750	5	0.0000258376
1960	Put/Call Average	24.250	5	0.0000296432
1965	Call	21.050	5	0.0000272588
1970	Call	18.100	5	0.0000233198
1975	Call	15.250	5	0.0000195486
1980	Call	12.750	5	0.0000162614
1985	Call	10.450	5	0.0000132609
1990	Call	8.450	5	0.0000106691
1995	Call	6.650	5	0.0000083544
2000	Call	4.950	5	0.0000061876
2005	Call	3.800	5	0.0000047264
2010	Call	2.875	5	0.0000035582
2015	Call	2.025	5	0.0000024938
2020	Call	1.450	5	0.0000017768
2025	Call	1.125	5	0.0000013718
2030	Call	0.725	5	0.0000008797
2035	Call	0.525	5	0.0000006339
2040	Call	0.500	5	0.0000006007
2045	Call	0.400	5	0.0000004782
2050	Call	0.250	5	0.0000002974
2055	Call	0.325	5	0.0000003848
2060	Call	0.225	5	0.0000002651
2065	Call	0.175	5	0.0000002052
2070	Call	0.150	5	0.0000001750
2075	Call	0.150	5	0.0000001742
2080	Call	0.250	5	0.0000002889
2085	Call	0.225	5	0.0000002588
2090	Call	0.100	5	0.0000001145
2095	Call	0.200	5	0.0000002278
2100	Call	0.100	15	0.0000003401
2125	Call	0.100	25	0.0000005536

Individual Contributions (Cont.)				
Near term Strike	**Option Type**	**Mid-quote Price**	**Delta-K**	**Contribution by Strike**
1965	Call	24.150	5	0.0000312732
1970	Call	21.100	5	0.0000271851
1975	Call	18.300	5	0.0000234584
1980	Call	15.700	5	0.0000200240
1985	Call	13.300	5	0.0000168776
1990	Call	11.100	5	0.0000140152
1995	Call	9.150	5	0.0000114952
2000	Call	7.400	5	0.0000092502
2005	Call	5.850	5	0.0000072763
2010	Call	4.650	5	0.0000057550
2015	Call	3.550	5	0.0000043718
2020	Call	2.700	5	0.0000033086
2025	Call	2.050	5	0.0000024997
2030	Call	1.550	5	0.0000018807
2035	Call	1.150	5	0.0000013885
2040	Call	0.875	5	0.0000010513
2045	Call	0.675	5	0.0000008070
2050	Call	0.575	7.5	0.0000010262
2060	Call	0.350	10	0.0000008248
2070	Call	0.250	7.5	0.0000004376
2075	Call	0.200	15	0.0000006968
2100	Call	0.150	25	0.0000008504
2125	Call	0.100	25	0.0000005536
2150	Call	0.100	37.5	0.0000008113
2200	Call	0.075	50	0.0000007748

Sum of Individual Contributions	0.000831402
$\frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i)$	0.018838

$$\frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i)$$

Sum of Individual Contributions	0.0006320516
$\frac{2}{T}\sum_i \frac{\Delta K_i}{K_i^2} e^{RT} Q(K_i)$	0.018494953

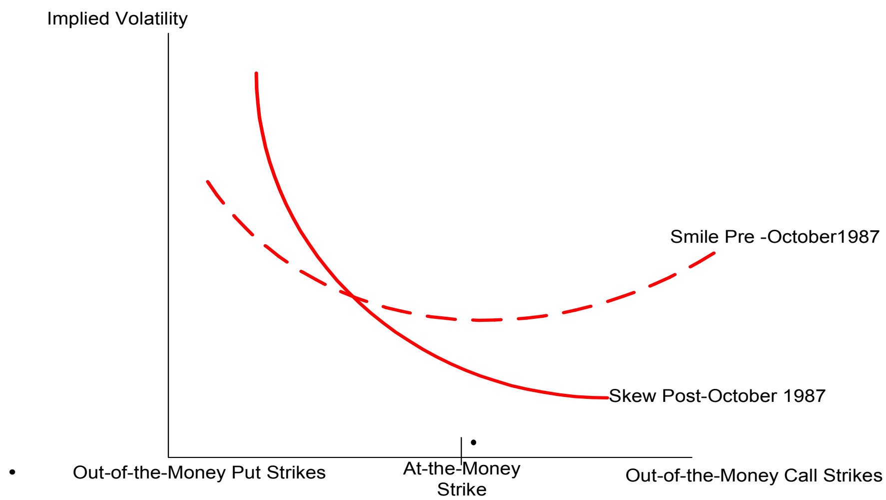
THE CBOE SKEW INDEX®℠ - SKEW®℠

THE CBOE SKEW INDEX®SM - SKEW®SM

Introduction

Since it emerged from a smile in the wake of the crash of October 1987, the curve of S&P 500® implied volatilities, a.k.a. the smile or "skew", has been one the most-studied features of S&P 500 option prices. As illustrated in Chart 1, the smile has lost its symmetry and it is biased towards the put side.

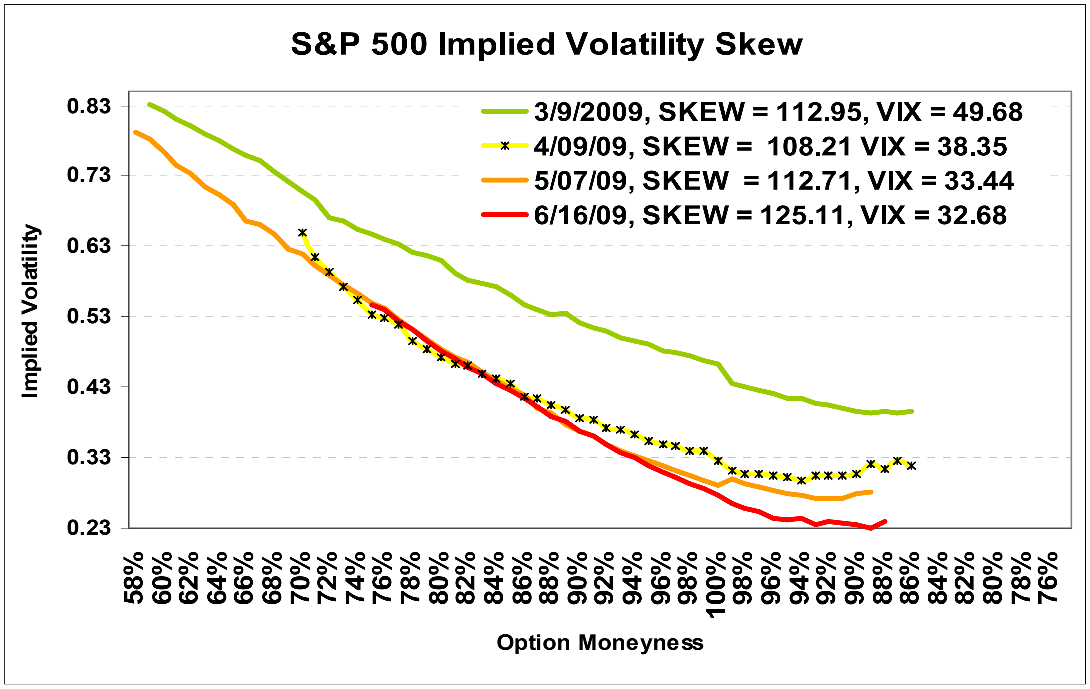
Chart 1. The S&P 500 Implied Volatility Curve Pre-and Post- 1987



Source: CBOE

To get at the core of the skew, the Chicago Board Exchange® (CBOE®) is introducing a new benchmark, the CBOE Skew Index® (SKEW). SKEW is a global, strike-independent measure of the slope of the implied volatility curve that increases as this curve tends to steepen. This is illustrated in Figure 2 with snapshots of the S&P 500 implied volatility curve, SKEW and the CBOE Volatility Index® (VIX®) from March 2009 to June 2009. There is no significant change in SKEW or the overall slope of the implied volatility curve between March and May 2009. By mid-June, SKEW is significantly higher, and the implied volatility curve is noticeably steeper. Chart 2 also illustrates the low correlation between variations in SKEW and VIX. SKEW is calculated from S&P 500 option prices using a method similar to that used for VIX.

Chart 2. Snapshots of Curve of S&P 500 Implied Volatilities, May to June 2009



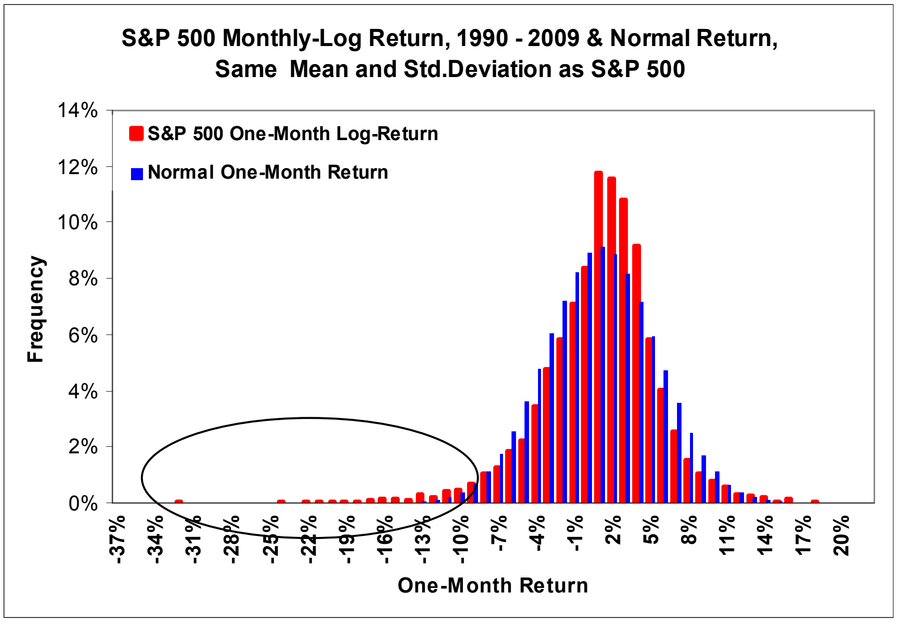
Scaled Differences of Implied Volatilities (IV), SKEW and VIX				
	9-Mar-09	9-Apr-09	7-May-09	16-Jun-09
(90% IV -110% IV) / 100% IV	0.27	0.25	0.30	0.48
SKEW	112.95	108.21	112.71	125.11
VIX	49.68	38.35	33.44	32.68

Source: CBOE

To understand SKEW, it helps to recall why the curve of S&P 500 implied volatilities no longer smiles. The change reflects the fact that investors now prize low strike puts more than they do high strike calls. Why? Because the October 1987 crash has sensitized the market to the possibility of large downwards jumps in the S&P 500. The distribution of S&P 500 log-returns ("S&P 500 distribution") is unlikely to be normal if there are large jumps in returns. Jumps fatten the weights of the tails and asymmetric jumps skew the distribution. The standard deviation of returns is then insufficient to characterize risk and the probability of returns two or three standard deviations below the mean is not negligible, as it is under a normal distribution.

Chart 3 confirms that the S&P 500 distribution is far from normal. It carries "tail risk": (a) the frequency of outlier returns is greater than for a normal distribution and (b) the distribution has a negative skew. This means that VIX, a proxy for the standard deviation of the S&P 500 distribution, may not fully capture the perceived risk of a cash or derivative investment in the S&P 500 or in correlated assets. In light of this, CBOE has developed a complementary indicator that measures perceived tail risk. That indicator is SKEW.

Chart 3. Frequency Distribution of S&P 500 Log-Return



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Source: CBOE

Similar to VIX, SKEW is calculated from the price of a tradable portfolio of out-of-the-money S&P 500 (SPX[SM]) options. This portfolio constitutes an exposure to the skewness of S&P 500 returns and its price encapsulates how the market prices tail risk. A detailed description of the SKEW methodology and the derivation of the SKEW portfolio are in Appendix I. A numerical example of the calculation of SKEW is in Appendix II.

1. Definition of SKEW

SKEW is derived from the price of S&P 500 skewness, denoted by S. S is defined similarly to a coefficient of statistical skewness:

$$S = E[(\frac{R-\mu}{\sigma})^3]$$

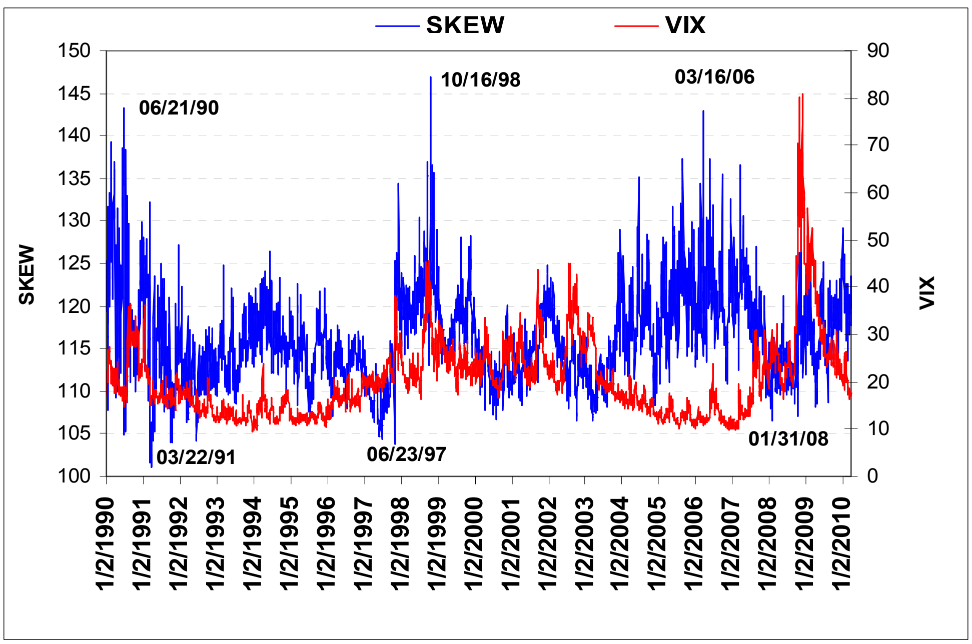
R is the 30-day log-return of the S&P 500, μ is its mean, and σ is its standard deviation; $x = (\frac{R-\mu}{\sigma})^3$ represents a skewness payoff, and S = E[x] is its market price, a risk adjusted expectation of x.

S is calculated from a portfolio of S&P 500 options that mimics an exposure to a skewness payoff. Since S tends to be negative and to vary within a narrow range (-4.69 to - .10 between 1990 and 2010), it is inconvenient to use it as an index. S is therefore transformed to SKEW by the following linear function:

SKEW = 100 – 10 * S

With this definition, SKEW increases as S becomes more negative and tail risk increases.

Chart 4. SKEW 1990 – 2010



Source: CBOE

2. Behavior of SKEW

a. Level of SKEW

Chart 4 follows the history of SKEW and VIX from 1990 to 2010. The minimum value of SKEW over this period is 101 and its maximum is 147. Table 1, a table of the historical frequencies of SKEW values provides further information about the range of SKEW. In this table, the frequency associated with a value of SKEW is the percentage of times that SKEW lied in the range between that value and the value above. For example, 17.55% of the time, SKEW ranged between 115 and 117.5.

Table 1. Historical Frequencies of SKEW

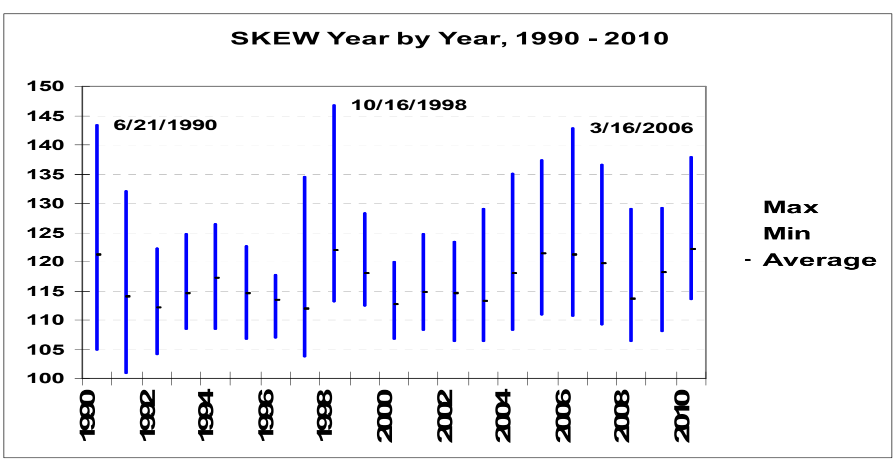
SKEW	Frequency 1990 - 2010	SKEW	Frequency 1990 - 2010
100.00	0.00%	127.50	3.07%
102.50	0.10%	130.00	1.55%
105.00	0.42%	132.50	0.79%
107.50	1.59%	135.00	0.40%
110.00	7.21%	137.50	0.30%
112.50	15.38%	140.00	0.10%
115.00	20.47%	142.50	0.02%
117.50	17.55%	145.00	0.04%
120.00	14.96%	147.50	0.02%
122.50	10.14%	150.00	0.00%
125.00	5.90%		

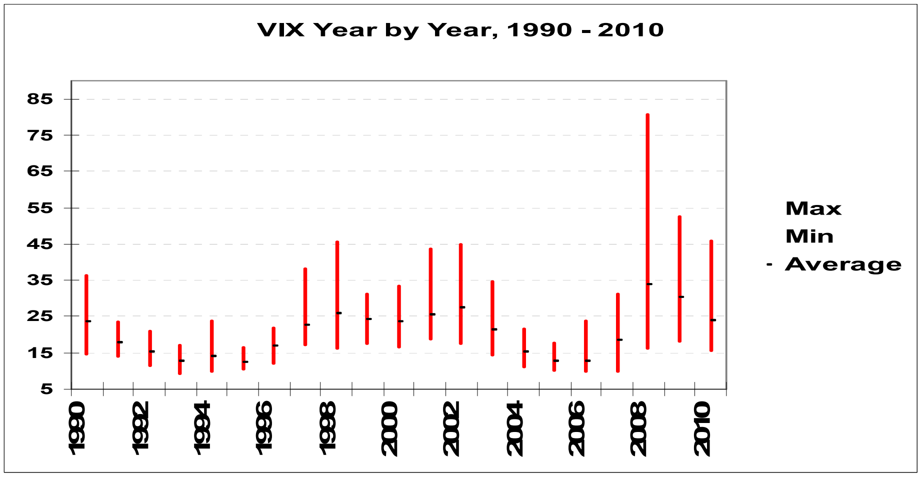
Source: CBOE

b. Annual Range of SKEW

Chart 5 shows the annual highs and lows of SKEW and VIX from 1990 to 2010.

Chart 5. Annual Highs and Lows of SKEW and VIX





Source: CBOE

c. Interpretation of SKEW

To get a sense of what high or very high tail risk means, one can translate the value of SKEW to a risk-adjusted probability that the one-month S&P 500 log-return falls two or three standard deviations below the mean, and use VIX as an indicator of the magnitude of the standard deviation. When SKEW is equal to 100, the distribution of S&P 500 log-returns is normal, and the probability of returns two standard devations below or above the mean is 4.6% (2.3% on each side); the probability decreases to .3% (.15% on each side) for three standard deviations. For a non-normal distribution, comparable probabilities are approximated[1] by adding a skewness term to the normal distribution. The resulting probabilities are shown in Table 2. The probability of a return two standard deviations below the mean gradually increases from 2.3% to 14.45% as SKEW increases from 100 to 145. The probability of a return three standard deviations below the mean increases from .15% to .45% as SKEW increases from 100 to 105 and increases to 2.81% when SKEW reaches 145.

[1] The probabilities shown are risk-adjusted estimates based on overlaying risk-neutral skewness over a normal distribution, as done in a Gram-Charlier expansion of the normal distribution, as in D. Backus, S. Fioresi and K. Li (1997). The risk-neutral kurtosis is omitted from the expansion because, as shown by G. Bakshi, N. Kapadia and D. Madan (2003), it is empirically not significant.

Table 2. Estimated Risk-Adjusted Probabilities of S&P 500 Log Returns Two and Three Standard Deviations below the Mean

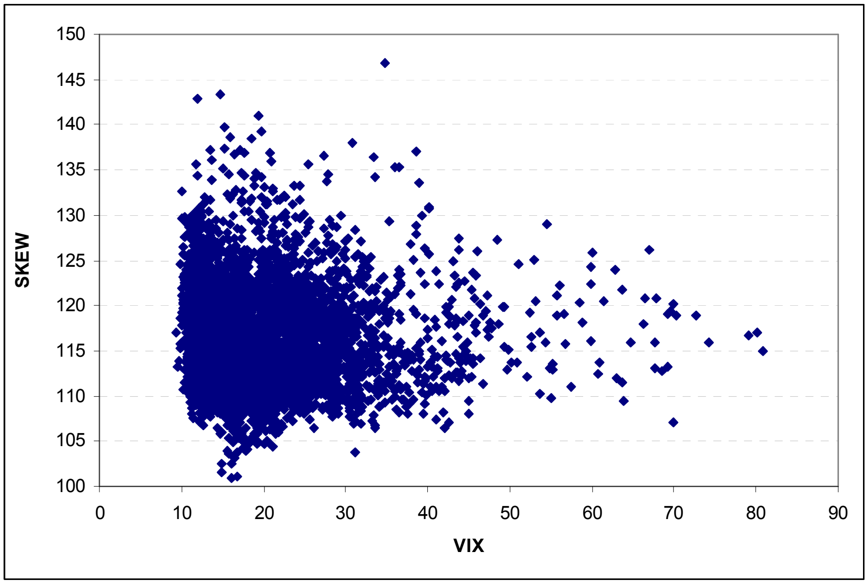
Estimated Risk Adjusted Probability		
SKEW	S&P 500 30-Day Log Return	
	2 Std. Dev	3 Std. Dev.
100	2.30%	0.15%
105	3.65%	0.45%
110	5.00%	0.74%
115	6.35%	1.04%
120	7.70%	1.33%
125	9.05%	1.63%
130	10.40%	1.92%
135	11.75%	2.22%
140	13.10%	2.51%
145	14.45%	2.81%

Source: CBOE

The probabilities in Table 2 apply to return variations measured in standard deviation units. VIX, a proxy for the standard deviation is therefore needed to complete the picture of risk. VIX captures the first layer of perceived risk, as it tells how far on average the S&P 500 log-return is likely to stray on either side of its mean, including the risky downside. Once this is gauged, SKEW catches the additional layer of risk implied by the left tail of the distribution.

Perceived tail risk increases when market participants increase their probability of a catastrophic market decline, what has come to be called a "black swan". As illustrated by Chart 6, a scatter plot of VIX and SKEW, high values of SKEW occur in conjunction with both low or high values of VIX. Note that the upper bound of SKEW values decreases as VIX rises to extreme values above 40. The probable reason is that VIX surges during periods of crashing stock prices, when a repeat crash may not be viewed as that likely.

Chart 6. Scatter plot of SKEW and VIX, 1990 – 2010



Source: CBOE

d. Volatility of SKEW

The definition of SKEW magnifies variations of S by 10, but it reduces its daily percentage variations as well as its realized volatility. To illustrate, the absolute daily change in S varies between .0001 and 3.40 around an average of .18 and that of SKEW varies between .001 and 34 around an average of 1.76 . The absolute daily rate of change of S varies between .004% and 375% around an average of 11.1%, that of SKEW varies between .001% and 25% around an average of 1.49%. The 30–day realized volatility of S is 872, and that of SKEW is 110. This compares to a 30-day realized volatility of 372 for VIX.

3. One Last Thing You Should Know About SKEW

CBOE calculates a daily term structure of SKEW. Historical prices for the SKEW Index and for this term structure can be found on the CBOE website at http://www.cboe.com/micro/IndexSites.aspx under CBOE SKEW Indexes.

APPENDIX I. DERIVATION OF SKEW & SKEW PORTFOLIO

Derivation of SKEW

SKEW is defined as SKEW = 100 – 10 * S, where $S = E[\frac{(R - \mu)^3}{\sigma^3}]$, R is the 30-day log-return of the S&P 500, μ = E[R] is its expected value, and σ = $E[(R- \mu)^2]^{1/2}$ is its standard deviation, with all expectations E[x] taken under the risk-neutral density.

S is easily recognized as the risk-neutral version of a coefficient of statistical skewness. S is also the expectation, or market price of a skewness payoff[2] determined by the asymmetry of the S&P 500 log-return. When the S&P 500 log-return is symmetric, the payoff is equal to 0, and when the S&P 500 log-return is biased toward negative (positive) values, the payoff is negative (positive).

In general, 30-day options are not available and S is derived by inter or extrapolation from S_{near} and S_{next}, the prices of skewness at adjacent expirations:

$$S = w\, S_{near} + (1\text{-}w)\, S_{next}$$

where $w = (T_{next} - T_{30})/(T_{next} - T_{near})$, and T_{near}, T_{next} and T_{30} are the times to expiration of the near and next term options expressed in minutes, and T is the number of minutes in 30 days.

To streamline exposition, in what follows, S refers to either S_{near} or S_{next}.

S is expanded as the following function of the prices P_1, P_2, and P_3 of the power payoffs R, R^2, and R^3 :

$$S = \frac{E[R^3] - 3E[R]E[R^2] + 2E[R]^3}{(E[R^2] - E^2[R])^{3/2}} = \frac{P_3 - 3P_1P_2 + 2P_1^3}{(P_2 - P_1^{\ 2})^{3/2}}$$

Similar to realized variance, power payoffs can be replicated by delta-hedging portfolios of at- and out-of-the money options[3]. Hence, the calculation of P_1, P_2, and P_3, and from there SKEW, is analogous to the calculation of VIX. The selection of S&P 500 contract months and the screening of S&P 500 series are the same, as is the inter or extrapolation of SKEW from SKEW-like measures at option expiration dates adjacent to 30 calendar days Where the two calculations diverge is in the equations that are applied to the option prices to derive P_1 , P_2 and P_3:

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[2] See G. Bakshi, N. Kapadia and D. Madan, Stock Return Characteristics, Skew Laws, and the Differential Pricing of Individual Equity Options, The Review of Financial Studies, 16(1), 101-143, 2003.

[3] P. Carr and D. Madan, Towards a Theory of Volatility Trading, Volatility, Robert Jarrow, ed., Risk Publications, pp. 417-427, 2002 show that any continuous payoff can be expanded in terms of sums of option payoffs. This is sufficient to expand power returns as sum of option payoffs. For realized variance, one also needs to apply Ito's lemma.

(1) $P_1 = \mu = E[R_T] = e^{rT}(-\sum_i \frac{1}{K_i^2} Q_{K_i} \Delta_{K_i}) + \varepsilon_1$

(2) $P_2 = E[R_T^2] = e^{rT}(\sum_i \frac{2}{K_i^2}(1 - \ln(\frac{K_i}{F_0}))Q_{K_i}\Delta_{K_i}) + \varepsilon_2$

(3) $P_3 = E[R_T^3] = e^{rT}(\sum_i \frac{3}{K_i^2}\{2\ln(\frac{K_i}{F_0}) - \ln^2(\frac{K_i}{F_0})\}Q_{K_i}\Delta_{K_i}) + \varepsilon_3$

where

F_0	Forward index level derived from index option prices
K_0	First listed strike below F_0
K_i	Strike price of ith out-of-the-money option; a call if $K_i>K_0$ and a put if $K_i< K0$; both put and call if Ki=K0.
ΔKi	Half the difference between the strike on either side of Ki: $\Delta K_i = \frac{1}{2}(K_{i+1} - K_{i-1})$ (Note: For the minimum (maximum) strike, ΔKi is simply the distance to the next strike above (below).
r	Risk-free interest rate to expiration
Q(Ki)	The midpoint of the bid-ask spread for each option with strike Ki.
T	The time to expiration expressed as a fraction of a year.
ε_j	Adjustment terms compensating for the difference between K_0 and F_0

(4) $\varepsilon_1 = -(1 + \ln(\frac{F_O}{K_O}) - \frac{F_O}{K_O}),$

(5) $\varepsilon_2 = 2\ln(\frac{K_O}{F_O})(\frac{F_O}{K_O} - 1) + \frac{1}{2}\ln^2(\frac{K_O}{F_O}),$

(6) $\varepsilon_3 = 3\ln^2(\frac{K_O}{F_O})(\frac{1}{3}\ln(\frac{K_O}{F_O}) - 1 + \frac{F_O}{K_O})$

SKEW Portfolio

Recall that SKEW = 100 – 10 S, where S prices a portfolio that replicates an exposure to 30 day-skewness, which we call the "skewness" portfolio. This implies that SKEW is also the price of a portfolio, namely the portfolio that overlays a position short 10 times the skewness portfolio over a money market position.

To determine the composition of the skewness portfolio, note that its payoff is a linear function of the power payoffs R, R^2 and R^3

$$\frac{(R \quad -\mu)^3}{\sigma^3} = \frac{R^3 - 3\mu R^2 + 3\mu^2 R - \mu^3}{\sigma^3} = a_1 R + a_2 R^2 + a_3 \; R^3 - (\frac{\mu}{\sigma})^3 .$$

where $\mu = E[R] = P_1$, and $\sigma = E[(R- \mu)^2]^{½} = E[R^2]- E[R]^2= P_2 - P_1^2$.

Each power payoff is replicated by a portfolio of SPX options. Hence, the skewness portfolio is obtained by aggregating the three power portfolios and overlaying the combination on a money market position with payoff $-(\frac{\mu}{\sigma})^3$.

The compositions of the power portfolios are implicit in equations (1) to (3). Each consists of a strip of at- and out-of-the-money S&P 500 puts and calls weighted by different coefficients. The first strip is delta-hedged by a static position in S&P 500 forward contracts. The number of put or call options at strike K held in the three power strips are as follows:

R: $b_{1K} = -\frac{\Delta K}{K^2}$

R^2: $b_{2K} = 2\frac{\Delta K}{K^2} * (1 - \ln\frac{K}{F_0})$,

R^3: $b_{3K} = 3\frac{\Delta K}{K^2} * (2\ln(\frac{K}{F_0}) - \ln^2(\frac{K}{F_0}))$

An exposure to the skewness payoff is constructed by aggregating the number of calls or puts at each strike.

The number of puts or calls held at strike K is equal to $\alpha_K = a_1 b_{1K} + a_2 b_{2K} + a_3 b_{3K}$. Afer substituting the expressions for a_i and b_{iK}, α_K is found equal to:

$$\alpha_K = \frac{3\Delta K}{\sigma^3 K^2}\{-\ln^2(\frac{K}{F_0}) + 2\ln(\frac{K}{F_0})(1+\mu)\} - \mu(\mu+2)\}$$

Substituting the different option and money market positions in SKEW, and taking into account the $100 multiplier of S&P 500 options, we finally obtain the SKEW portfolio:

Money market position : $e^{-rT}\{100 - 10\ [w*(-(\frac{\mu_{near}}{\sigma_{near}})^3) + (1-w) * (-(\frac{\mu_{next}}{\sigma_{next}})^3)]\}$

Portfolio of OTM options : - .01* 10 * w * $a_{K\ near}$ of near term option with strike K , and

- .01* 10 * (1-w)* $a_{K\ next}$ of next term option with strike K .

The options at the near and next expiration are delta hedged by shorting 10 / M S&P 500 forward contracts, where M is the multiplier of an S&P 500 forward contract with the same expiration.

APPENDIX II THE SKEW CALCULATION STEP-BY-STEP

The calculation of SKEW proceeds in two parts. The first is to determine the composition of the portfolio of S&P 500 puts and calls to be used. This part proceeds exactly as for VIX. Once the portfolio is established, formulas (1) to (6) are applied to put and call prices to find S_{near} and S_{next}. This leads directly to SKEW. The determination of the SKEW portfolio is a by-product of the calculation.

The following hypothetical example of the calculation of SKEW on July 28, 2010, at 10:45 am Chicago time illustrates the calculation step-by step. An extract of the data used is shown in the example.

Step 1: *Determinination of options in SKEW portfolio.*

- Selection of option months: The near and next-term options are usually the first and second SPX contract months. "Near-term" options must have at least one week to expiration; this requirement is intended to minimize pricing anomalies that might occur close to expiration. When the near-term options have less than a week to expiration, SKEW "rolls" to the second and third SPX contract months. For example, on the second Friday in June, SKEW would be calculated using SPX options expiring in June and July. On the following Monday, July would replace June as the "near-term" and August would replace July as the "next-term.".

  On July 28, 2010, August 2010 and September 2010 options are selected as the near and next term options.

- Calculation of time to expiration: The time to expiration of the selected options is calculated next. This is needed to calculated interest rate factors and also to interpolate between values at adjacent months to get the 30-day SKEW. The time to expiration is expressed as a fraction of a year, based on the number of minutes to expiration. The options are deemed to expire at 8:30 am Chicago time on the third Friday and a year is deemed to have 365 days.

August 2010 options expire on the 20th and September 2010 options expire on the 17th . At 10:45 am on July 28, 2010, the times to expiration of August and September 2010 options are equal to 0.065 and 0.142.

- Interest rate used: The second piece of data to calculate interest rate discount factors is the risk-free interest rate, r. r is the bond-equivalent yield of the U.S. T-bill maturing closest to the expiration dates of relevant SPX options. As such, the SKEW calculation may use different risk-free interest rates for near- and next-term options.

In this example, R = 0.00155 for both sets of options.

- Calculation of S&P 500 forward price and determination of at-the-money strike: Similar to VIX, is calculated from at and out-of-the-money puts and calls. The at-the-money strike is defined as the listed strike immediately below the S&P 500 forward price. To find the forward price, find the strike for which the difference between the midquotes of the call and put is at a minimum. Then calculate the forward price as $F = e^{rT} * (C - P) + K$, where T is the time to expiration, C and P are the call and put midquotes, and K is the strike at which minimum occurs.

As seen in Table 1 below, for August 2010 options, the strike at which the minimum of the midquote difference is attained is 1105. The 1105 row is highlighted in green. The forward price for August 2010 is equal to

$$F_{Aug} = e^{.00155 * 0.65} * (23.7 - 21.85) + 1105 = 1106.85.$$

The strike for September 2010 options also turns out to be 1105. By a similar calculation, F_{Sep} = 1106.45. Thus the at-the-money strike for both August and September is 1105. Puts at 1105 or below and calls at 1105 or above will be included in the calculation.

Table 1. Extract from August 2010 option data on July 28, 2010, 10:45 am Chicago time.

Strike	Put Bid	Put Ask	Put Midquote	delta k	Call Bid	Call Ask	Call Midquote	midcall - midput
690	0	0	**0**		414.4	418.5	**416.45**	
695	0	0	**0**		410	414.1	**412.05**	
700	0.05	0.1	**0.075**	5	405.3	410.3	**407.8**	407.725
705	0.05	0.1	**0.075**	5	401.6	405.7	**403.65**	403.575
710	0.05	0.1	**0.075**	5	396.3	400.3	**398.3**	398.225
715	0.05	0.1	**0.075**	5	389.6	393.7	**391.65**	391.575
720	0.05	0.1	**0.075**	5	385.3	390.3	**387.8**	387.725
...	...	...	...	...	...	...	...	...
1095	16.7	19.2	**17.95**	5	28.9	31.2	**30.05**	12.1
1100	19	20.5	**19.75**	5	25.7	27.6	**26.65**	6.9
1105	20	23.7	**21.85**	5	22.5	24.9	**23.7**	1.85
1110	23.5	25	**24.25**	5	20.6	22.1	**21.35**	-2.9
1115	25.1	28	**26.55**	5	18.5	20.8	**19.65**	-6.9
1120	28.3	30.1	**29.2**	5	14.3	17.8	**16.05**	-13.15
1125	30.9	32.9	**31.9**	5	13.7	14.9	**14.3**	-17.6
1130	34	36.1	**35.05**	5	11.3	12.6	**11.95**	-23.1
1135	36.6	38.8	**37.7**	5	9.2	10.7	**9.95**	-27.75
...	...	...	...	...	...	...	...	...
1205	97	100.2	**98.6**	5	0.05	0.9	**0.475**	-98.125
1210	100.2	104.1	**102.15**	5	0	0	**0**	-102.15
1215	106.9	110.1	**108.5**	5	0.05	1	**0.525**	-107.98
1220	111.9	115.1	**113.5**	5	0	0	**0**	-113.5
1225	116.8	120	**118.4**	5	0.1	0.3	**0.2**	-118.2
1230	121.8	125.3	**123.55**	5	0.05	0.3	**0.175**	-123.38
1235	125.3	129.3	**127.3**	5	0.05	0.25	**0.15**	-127.15
1240	130.7	134.7	**132.7**	5	0.05	0.7	**0.375**	-132.33
1245	136.7	140.7	**138.7**	5	0.05	0.2	**0.125**	-138.58
1250	140.7	144.7	**142.7**	5	0.05	0.1	**0.075**	-142.63
1255	146.7	150	**148.35**	5	0.05	0.3	**0.175**	-148.18
1260	151.7	155	**153.35**	5	0	0.9	**0**	
1265	156.7	160	**158.35**	5	0	0.25	**0**	

Source : CBOE

- <u>Elimination of strikes</u>. The SKEW calculation only uses at or out-of-the money strikes. In addition, only options with non-zero bid prices are used, and once two consecutive puts with 0 bid prices are found, all puts with lower strike prices are eliminated. Similarly, once two consecutive calls with 0 bid prices are found, all calls with higher strike prices are eliminated. In Table 1, all data for eliminated strikes are grayed out, and puts and calls eliminated because they were below and above two consecutive strikes with zero bids are not shown. Data for strikes ranging from 720 to 1095 and from 1135 to 1205 are replaced by dots (…) to provide a more compact display.

  For August 2010 options, this elimination process leaves puts with strikes from 700 to 1105 and calls with strikes from 1105 to 1255. Also leave out calls with strikes 1210 and 1220 because they have 0 bids. For September 2010 options, use puts with strikes from 725 to 1105 and calls with strikes from 1105 to 1280.

  One important note: as volatility rises and falls, the strike price range of options with non-zero bids tends to expand and contract. As a result, the number of options used in the SKEW calculation may vary from month-to-month, day-to-day and possibly, even minute-to-minute.

<u>Step 2</u> – *Calculate SKEW for both near-term and next-term options*

Recall that SKEW = 100 – 10 S, where S the price of skewness can be derived from the prices of S&P 500 options:

$$S = \frac{E[R^3] - 3E[R]E[R^2] + 2E[R]^3}{(E[R^2] - E^2[R])^{3/2}} = \frac{P_3 - 3P_1P_2 + 2P_1^3}{(P_2 - P_1^{\ 2})^{3/2}}$$

(1) $$P_1 = \mu = E[R_T] = e^{rT}\left(-\sum_i \frac{1}{K_i^{\ 2}} Q_{K_i} \Delta_{K_i}\right) + \varepsilon_1$$

(2) $$P_2 = E[R_T^2] = e^{rT}\left(\sum_i \frac{2}{K_i^{\ 2}}\left(1 - \ln\left(\frac{K_i}{F_0}\right)\right) Q_{K_i} \Delta_{K_i}\right) + \varepsilon_2$$

(3) $$P_3 = E\,[R_T^3] = e^{rT}\left(\sum_i \frac{3}{K_i^{\ 2}}\left\{2\ln\left(\frac{K_i}{F_0}\right) - \ln^2\left(\frac{K_i}{F_0}\right)\right\} Q_{K_i} \Delta_{K_i}\right) + \varepsilon_3$$

(4) $$\varepsilon_1 = -\left(1 + \ln\left(\frac{F_O}{K_O}\right) - \frac{F_O}{K_O}\right),$$

(5) $$\varepsilon_2 = 2\ \ln\left(\frac{K_O}{F_O}\right)\left(\frac{F_O}{K_O} - 1\right) + \frac{1}{2}\ln^2\left(\frac{K_O}{F_O}\right),$$

(6) $$\varepsilon_3 = 3\ \ln^2\left(\frac{K_O}{F_O}\right)\ \left(\frac{1}{3}\ln\left(\frac{K_O}{F_O}\right) - 1 + \frac{F_O}{K_O}\right)$$

For this calculation, we need the interest rate factor, the relevant option prices, the at-the-money strike K_0, the forward price F_0 and the strike intervals ΔK. All but the strike intervals have already been determined. At the smallest and largest strike, the strike interval is specified as the difference between that strike and the next. At all other strikes the strike interval is specified as half the distance between adjacent strikes.

As seen in Table 1, on July 28, 2010, the strike intervals at the extreme strikes as well as at intermediate strikes are all equal to 5 for S&P 500 August 2010 options selected for the calculation of SKEW.

With strikes intervals determined, all that remains to be done is :

- Calculate each of the components of the sums in P_1, P_2, P_3.
- Add the components up, multiply by the interest rate factor and add the adjustment term, the epsilons.

- Use the formula for S to calculate the price of skewness from P_1, P_2, P_3 at each expiration
- Interpolate or extrapolate the 30-day value of S.
- Calculate SKEW as 100 – 10S

The calculated values of the components of the three sums are shown in Table 2. The column labeled "for P1" contains the value $x = \frac{\Delta K}{K^2} * OptionMidquote$ at each strike, and it picks up the put midquote for strikes below the money, the call midquote for strikes above the money, and the average midquote at -the- money.

The column labeled "for P2" contains the value y $= 2x*(1-\ln(\frac{K}{F_0})$ at each strike.

The column labeled "for P3" contains the value z = $3x*(2\ln(\frac{K}{F_0})-\ln^2(\frac{K}{F_0}))$ at each strike.

Table 2. Sample of calculated values of components of SKEW

Strike	Put Midquote	delta k	Call Midquote	midcall - midput	for P1	for P2	for P3	Exposure to -10 * skewness portfolio
690	0		416.45					
695	0		412.05					
700	0.075	5	407.8	407.725	7.6531E-07	2.23E-06	-2.59E-06	0.009930169
705	0.075	5	403.65	403.575	7.5449E-07	2.19E-06	-2.5E-06	0.009681804
710	0.075	5	398.3	398.225	7.4390E-07	2.15E-06	-2.42E-06	0.009438799
715	0.075	5	391.65	391.575	7.3353E-07	2.11E-06	-2.34E-06	0.00920102
720	0.075	5	387.8	387.725	7.2338E-07	2.07E-06	-2.27E-06	0.008968339
...	...	...	...	...				
1095	17.95	5	30.05	12.1	7.4852E-05	0.000151	-4.86E-06	0.000103684
1100	19.75	5	26.65	6.9	8.1612E-05	0.000164	-3.05E-06	5.1038E-05
1105	21.85	5	23.7	1.85	9.3262E-05	0.000187	-9.37E-07	-6.63095E-07
1110	24.25	5	21.35	-2.9	8.6641E-05	0.000173	1.48E-06	-5.14376E-05
1115	26.55	5	19.65	-6.9	7.9028E-05	0.000157	3.47E-06	-0.000101303
1120	29.2	5	16.05	-13.15	6.3975E-05	0.000126	4.51E-06	-0.000150277
1125	31.9	5	14.3	-17.6	5.6494E-05	0.000111	5.47E-06	-0.000198376
1130	35.05	5	11.95	-23.1	4.6793E-05	9.16E-05	5.75E-06	-0.000245616
1135	37.7	5	9.95	-27.75	3.8619E-05	7.53E-05	5.75E-06	-0.000292014
...	...	...	...	...				
1205	98.6	5	0.475	-98.125	1.6356E-06	2.99E-06	7.98E-07	-0.000861405
1210	102.15	5	0	-102.15	0.0000E+00	0	0	0
1215	108.5	5	0.525	-107.98	1.7782E-06	3.22E-06	9.48E-07	-0.000931744
1220	113.5	5	0	-113.5	0.0000E+00	0	0	0
1225	118.4	5	0.2	-118.2	6.6639E-07	1.2E-06	3.85E-07	-0.000999623
1230	123.55	5	0.175	-123.38	5.7836E-07	1.03E-06	3.47E-07	-0.001032668
1235	127.3	5	0.15	-127.15	4.9173E-07	8.76E-07	3.06E-07	-0.001065131
1240	132.7	5	0.375	-132.33	1.2194E-06	2.16E-06	7.84E-07	-0.001097021
1245	138.7	5	0.125	-138.58	4.0322E-07	7.12E-07	2.68E-07	-0.001128349
1250	142.7	5	0.075	-142.63	2.4000E-07	4.22E-07	1.64E-07	-0.001159126
1255	148.35	5	0.175	-148.18	5.5555E-07	9.72E-07	3.92E-07	-0.00118936
1260	153.35	5	0					
1265	158.35	5	0					

Source: CBOE

Table 3. Final Results from August and September 2010 S&P 500 options

Trade Date	07/28/10	P1 = E[R]	-0.00173	Trade Date	07/28/10	P1 = E[R]	-0.0041
Expiration Date	08/20/10	P2=E[R^2]	0.003606	Expiration Date	09/17/10	P2=E[R^2]	0.00864
Time to Expiration= tau	0.065	P3=E[R^3]	-0.00049	Time to Expiration	0.142	P3=E[R^3]	-0.001
Treasury Bill Rate	0.00155	Std. Dev. [R]	0.060021	Treasury Bill Rate	0.00155	Std. Dev. [R]	9.29%
Forward Price	1106.85	Skewness	-2.19656	Forward Price	1106.45	Skewness	-1.68
Center Strike	1105	SKEW @ 23 days	121.9656	Center Strike	1105	SKEW @ 51day	116.75
Epsilon 1	1.40E-06	VIX @ 23 days	22.98	Epsilon 1	8.61E-07	VIX @ 51 days	24.01
Epsilon 2	-4.2E-06	Delta Hedge Position	-0.41	Epsilon 2	-2.58E-06	Delta Hedge Position	-0.62984
Epsilon 3	1.176E-11	TBill Position	100.00	Epsilon 3	4.442E-12	TBill Position	100.00

Source: CBOE

Table 3 shows the calculated values of the epsilons using equations (4) to (6) and based on forward prices and at-the-money strikes for the August and September 2010 expirations, and the final results from summing up the elements of P1, P2, P3 in each of their corresponding columns.

$P_1 = -e^{rT} \text{ sum } x + \varepsilon_1 \quad P_2 = e^{rT} \text{ sum } y + \varepsilon_2 \quad P_3 = e^{rT} \text{ sum } z + \varepsilon_3$

The three P values are now substituted in the formula for S to get the value of skewness at each expiration. The SKEW- like value for each expiration is shown in the table.

Note that the value of VIX is also shown in the table. VIX is easily derived from the elements in column 1. Specifically VIX = 100 * sqrt{-(T^{-1}) * P_1}

Oops.. .we almost forgot

Last Step of Calculation – *Calculate the 30-day weighted average of S_1 and S_2. Then take the difference between 100 and 10 times that weighted average to get SKEW.*

$$SKEW = 100 - S = 100 - 10 * \{w\ S_1 + (1-w)_2 S_2\}$$

$$w = \frac{\text{minutes to next expiration} - \text{minutes to } 30 \text{ days}}{\text{minutes btw next \& near term expirations}}$$

When the near-term options have less than 30 days to expiration and the next-term options have more than 30 days to expiration, the resulting SKEW value reflects an interpolation of S_1 and S_2 ; i.e., each individual weight is less than or equal to 1 and the sum of the weights equals 1.

At the time of the SKEW "roll," both the near-term and next-term options have more than 30 days to expiration. The same formula is used to calculate the 30-day weighted average, but the result is an extrapolation of S_1 and S_2 ; i.e., the sum of the weights is still 1, but the near-term weight is greater than 1 and the next-term weight is negative (e.g., 1.25 and −0.25).

Continuing with the July 28, 2010 example,

S = 0.730208333 * (-2.19656) + 0.269791667 *(-1.68) = -2.056

SKEW = 100 – 10*(-2.056) = 120.56

Special Note: All CBOE Volatility Indexes – SKEW,VIX, VXD, VXN, RVX, VXV, OVX, GVZ and EVZ – are calculated using option price quotes from CBOE exclusively.

References

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Bakshi, G., Kapadia, N. and Madan, D., "Stock Return Characteristics, Skew Laws, and the Differential Pricing of Individual Equity Options,", *The Review of Financial Studies* 16(1):2003, 101–143.

Exhibit__(NYCRP-9)

https://www.wsj.com/articles/silicon-valley-bank-svb-financial-what-is-happening-299e9b65

HEARD ON THE STREET Follow

What Happened With Silicon Valley Bank?

Some questions and answers to explain what is happening after the government took action

By Telis Demos Follow

Updated March 14, 2023 3:00 pm ET

A share-sale announcement from SVB Financial led the stock to crater. PHOTO: MICHAEL NAGLE/BLOOMBERG NEWS

Last week, Silicon Valley Bank failed and was taken over by regulators. On Sunday, another bank, Signature Bank, was also closed. That day, the government stepped in to protect all of those banks' deposits and create a way for other banks to get access to more cash.

Why did all that happen, and what could happen next? Here are some questions and answers to help guide readers.

Why did SVB fail?

Since the pandemic began, Silicon Valley Bank had been buying lots of what are often considered "safe" assets like U.S. Treasurys and government-backed mortgage bonds. But when interest rates start to rise quickly, as they did last year, their fixed interest payments don't keep up with rising rates. Those assets were no longer worth what the bank paid for them, and the bank was sitting on more than $17 billion in potential losses on those assets as of the end of last year.

Then last week, the bank faced a tidal wave of $42 billion of deposit withdrawal requests. It wasn't able to raise the cash it needed to cover the outflows, which prompted regulators to step in and close the bank.

Why was there a run on the bank?

It is hard to say what specifically causes a run; it is a matter of crowd psychology. But fears may have emerged after the bank announced a capital raise and the sale of a large amount of securities at a loss. The bank catered to venture capitalists and technology startups. Because these were corporate deposits, they were often larger than the Federal Deposit Insurance Corp.'s $250,000 insurance limit. SVB had over $150 billion in uninsured deposits as of the end of last year.

Could SVB have sat on paper losses until rates declined?

In theory the bank could have muddled through, letting securities mature and getting back its money. This might have covered a relatively steady outflow of deposits until conditions changed. But it didn't have that time after deposit withdrawals surged.

What happened to Signature Bank?

SVB's problems appeared to spill over to Signature Bank, sparking its own depositors to make big withdrawal requests. Like SVB, Signature had a relatively large amount of uninsured deposits because of its business model catering to private companies. It probably didn't help that the bank was one of the largest serving cryptocurrency firms. Another crypto-focused bank, Silvergate Capital, close down on March 8.

What happened to those uninsured deposits?

The FDIC on Friday said that insured depositors of SVB would have access to their money no later than Monday morning. Initially, it said that uninsured depositors would receive a dividend, and then receivership certificates for the remaining balances that could be paid out over time, meaning repayment wasn't certain.

But then on Sunday, the FDIC, along with the Treasury Department and Secretary Janet Yellen, the Federal Reserve, and President Biden, said that they would use a "systemic risk exception" to cover the uninsured deposits of SVB and Signature. Customers could then also access these deposits on Monday morning.

Was that a bailout of SVB and Signature?

It is the case that the two banks' uninsured depositors are receiving special government assurances. But the regulators stipulated that in the event that proceeds from the sale of the bank or its assets aren't sufficient to cover the uninsured deposits, any losses to the Deposit Insurance Fund to cover them would be recovered by a special assessment charged to banks.

The banks' shareholders and unsecured bondholders—meaning those creditors to the bank who didn't have explicit collateral backing their debts—weren't given any support by regulators.

What happens to SVB employees? Can SVB recover?

Senior managers, including the CEO, Greg Becker, were removed. For now, many other employees are being asked by regulators to do their same jobs as the bank is unwound by regulators.

The bank could possibly be sold by regulators as they try to recoup money used to cover deposits. There were also other parts of SVB Financial Group's broader business, such as an investment bank, that could also be sold off.

Silicon Valley Bank counts many startups and venture-capital firms as clients. PHOTO: DAVID PAUL MORRIS/BLOOMBERG NEWS

Are other banks at risk?

While there are anecdotes of people pulling deposits from other banks, no other failures have yet emerged. At least one bank has said it has secured additional access to cash. The Federal Reserve also created a new lending facility, called the Bank Term Funding Program, which banks can use to borrow cash in exchange for posting certain assets as collateral. In theory, banks could use that cash to cover deposit requests.

Could SVB's collapse cause a recession?

The guarantee of the unsecured deposits may help to contain immediate fallout, like companies that had money at SVB and Signature not being able to make payroll. But if other banks are worried about their deposits or capital, it could constrain lending that would tie up their resources. A big question is whether the events change the Federal Reserve's pace of interest-rate increases.

What can we expect next?

The process of attempting to sell off SVB will be closely watched. Attention will also turn to longer-term questions about banks' health, which investors are already asking. The Fed's borrowing facility may solve acute cash problems, but it won't do anything to rebuild the value of banks' securities portfolios, assuming interest rates stay around where they are. Banks in many ways had fallen off Washington's radar in the years since the financial crisis. That has all changed now.

Write to Telis Demos at Telis.Demos@wsj.com

Exhibit__(NYCRP-10)

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Damodaran ONLINE

About Teaching Writing Data Tools Blog YouTube Podcasts

My name is Aswath Damodaran, and I teach corporate finance and valuation at the Stern School of Business at New York University. I am a teacher first, who also happens to love untangling the puzzles of corporate finance and valuation, and writing about my experiences. As a result, I am at the intersection of three businesses, education, publishing and financial services, that are all big, inefficiently run and deserve to be disrupted. I may not have the power to change the status quo in any of these businesses, but I can stir the pot, and this website is my attempt to do so.

Broadly speaking, the website is broken down into four sections. The first, teaching, includes all of my classes, starting with the MBA classes that I teach at Stern and including the shorter (2-day to 3-day) executive sessions I have on corporate finance and valuation. You will find not only the material for the classes (lecture notes, quizzes), but also webcasts of the classes that you can access on different platforms. I also have classes specifically tailored to an online audience on valuation, corporate finance and investment philosophies, as well as my quirky versions of accounting and statistics classes. The second, writing, includes links to almost everything I have written and continue to write, starting with my books and extending to my practitioner papers (on equity risk premiums, cash flows and other things valuation-related). The third, data, contains the annual updates that I provide on industry averages, for US and global companies, on both corporate finance and valuation metrics (including multiples). It is also where I provide my estimates of equity risk premiums and costs of capital. The fourth, tools, incorporates the spreadsheets that I have developed over time to value and analyze companies and short in-practice webcasts on how to analyze companies. (If you have trouble with any of the links, try a different browser, since Google Chrome, in particular, seems to have developed an aversion to downloads on my site.)

I have been told that my website is ugly, and I apologize for its clunky look and feel. While some of you have offered to make it look better for me, and I thank you for your kindness, I need to be able to tweak, modify and adapt the website as I go along and to do that, I have to work with what I know about website design, which is not much. You can try the search engine below and if that does not work, try this guide to the site.

ENHANCED BY Google

Equity Risk Premiums (Data, Updates and Papers)

Implied ERP on March 1, 2026 = 4.38% (Trailing 12 month, with adjusted payout); 4.37% (Trailing 12 month cash yield); 5.38% (Average CF yield last 10 years);4.15% (Net cash yield); 3.74% (Normalized Earnings & Payout) (with the US treasury rate of 3.96% used as the riskfree rate in US dollars; increase each of the premiums by the default spread (0.23%)for the US, if you are netting that out of the treasury to get to an adjusted dollar riskfree rate of 3.73%)

Implied ERP in previous month = 4.17% (Trailing 12 month, with adjusted payout); 4.25% (Trailing 12 month cash yield); 6.20% (Average CF yield last 10 years); 3.98% (Net cash yield); 3.63% (Normalized Earnings & Payout) (with the US treasury rate of 4.26% used as the riskfree rate in US dollars; increase each of the premiums by the default spread (0.23%)for the US, if you are netting that out of the treasury to get to an adjusted dollar riskfree rate of 4.03%)

Other Updates

Teaching:

1. *Stern Classes*: In Spring 2025, I taught my regular roster of classes - corporate finance and valuation to the MBAS, and valuation to the undergraduates, and it is fully archived. You can find a full listing of my regular classes here.
2. *Online classes (Free and NYU Certificate)*: The online versions of these classes can be found here and NYU is offering certificate versions here. In the next academic year, I will be teaching all three classes again and you can find the links to them here. In August 2024, I added a class on corporate life cycles, to accompany my book on the same topic.
3. *Short Prep Courses*: If you need a short brush up on the basics of finance, I have added a class on the foundations of finance as well as a minimalist accounting class to my online list. In 2021, I added a statistics class to the mix, again taught from the perspective of someone who uses statistics rather than a statistical expert.

Exhibit__(NYCRP-11)

August 2025

Survey of Capital Market Assumptions

2025 Edition

HORIZON actuarial

Atlanta | Cleveland | Denver | Irvine | Los Angeles | Miami | San Diego | San Francisco | Washington, DC

Horizon Actuarial Services, LLC is proud to serve as the actuary to over 100 multiemployer defined benefit pension plans across the United States and across various industries. As actuary to these plans, we must develop assumptions regarding future investment returns on plan assets. We then use those assumptions as we determine the actuarial values of the benefits promised by these plans to their participants and beneficiaries, as well as to project plan funding and solvency levels years into the future.

At Horizon Actuarial, we are retirement and healthcare actuaries, not investment professionals. Therefore, when developing assumptions as to what returns a pension plan's assets might be expected to earn in the future, we seek input from our colleagues in the investment advisory community. Each year, as part of this survey, we ask different investment firms to provide their "capital market assumptions" – their expectations for future risk and returns for different asset classes in which pension plans commonly invest. The information gathered from this survey can help answer the common question: "Are my plan's investment return assumptions reasonable?"

There are many factors to consider when evaluating a plan's investment return assumptions, such as its asset allocation, the maturity of its participant population, and the purpose of the measurement. Any of these factors can make the expected return for one plan very different from others. Therefore, this report does not opine on the reasonableness of any one plan's investment return assumptions. Nevertheless, we hope this report will be a useful resource for trustees, actuaries, and investment professionals alike.

Horizon Actuarial sincerely thanks the
41 investment advisors who participated in this survey.

Survey of Capital Market Assumptions: 2025 Edition

Table of Contents

Summary

Horizon Actuarial first conducted this survey in 2010, and it included 8 investment advisors. In 2012, we first published a report on the survey results, which included 17 advisors. The survey has expanded considerably in recent years; this 2025 edition of the survey includes assumptions from 41 different investment firms.

Readers of this survey are aware that expected returns declined significantly for all but a few asset classes from 2016 to 2022. The steepest declines were for fixed income investments such as US corporate bonds and Treasuries, whose return expectations fell more than 100 basis points from 2019 to 2021. We saw a reversal of this trend in 2023 with expectations increasing across asset classes. The 2024 survey brought only modest changes and this 2025 edition of the survey is a continuation of that trend, with marginally higher return expectations for some asset classes and marginally lower expectations for other asset classes.

As we have seen in prior surveys, expected returns are generally lower over the short term than over the long term, though short-term expected returns are higher than long-term expected returns for selected asset classes such as US Treasuries for the third straight year. This is likely the result of a flat or inverted yield curve at the time when many of the advisors developed their assumptions.

For less mature ongoing pension plans without solvency issues, a horizon of 20 years or more is often used to evaluate the reasonableness of the long-term investment return assumption. A shorter horizon, such as 10 years, may be more appropriate for evaluating the return assumption for a plan whose duration of liabilities is shorter or a plan that has solvency issues. Increasingly, actuaries are assigning weight to both short- and long-term expectations based on factors such as plan maturity, net cash flow, and the purpose of the measurement, when evaluating investment return assumptions. Therefore, this survey shows return expectations over horizons of both 10 years and 20 years.

For illustration, this report also constructs an asset allocation for a hypothetical multiemployer pension plan and uses the results from the survey to develop a range of reasonably expected returns for the plan. The expected returns for this 2025 edition were ***6 basis points lower over a 10-year horizon*** *than they were last year*. ***Over a 20-year horizon, expected returns are 2 basis points higher*** *than they were last year*.

If you have questions about how the results of this survey relate to your multiemployer plan, please contact your consultant at Horizon Actuarial or visit the "contact us" page on our website, www.horizonactuarial.com. For questions about the survey itself, please contact Ben Ablin at ben.ablin@horizonactuarial.com.

Survey of Capital Market Assumptions: 2025 Edition

Survey Participants

Exhibit 1 below lists the 41 investment advisors whose capital market assumptions are included in the 2025 survey. This report does not attribute specific assumptions to individual firms, which is a precondition of the survey.

Originally, this survey was exclusive to the multiemployer plan community; it included assumptions only from investment advisors to multiemployer pension plans. The survey has expanded over the years, and it now includes assumptions from investment advisors outside of the multiemployer plan community.

A complete listing of the firms participating in the survey is provided below.

Exhibit 1

2025 Survey Participants	
AJ Gallagher	Merrill
Alan Biller	Milliman
Amundi	Morgan Stanley
Aon	NEPC
The Atlanta Consulting Group	PFM Asset Management, LLC
Bank of New York Mellon*	PIMCO
BlackRock*	Principal
Callan Associates	Research Affiliates, LLC*
Cambridge Associates	Royal Bank of Canada
CapTrust	RVK
Envestnet	Segal Marco Advisors
Goldman Sachs Asset Management	SEI
Graystone Consulting	Sellwood Consulting
Invesco*	Sterling Capital Management, LLC
Investment Performance Services, LLC (IPS)	Truist Investment Advisory
J.P. Morgan Asset Management*	UBS
Mariner	The Vanguard Group*
Marquette Associates	Verus
Meketa Investment Group	Voya Investment Management*
Mercer	Willis Towers Watson
	Wilshire

**Assumptions obtained from published white paper.*

Investment Horizons

When evaluating the expected return assumption for an active, ongoing multiemployer pension plan, actuaries often consider investment returns over a long-term investment horizon of 20 years or more. A shorter time horizon, say over the next 10 years, may be more appropriate when evaluating the return assumption for a more mature plan whose liabilities have a shorter duration, a plan that has high negative cash flows, or a plan that is projected to become insolvent.

It is also important to understand the sensitivity of plan funding to changes in future investment returns. For example, an actuary may or may not attribute any weight to short-term expectations when setting the long-term investment return assumption for an active, ongoing plan. However, evaluating the sensitivity of funding results to short-term investment returns that are expected to be higher or lower than the long-term assumption is important regardless of the information that is used to set the long-term assumption.

Advisors provided their most recent capital market assumptions: expected returns for different asset classes, standard deviations (i.e., volatilities) for those expected returns, and a correlation matrix. The advisors also indicated the investment horizon(s) to which their assumptions apply. If the advisor develops separate assumptions for different time horizons, they provided multiple sets of assumptions, one for each time horizon.

In the 2025 edition of the survey, 14 advisors provided one set of assumptions, of which all 14 specified a time horizon of 10 years. The remaining 27 advisors provided assumptions over both shorter-term (5 to 10 years) and longer-term (20 years or more) horizons. Note that two of the advisors rely on the same assumptions as other survey participants. Each assumption set was only counted once, even if it was provided by more than one advisor. Each unique assumption set was given equal weight in the survey.

Exhibit 2 below summarizes the time horizons specified by each advisor.

Exhibit 2

Investment Time Horizons	
Time Horizon	**Total**
10 Years	14
Both Short- and Long-Term	27
Total	41

Short-Term vs. Long-Term

As noted in the previous section, survey participants provided expected returns over different time horizons. Given current market conditions, many investment advisors expect returns for certain asset classes to be different in the short term versus over the long term.

For comparability, this survey groups expected returns into two time horizons: 10 years and 20 years. As pension plan actuaries, we often refer to the 10-year expected returns as "short-term" and the 20-year expected returns as "long-term." Note, however, that many investment firms consider 10-year expectations to be "long-term."

When comparing the expected returns for the 27 advisors who provided both short-term and long-term assumptions,[1] we see some interesting differences. See Exhibit 3 below. The expected returns shown below are annualized (geometric) over the indicated time horizons.

Exhibit 3

Average Expected Returns: Short-Term vs. Long-Term
Subset of 27 Survey Respondents

Asset Class	10-Year Horizon	20-Year Horizon	Difference
US Equity - Large Cap	6.41%	7.00%	0.59%
US Equity - Small/Mid Cap	6.98%	7.38%	0.39%
Non-US Equity - Developed	7.20%	7.35%	0.15%
Non-US Equity - Emerging	7.64%	7.91%	0.27%
US Corporate Bonds - Core	5.00%	5.10%	0.09%
US Corporate Bonds - Long Dur.	5.04%	5.28%	0.24%
US Corporate Bonds - High Yield	6.10%	6.33%	0.24%
Non-US Debt - Developed	3.86%	3.99%	0.13%
Non-US Debt - Emerging	6.17%	6.30%	0.13%
US Treasuries (Cash Equivalents)	3.63%	3.59%	-0.04%
TIPS (Inflation-Protected)	4.44%	4.41%	-0.03%
Real Estate	5.95%	6.38%	0.44%
Hedge Funds	6.06%	6.24%	0.18%
Commodities	4.93%	4.76%	-0.18%
Infrastructure	7.25%	7.52%	0.28%
Private Equity	9.21%	9.63%	0.42%
Private Debt	8.02%	8.08%	0.07%
Inflation	2.39%	2.40%	0.01%

The 10-year and 20-year returns shown above are the averages for the 27 advisors who provided both short-term and long-term assumptions.
Expected returns are annualized (geometric).

The consensus among these 27 advisors is that returns for most asset classes are expected to be lower in the short term compared to the long term. In general, the difference between long-term and short-term returns is more pronounced for equity type investments. Short-term expected returns are higher than long-term expected returns for certain fixed income classes for the third straight year, likely due to the relatively flat yield curve.

As noted earlier, the results shown in Exhibit 3 are based on a subset of 27 advisors. If we include all 41 survey advisors, the results do not change dramatically for most asset classes. See Exhibit 4 below.

Exhibit 4

Average Expected Returns: Short-Term vs. Long-Term
All Survey Respondents

Asset Class	10-Year Horizon	20-Year Horizon	Difference
US Equity - Large Cap	6.39%	7.00%	0.61%
US Equity - Small/Mid Cap	6.92%	7.38%	0.46%
Non-US Equity - Developed	7.03%	7.35%	0.32%
Non-US Equity - Emerging	7.38%	7.91%	0.53%
US Corporate Bonds - Core	5.00%	5.10%	0.10%
US Corporate Bonds - Long Dur.	5.04%	5.28%	0.24%
US Corporate Bonds - High Yield	5.97%	6.33%	0.36%
Non-US Debt - Developed	3.89%	3.99%	0.10%
Non-US Debt - Emerging	6.03%	6.30%	0.27%
US Treasuries (Cash Equivalents)	3.58%	3.59%	0.00%
TIPS (Inflation-Protected)	4.44%	4.41%	-0.03%
Real Estate	6.21%	6.38%	0.17%
Hedge Funds	5.92%	6.24%	0.32%
Commodities	4.67%	4.76%	0.09%
Infrastructure	7.22%	7.52%	0.30%
Private Equity	9.13%	9.63%	0.50%
Private Debt	7.91%	8.08%	0.18%
Inflation	2.38%	2.40%	0.02%

10-year horizon results include all 41 survey respondents.
20-year horizon results include a subset of 27 survey respondents.
Expected returns are annualized (geometric).

The 10-year expected returns shown above include assumptions from all 41 advisors, while the 20-year expected returns include assumptions from only the 27 advisors who provided longer-term assumptions.

The differences between short- and long-term expectations have widened marginally since 2024, but remain small when compared to previous versions of this survey. Nonetheless, it remains important for actuaries to illustrate the effects of near-term underperformance on their clients' pension funds. Furthermore, it may be appropriate for actuaries to attribute more weight to nearer term expectations when setting the investment return assumption for more mature plans or plans whose liabilities have a shorter duration.

[1] In cases where an advisor indicated a time horizon shorter than 10 years, the shorter-term expected returns were combined with the longer-term expected returns to achieve a 10-year horizon. Similarly, if an advisor indicated a time horizon longer than 20 years, the longer-term expected returns were combined with the shorter-term expected returns to achieve a 20-year horizon.

Differing Opinions

Exhibit 5 below shows the distribution of expected returns and standard deviations (i.e., volatilities) for each asset class in the survey, as provided by the 41 individual advisors in the survey. The expected returns shown are geometric.

Note that the exhibit below focuses on a 10-year horizon in order to include assumptions from all 41 advisors. See Exhibits 18 and 19 in the appendix to this report for a more detailed look at the distribution of expected returns and standard deviations over both 10- and 20-year horizons. The ranges of expected returns by asset class can be found in the appendix as Exhibits 20 and 21.

A summary of the average survey assumptions can be found in the appendix to this report as Exhibit 17. This summary includes expected returns, standard deviations, and a correlation matrix.

The exhibit below shows that there are significant differences in expected returns and standard deviations among investment advisors. As the saying goes, "reasonable people may differ."

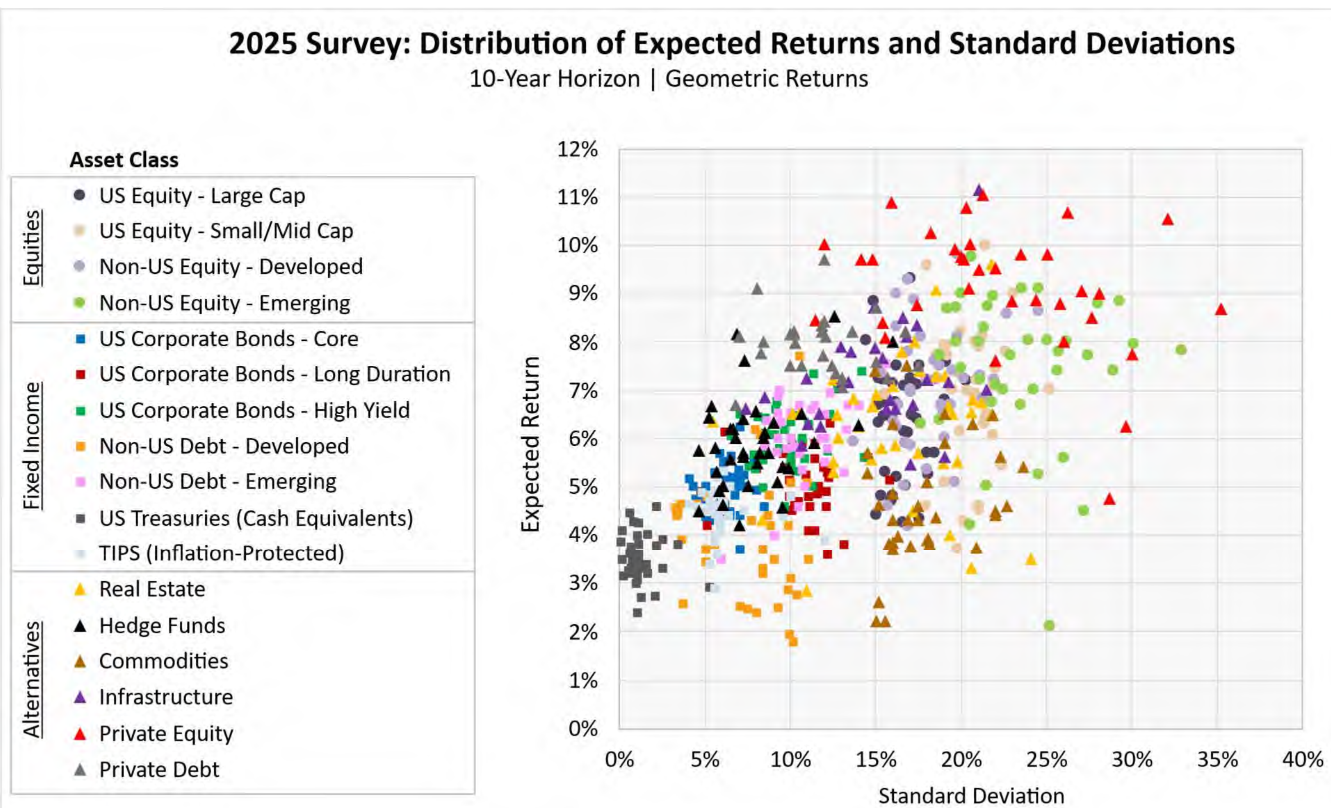
The differences in assumptions are more pronounced for alternative investments such as real estate, hedge funds, and private equity. A contributing factor may be differences in the underlying strategies different advisors apply to these alternative investments.

To contrast, the differences in expected returns and volatilities are smaller for more traditional investments, such as US equity and US fixed income.

Another reason for the significant differences among investment advisors may be the effective date of the assumptions. Ideally, this survey would compile and compare assumptions that all have the same effective date. However, this is not feasible when aggregating results from 41 advisors who update their assumptions on different schedules.

The vast majority of advisors specified effective dates on or around January 1, 2025. However, a few specified effective dates as early as October 1, 2024 and a few specified dates as late as March 31, 2025.

Exhibit 5



Changing Outlooks: 2021 to 2025

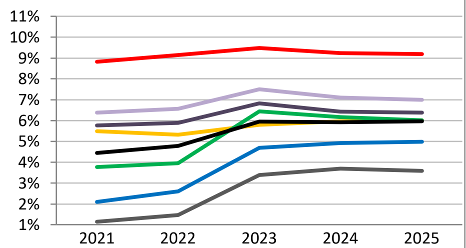
In recent years, there has been much discussion about whether it is reasonable to expect that future investment returns will be as high as they have been historically. Citing various reasons over the years, many advisors lowered their expectations gradually from year-to-year before reducing them considerably from 2019 to 2021.

With interest rates on the rise and lower equity valuations at the end of 2022, we saw a sharp reversal of this trend, with markedly higher expectations across asset classes in 2023. In 2024, we saw continued increases in expectations for fixed income alongside lower expectations for equities. Expectations in 2025 remain largely the same as they were in 2024 across asset classes.

Exhibit 6 below shows average expected returns over a 10-year horizon for selected asset classes each year from 2021 to 2025. For consistency, this exhibit includes only the 38 advisors who provided short-term assumptions in each of these years.

Exhibit 6

Average Expected Returns (10-Year Horizon)



	2021	2022	2023	2024	2025
Private Equity	8.8%	9.1%	9.5%	9.2%	9.2%
Non-US Eq. (Dev)	6.4%	6.6%	7.5%	7.1%	7.0%
US Eq. (Large Cap)	5.8%	5.9%	6.8%	6.4%	6.4%
Real Estate	5.5%	5.3%	5.8%	6.0%	6.0%
US Bonds (HY)	3.8%	4.0%	6.4%	6.2%	6.0%
Hedge Funds	4.4%	4.8%	5.9%	5.9%	6.0%
US Bonds (Core)	2.1%	2.6%	4.7%	4.9%	5.0%
US Treasuries	1.2%	1.5%	3.4%	3.7%	3.6%

Figures are average geometric returns for selected asset classes for the 38 advisors who provided short-term assumptions in each of the surveys from 2021 through 2025.

For this subset of advisors, average expected returns over a 10-year horizon increased slightly from 2021 to 2022 before increasing dramatically in 2023. The sharpest increases in 2023 were for fixed income classes, such as US Treasuries, core US bonds, and high-yield US bonds.

The increases in expectations continued from 2023 to 2024 for Core US Bonds and Treasuries. Conversely, return expectations declined in 2024 for equity-type investments. Average expected returns over a 10-year horizon did not change significantly from 2024 to 2025.

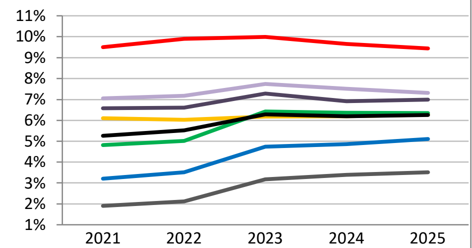
Despite the ups and downs, expectations for all of the asset classes shown increased from 2021 to 2025.

Exhibit 7 below shows how average expected returns have changed for the same asset classes for a subset of 22 advisors who provided assumptions each year from 2021 to 2025 over a 20-year horizon.

Note that the expected returns shown in Exhibits 6 and 7 are not directly comparable with those in other sections or previous surveys because we include only a subset of advisors who participated in each of the last 5 years.

Exhibit 7

Average Expected Returns (20-Year Horizon)



	2021	2022	2023	2024	2025
Private Equity	9.5%	9.9%	10.0%	9.7%	9.4%
Non-US Eq. (Dev)	7.1%	7.2%	7.7%	7.5%	7.3%
US Eq. (Large Cap)	6.6%	6.6%	7.3%	6.9%	7.0%
Real Estate	6.1%	6.0%	6.2%	6.2%	6.3%
US Bonds (HY)	4.8%	5.0%	6.4%	6.4%	6.4%
Hedge Funds	5.3%	5.5%	6.3%	6.2%	6.3%
US Bonds (Core)	3.2%	3.5%	4.7%	4.9%	5.1%
US Treasuries	1.9%	2.1%	3.2%	3.4%	3.5%

Figures are average geometric returns for selected asset classes for the 22 advisors who provided long-term assumptions in each of the surveys from 2021 through 2025.

Although the expected returns are generally higher over a 20-year horizon than a 10-year horizon, the trends over the period from 2021 to 2025 are similar. Namely, slight increases in return expectations for fixed income investments from 2021 to 2022, followed by a dramatic increase in 2023 and relative stability from 2023 to 2025. Overall, expectations for fixed income investments remain elevated when compared to their 2021 levels as a result of rising interest rates during the period.

On the equity side, the increases in return expectations that we saw from 2021 to 2023 were pared back modestly in 2024 and again in 2025. Overall, expected returns for equity-type investments in 2025 are largely the same as they were in 2021 for this subset of advisors, with the exception of US Large Cap Equities whose expected returns are 40 basis points higher in 2025 than they were in 2021.

Return expectations for hedge funds have increased significantly over both 10- and 20-year horizons as evidenced by the black line in the graphs above.

Evaluating the Return Assumption

Multiemployer pension plans are usually invested in a well-diversified mix of stocks, bonds, real estate, and alternative investments structured to meet the goals of the Trustees. This typically involves maximizing returns over the long term while minimizing return volatility.

The actuary of a multiemployer pension plan must consider the plan's asset allocation and, based on expectations of future returns, develop an assumption for what plan assets are projected to earn over the long term. This assumption is then used (along with others) to determine the actuarial present value of the benefits promised by the plan to its participants and beneficiaries.

The actuary will often seek input on future return expectations from the plan's investment advisor in developing the plan's investment return assumption. However, as noted earlier, different investment advisors often have widely differing opinions on what future returns will be. Therefore, it can be beneficial to keep in mind other advisors' expectations when setting the investment return assumption.

In the following exhibits, we will evaluate the investment return assumption for a hypothetical multiemployer pension plan. Exhibit 8 below shows the asset allocation for this hypothetical plan. The asset allocations are arbitrary, except for the fact that we made sure to include at least a small allocation to every asset class in the survey.

Exhibit 8

Asset Class - Hypothetical Plan	Weight
US Equity - Large Cap	20.0%
US Equity - Small/Mid Cap	10.0%
Non-US Equity - Developed	7.5%
Non-US Equity - Emerging	5.0%
US Corporate Bonds - Core	7.5%
US Corporate Bonds - Long Duration	2.5%
US Corporate Bonds - High Yield	5.0%
Non-US Debt - Developed	5.0%
Non-US Debt - Emerging	2.5%
US Treasuries (Cash Equivalents)	5.0%
TIPS (Inflation-Protected)	5.0%
Real Estate	7.5%
Hedge Funds	5.0%
Commodities	2.5%
Infrastructure	2.5%
Private Equity	5.0%
Private Debt	2.5%
TOTAL PORTFOLIO	**100.0%**

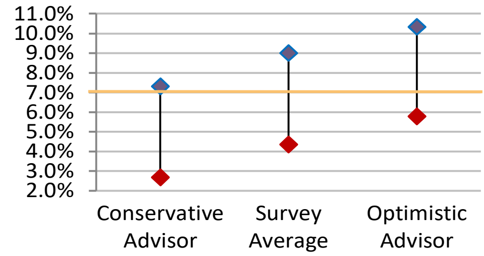
Exhibit 9 shows expected annualized (geometric) returns for the hypothetical plan over a 10-year horizon.

Exhibit 9

Annualized Expected Returns

Hypothetical Multiemployer Pension Fund

10-Year Horizon



	Conservative Advisor	Survey Average	Optimistic Advisor
◆ 75th percentile	7.30%	9.00%	10.33%
◆ 25th percentile	2.66%	4.34%	5.78%
Probability of Meeting or Exceeding:			
7.50% per Year	23.2%	40.5%	56.5%
7.00% per Year	27.9%	46.2%	62.3%
6.50% per Year	33.0%	52.0%	67.7%

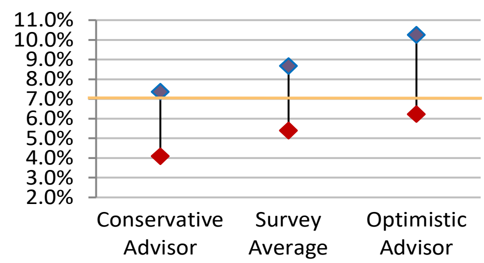
Exhibit 10 shows expected annualized (geometric) returns for the hypothetical plan over a 20-year horizon based on assumptions from the 27 advisors who provided longer-term assumptions.

Exhibit 10

Annualized Expected Returns

Hypothetical Multiemployer Pension Fund

20-Year Horizon



	Conservative Advisor	Survey Average	Optimistic Advisor
◆ 75th percentile	7.37%	8.66%	10.25%
◆ 25th percentile	4.09%	5.39%	6.22%
Probability of Meeting or Exceeding:			
7.50% per Year	23.3%	42.3%	59.7%
7.00% per Year	30.0%	50.4%	66.0%
6.50% per Year	37.5%	58.6%	71.9%

Depending on factors such as plan maturity, net cash flow, solvency considerations, and the purpose of the measurement, actuaries might assign varying weights to the short- and long-term expectations when evaluating the investment return assumption.

Evaluating the Return Assumption (cont.)

It is important to keep in mind that the expected returns shown in Exhibits 9 and 10 apply only to the hypothetical asset allocation shown in Exhibit 8. The expected returns will be different – perhaps significantly – for different asset allocations. The following are points to consider when reviewing the results in Exhibits 9 and 10:

Range of Reasonable Assumptions: When setting the investment return assumption for pension valuations, actuaries traditionally constructed a range of reasonable assumptions and then selected a best-estimate point within that range. Actuaries would often consider the reasonable range to be the middle 50 percent of possible results, bounded by the 25th and 75th percentiles.

The applicable actuarial standards of practice were updated in 2013, and the updated standards de-emphasize use of the reasonable range when setting the investment return assumption. Nevertheless, considering this range remains instructive; it may be difficult for an actuary to justify an assumption outside of this range.

Based on the average assumptions in this 2025 survey, the middle 50 percent range for this hypothetical pension plan is very wide: 5.39% to 8.66% over the next 20 years. Note that the range is even wider for a 10-year horizon: 4.34% to 9.00%. This is due to the fact that, while returns may be volatile from one year to the next, deviations will be lower when returns are annualized (in other words, smoothed out) over longer horizons.

Probability of Meeting/Exceeding the Benchmark: For example, say that the actuary for this hypothetical pension plan expects its investment returns to be 7.00% per year, represented by the gold lines in Exhibits 9 and 10. Based on the average assumptions in this 2025 survey, there is a 50.4% probability the plan will meet or beat its 7.00% benchmark on an annualized basis over a 20-year period. The probability is lower, 46.2%, that the plan will meet or beat its benchmark over the next 10 years.

Also note that over a 20-year period, the probability that the annualized investment return will exceed 7.50% (arbitrarily, 50 basis points above the benchmark return) is 42.3%. The probability that the annualized return will exceed 6.50% (50 basis points below the benchmark) is 58.6%. These probabilities are a bit lower when focusing on a 10-year horizon rather than a 20-year horizon.

Purpose of the Measurement: It is important to note that this survey focuses on the investment return assumption, which may (or may not) be the same as the assumption used to discount a plan's projected benefit payments to measure its liabilities. The applicable standards of practice emphasize that the actuary should consider the purpose of the measurement (e.g., contribution budgeting, defeasance or settlement, market measurements, pricing) as a primary factor in choosing a discount rate.

Optimistic and Conservative Assumptions: As previously noted, different investment advisors may have widely varying future capital market expectations. Therefore, it may also be interesting to consider the range of expected returns based on the assumptions provided by the most conservative and most optimistic advisors in the survey.

For this hypothetical asset allocation, the assumptions from the most conservative advisor indicate that the probability of beating the 7.00% benchmark assumption over the next 20 years is 30.0%. Using assumptions from the most optimistic advisor results in a probability of 66.0%. Again, reasonable people may differ.

Limitations: The following are some important limiting factors to keep in mind when reviewing these results.

- The asset classes in this survey do not always align perfectly with the asset classes provided by the investment advisors. Adjustments were made to standardize the different asset classes provided.
- Many of the advisors develop their future assumptions based on investment horizons of no more than 10 years, and returns are generally expected to be lower in the short term. The typical multiemployer pension plan will have an investment horizon that is longer than 10 years.
- The return expectations are generally based on market returns. In other words, they do not reflect any additional returns that may be earned due to active asset managers outperforming the market ("alpha").
- The return expectations do not adjust for plan size. Specifically, they do not take into account the fact that certain investment opportunities are more readily available to larger plans, as well as the fact that larger plans may often receive more favorable investment fee arrangements than smaller plans.
- The ranges of expected annualized returns were constructed using basic, often simplified, formulas and methodologies. More sophisticated investment models – which may consider various economic scenarios, non-normal distributions, etc. – could produce significantly different results.

Use of the Survey: This survey is not intended to be a substitute for the expectations of individual portfolio managers, advisors, or actuaries performing their own independent analyses. The actuarial standards of practice provide for various methods of selecting and supporting the investment return assumption. This survey is intended to be used in conjunction with these methods, with appropriate weighting of various resources based on the plan actuary's professional judgment.

Survey of Capital Market Assumptions: 2025 Edition

Comparison with Prior Surveys

Exhibits 6 and 7 showed how expected returns for certain asset classes have changed over the past few years. Similarly, Exhibits 11 and 12 below show how return expectations for the hypothetical multiemployer pension plan whose asset allocation is shown in Exhibit 8 have changed from 2021 to 2025.

Both exhibits show the probabilities that the hypothetical pension plan will meet or exceed its 7.00% benchmark return on an annualized basis over the given time horizon. Exhibit 11 focuses on expected returns over a 10-year period and Exhibit 12 focuses on expected returns over a 20-year period. Probabilities are shown for the survey average for each year from 2021 through 2025. For comparison, probabilities are also shown for the most conservative and optimistic advisors in each survey.

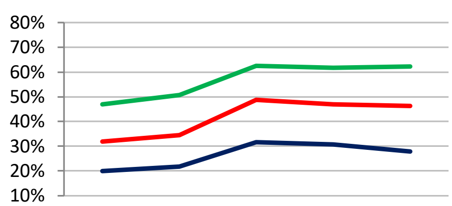
See Exhibits 14 and 15 in the appendix for a more complete range of expected returns over 10- and 20-year horizons for each survey from 2016 through 2025.

Exhibit 11

Probability of Meeting 7.00% Benchmark

Hypothetical Multiemployer Pension Fund

10-Year Horizon



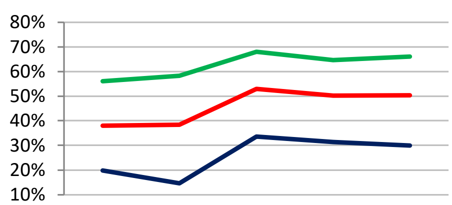
Survey Year	2021	2022	2023	2024	2025
Most Optimistic	46.9%	50.7%	62.5%	61.7%	62.3%
Survey Average	31.9%	34.5%	48.7%	46.9%	46.2%
Most Conservative	20.0%	21.8%	31.6%	30.6%	27.9%

Exhibit 12

Probability of Meeting 7.00% Benchmark

Hypothetical Multiemployer Pension Fund

20-Year Horizon



Survey Year	2021	2022	2023	2024	2025
Most Optimistic	56.1%	58.2%	68.0%	64.7%	66.0%
Survey Average	38.0%	38.4%	52.8%	50.2%	50.4%
Most Conservative	19.9%	14.6%	33.6%	31.4%	30.0%

As shown in Exhibit 11, the probability that this hypothetical pension plan would meet or beat a benchmark return of 7.00% over a 10-year horizon increased marginally from 2021 to 2022, went up sharply in 2023, and declined slightly from 2023 to 2025. Exhibit 12 shows that the probability this hypothetical pension plan would meet or beat a benchmark return of 7.00% over a 20-year horizon was flat from 2021 to 2022, increased materially in 2023, and declined slightly from 2023 to 2025.

For example:

- Based on the average assumptions from the 2025 survey, the probability of this hypothetical plan meeting or exceeding an annualized return of 7.00% over the next 10 years is 46.2%. The probability was considerably lower (31.9%) five years ago when the 2021 survey was conducted.
- Based on the average assumptions from the 2025 survey, the probability of this hypothetical plan meeting or exceeding an annualized return of 7.00% over the next 20 years is 50.4%. This is about the same as last year when the probability was 50.2% but remains higher than 2021 when the probability was 38.0%. The increase from 2022 to 2023 was driven by increases in expectations across asset classes, with fixed income expectations rising the most.

Other points of note when comparing the results from the 2025 survey to those from prior years:

- The results for the most conservative advisor over a 10-year horizon hovered just above 20.0% from 2021 to 2022 before increasing to over 30.0% in 2023 and 2024 and declining slightly to 27.9% in 2025. Over a 20-year horizon, the results for the most conservative advisor reached a low of 14.6% in 2022, before rebounding to around 30.0% in 2023, 2024, and 2025. In other words, the most conservative advisor in 2022 projected a mere 1 in 7 chance of meeting the 7.00% benchmark over a 20-year horizon while the most conservative advisors in 2023 to 2025 projected a 1 in 3 chance of meeting the same benchmark return.
- The results for the most optimistic advisor over a 10-year horizon remained level at about 62.0% in 2025. Over a 20-year horizon, the results for the most optimistic advisor still represent an approximately 2 in 3 chance of meeting the 7.00% benchmark.
- Note that the most conservative and most optimistic advisors are not necessarily the same from year to year or for different time horizons.

Glossary

The following are basic definitions of some of the investment terminology used in this report.

Expected Return

The *expected return* is the amount, as a percentage of assets, that an investment is expected to earn over a period of time. Expected returns in this survey are generally market returns that do not reflect value added or fees due to active management. Returns for asset classes where passive investments are not available (e.g., hedge funds and private equity) are generally net of fees.

Arithmetic vs. Geometric Returns

An *arithmetic* return is the average return in any one year. A *geometric* return is the annualized return over a multi-year period. In general, it is more appropriate to focus on geometric returns when evaluating expected returns over multi-year horizons. However, arithmetic returns are also important. For example, the expected return of a portfolio is calculated as the weighted average of arithmetic returns, not geometric returns.

This survey focuses on geometric returns. Many advisors provide both arithmetic and geometric expected returns. For advisors who provided expected returns only on an arithmetic basis, we converted them to geometric returns for consistency. The following formula was used to make this conversion.

$$E[R_G] = ((1 + E[R_A])^2 - VAR[R])^{1/2} - 1$$

In this formula, $E[R_G]$ is the expected geometric return, $E[R_A]$ is the expected arithmetic return, and VAR[R] is the variance of the expected annual (arithmetic) return.

Standard Deviation

The *standard deviation* is a measure of the expected volatility in the returns. Generally, the standard deviation expresses how much returns may vary in any one year. Assuming that returns are "normally distributed," there is about a 68% probability that the actual return for a given year will fall within one standard deviation (higher or lower) of the expected return. There is about a 95% probability that the actual return will fall within two standard deviations of the expected return.

Correlation

The degree to which the returns for two different asset classes move in tandem with one another is their *correlation*. For example, if two asset classes are perfectly correlated, their correlation coefficient will be 1.00; in other words, if one asset class has a return of X% in a given market environment, then the other asset class is expected to also have a return of X%. A portfolio becomes better diversified as its asset classes have lower (or even negative) correlations with each other.

Methodology

The following is a high-level description of the methodology used in compiling the survey results.

Standardized Asset Classes

Not all investment advisors use the same asset classes when developing their capital market assumptions. Some are very specific (more asset classes), while others keep things relatively simple (fewer asset classes).

We exercised judgment in classifying each advisor's capital market assumptions into a standard set of asset classes. In the event that an advisor did not provide assumptions for a given asset class, the average assumptions from the other advisors was used when developing expected returns for that advisor.

Investment Horizons

This survey considers "short-term" expected returns to apply to a 10-year investment horizon, and "long-term" expected returns to apply to a 20-year horizon.

In this 2025 edition of the survey, 14 of the 41 advisors provided only short-term assumptions, indicating a horizon of no more than 10 years. Included in this group is one advisor who provided assumptions over a horizon of seven years.

All 27 advisors who provided long-term assumptions over horizons of 20 years or more also provided short-term assumptions. In cases where such an advisor indicated a horizon shorter than 10 years, the shorter-term expected returns were combined with the longer-term expected returns to achieve a 10-year horizon. If an advisor indicated a time horizon longer than 20 years, the longer-term expected returns were combined with the shorter-term expected returns to achieve a 20-year horizon.

No Adjustment for Alpha

No adjustment was made to reflect the possible value added by an active investment manager outperforming market returns (earning "alpha").

Normally-Distributed Returns

This survey assumes that investment returns will be normally distributed according to the capital market assumptions provided. The survey also assumes that the investment return in one year does not affect the investment return in the following year.

Equal Weighting

Each unique assumption set was given equal weight in developing the average assumptions for the survey, regardless of factors such as total assets under advisement, research methodology, etc.

Exhibit 13

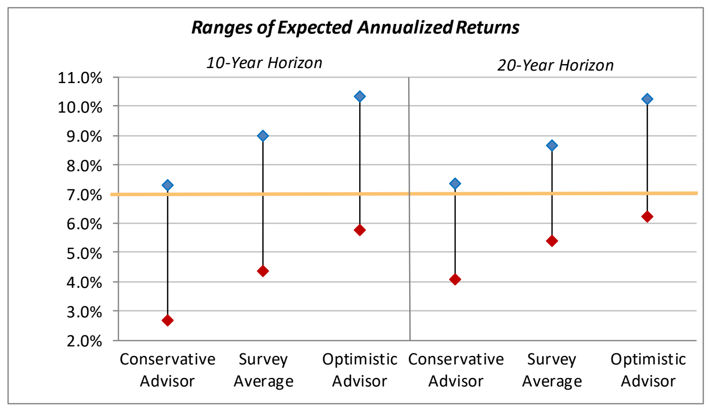
The following exhibit evaluates the investment return assumption for a hypothetical multiemployer pension plan. It reflects the same hypothetical asset allocation as shown in Exhibit 8, and it provides more detail than Exhibits 9 and 10. Note that the most conservative and optimistic advisors for the 10-year horizon are not necessarily the same as the most conservative and optimistic advisors for the 20-year horizon. This hypothetical pension plan has a benchmark return of 7.00% per year, which is indicated by the gold line in the exhibit below.

Hypothetical Multiemployer Plan

2025 Survey of Capital Market Assumptions

Asset Class	Portfolio Weight	*Average Survey Assumptions* 10-Year Horizon	20-Year Horizon	Standard Deviation
US Equity - Large Cap	20.0%	6.39%	7.00%	16.54%
US Equity - Small/Mid Cap	10.0%	6.92%	7.38%	20.44%
Non-US Equity - Developed	7.5%	7.03%	7.35%	18.20%
Non-US Equity - Emerging	5.0%	7.38%	7.91%	23.43%
US Corporate Bonds - Core	7.5%	5.00%	5.10%	6.22%
US Corporate Bonds - Long Duration	2.5%	5.04%	5.28%	10.74%
US Corporate Bonds - High Yield	5.0%	5.97%	6.33%	9.77%
Non-US Debt - Developed	5.0%	3.89%	3.99%	7.48%
Non-US Debt - Emerging	2.5%	6.03%	6.30%	10.62%
US Treasuries (Cash Equivalents)	5.0%	3.58%	3.59%	1.47%
TIPS (Inflation-Protected)	5.0%	4.44%	4.41%	6.04%
Real Estate	7.5%	6.21%	6.38%	16.24%
Hedge Funds	5.0%	5.92%	6.24%	7.97%
Commodities	2.5%	4.67%	4.76%	17.83%
Infrastructure	2.5%	7.22%	7.52%	14.86%
Private Equity	5.0%	9.13%	9.63%	22.18%
Private Debt	2.5%	7.91%	8.08%	11.75%
Inflation	N/A	2.38%	2.40%	1.90%
TOTAL PORTFOLIO	**100.0%**	*Expected returns are geometric.*		

	10-Year Horizon Conservative Advisor	Survey Average	Optimistic Advisor	*20-Year Horizon* Conservative Advisor	Survey Average	Optimistic Advisor
Expected Returns						
Average Annual Return (Arithmetic)	5.55%	7.23%	8.58%	6.28%	7.57%	9.06%
Annualized Return (Geometric)	4.98%	6.67%	8.05%	5.73%	7.03%	8.23%
Annual Volatility (Standard Deviation)	10.88%	10.92%	10.67%	10.85%	10.83%	13.36%
Range of Expected Annualized Returns						
◆ 75th Percentile	7.30%	9.00%	10.33%	7.37%	8.66%	10.25%
◆ 25th Percentile	2.66%	4.34%	5.78%	4.09%	5.39%	6.22%
Probabilities of Exceeding Certain Returns						
7.50% per Year, Annualized	23.2%	40.5%	56.5%	23.3%	42.3%	59.7%
7.00% per Year, Annualized	27.9%	46.2%	62.3%	30.0%	50.4%	66.0%
6.50% per Year, Annualized	33.0%	52.0%	67.7%	37.5%	58.6%	71.9%



Considerations and Limitations

- Allocations may be approximated if certain asset classes are not included in the survey.
- Many investment advisors provided only shorter-term assumptions (10 years or less).
- Assumptions are generally based on indexed returns and do not reflect anticipated alpha.
- Assumptions do not reflect investment opportunities or fee considerations available to larger funds.

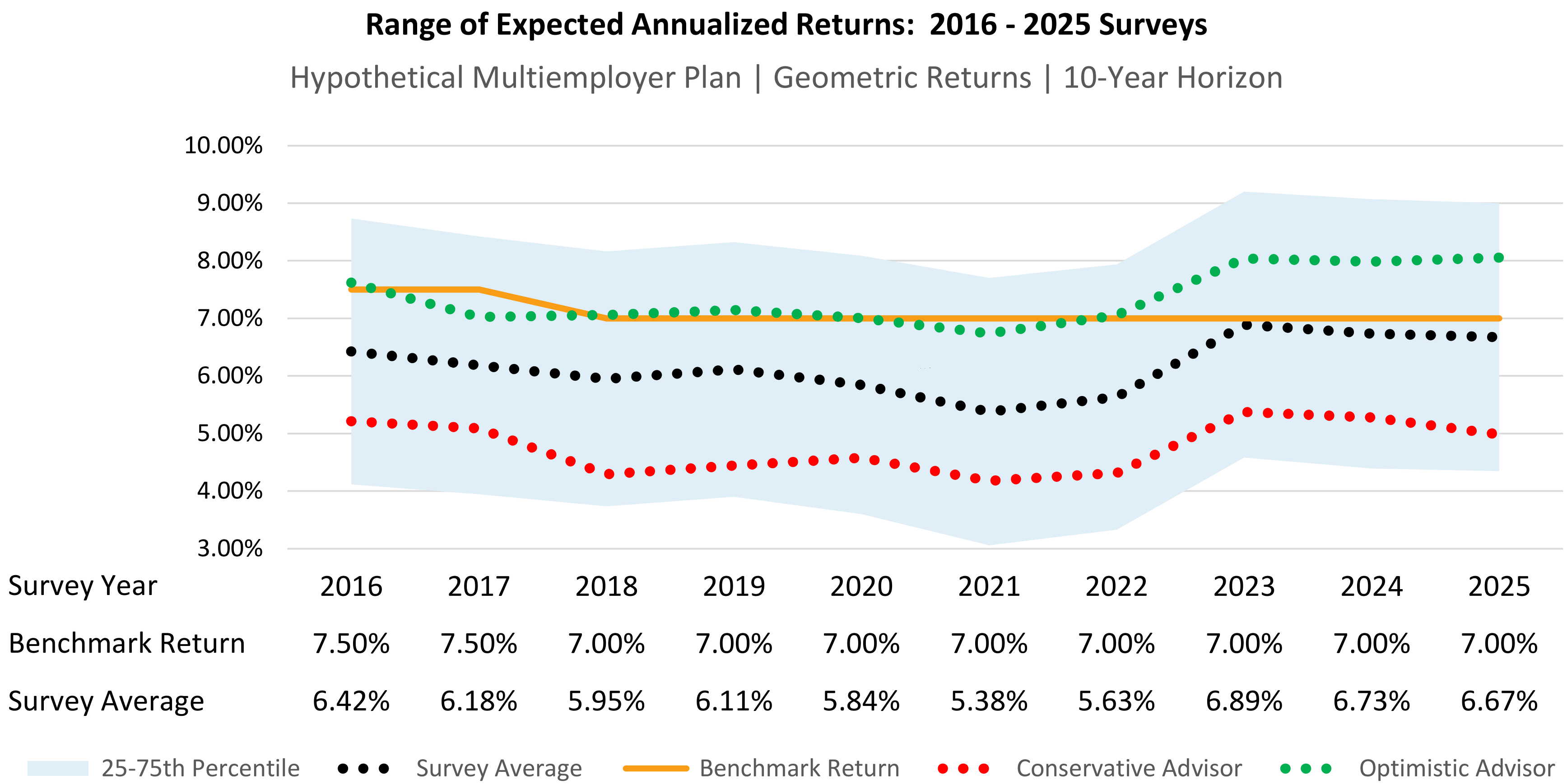
SOURCE: Horizon Actuarial 2025 Survey of Capital Market Assumptions

Expected returns over a 10-year horizon include all 41 survey participants.

Expected returns over a 20-year horizon are based a subset of 27 survey participants who provided long-term assumptions.

Exhibit 14

The following exhibit shows the range of expected annualized returns for each of the surveys from 2016 to 2025 over a 10-year horizon. The results for 2019 through 2025 reflect the same hypothetical asset allocation as shown in Exhibit 13. Note that the hypothetical asset allocation was modified slightly in 2019 to include a small allocation to private debt. Please refer to the 2018 survey for the hypothetical asset allocation used to develop the results for 2016 through 2018. Similar to Exhibit 13, the benchmark return for this hypothetical plan is indicated by the gold line. The most conservative advisor in each survey is indicated by the red dotted line and the most optimistic advisor in each survey is indicated by the green dotted line. The black dotted line shows the survey average return and the blue shaded region shows the 25th – 75th percentile of returns assuming a normal distribution using the survey average expected return and survey average standard deviation.



Survey Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Benchmark Return	7.50%	7.50%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%
Survey Average	6.42%	6.18%	5.95%	6.11%	5.84%	5.38%	5.63%	6.89%	6.73%	6.67%

SOURCE: Horizon Actuarial Survey of Capital Market Assumptions (2016 - 2025)
Expected returns over a 10-year horizon include all survey participants in each survey year.

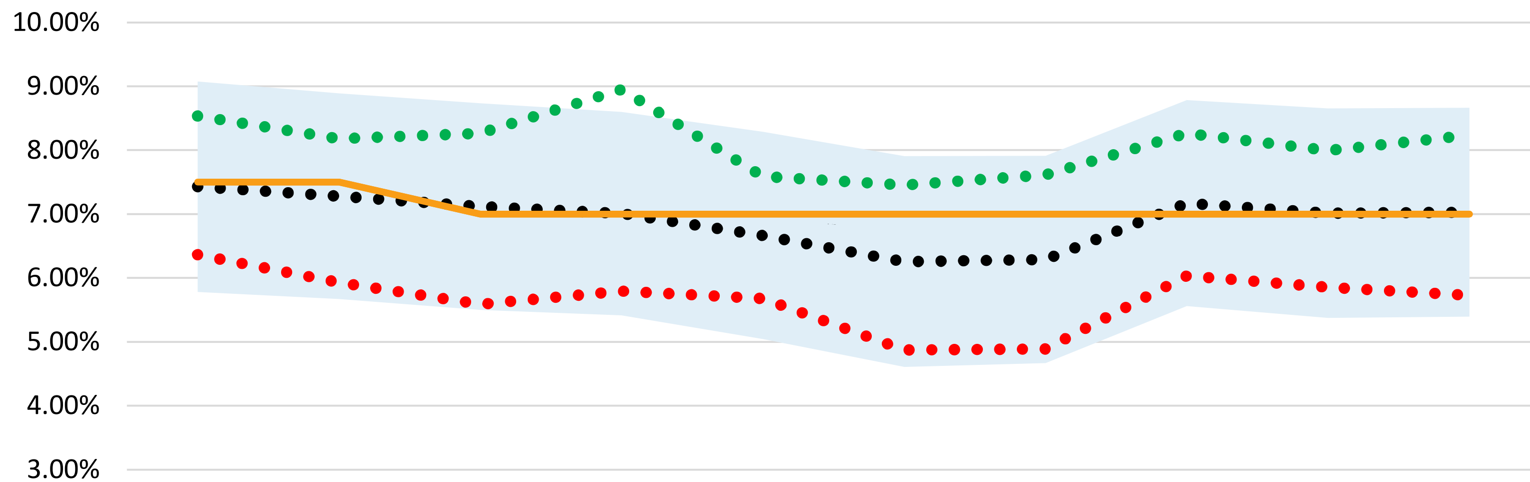
Exhibit 15

Exhibit 14 showed the range of expected annualized returns for each of the surveys from 2016 to 2025 over an investment horizon of 10 years. The exhibit below shows the same information, but for a horizon of 20 years. While Exhibit 14 included all advisors in each survey year shown, the exhibit below only includes assumptions for the advisors who provided longer-term assumptions (horizons of 20 years or more) each year. Please refer to prior editions of the survey for the count of advisors in each year.

Note that the 25th – 75th percentile range over a 20-year horizon is narrower than for a 10-year horizon. This is due to the fact that deviations will be lower when returns are annualized (in other words, smoothed out) over longer horizons.

Range of Expected Annualized Returns: 2016 - 2025 Surveys

Hypothetical Multiemployer Plan | Geometric Returns | 20-Year Horizon



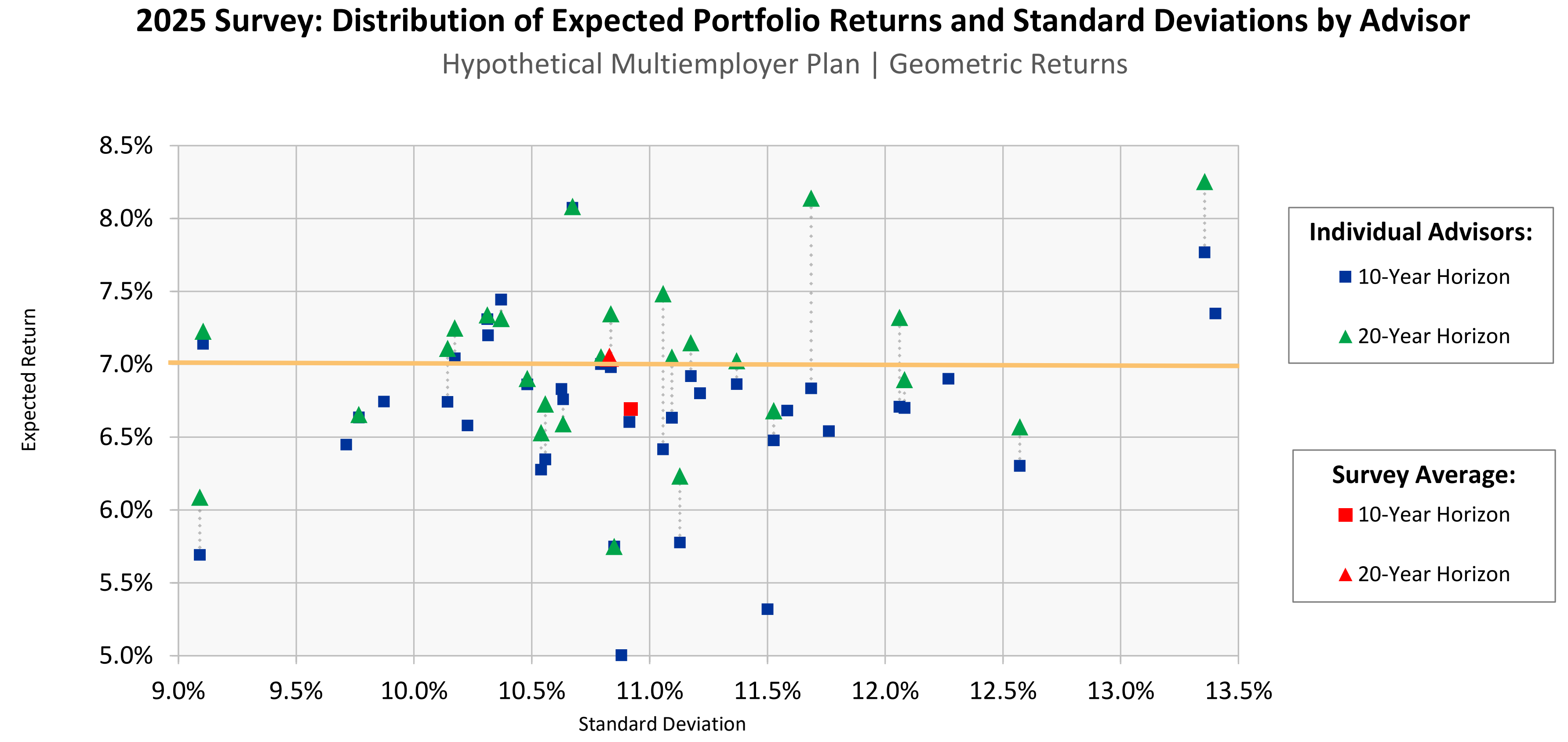
Survey Year	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Benchmark Return	7.50%	7.50%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%	7.00%
Survey Average	7.43%	7.28%	7.12%	7.01%	6.66%	6.25%	6.29%	7.17%	7.01%	7.03%

25-75th Percentile • • • Survey Average — Benchmark Return • • • Conservative Advisor • • • Optimistic Advisor

SOURCE: Horizon Actuarial Survey of Capital Market Assumptions (2016 - 2025)
Expected returns over a 20-year horizon are based a subset of survey participants who provided long-term assumptions.

Exhibit 16

The following exhibit shows the distribution of expected annualized returns and annual standard deviations for the same hypothetical asset allocation that is shown in Exhibit 13. The expected annualized return and annual standard deviation of the hypothetical asset allocation are shown separately for each advisor who participated in the survey. Individual advisors are shown separately by investment horizon, and the short- and long-term assumptions for advisors who provided both are connected by a dotted line. The survey average assumptions are shown in red. Similar to Exhibit 13, the benchmark return of 7.00% for this hypothetical plan is indicated by the gold line. The exhibit shows that there are a wide variety of investment return assumptions that could be considered to be reasonable for any given asset allocation.



SOURCE: Horizon Actuarial 2025 Survey of Capital Market Assumptions
Expected returns over a 10-year horizon include all 41 survey participants.
Expected returns over a 20-year horizon are based a subset of 27 survey participants who provided long-term assumptions.

Exhibit 17

The following exhibit provides the average capital market assumptions for all 41 investment advisors in the survey. Each unique assumption set was given equal weight in determining the average assumptions. For reference, expected returns are shown over 10-year and 20-year horizons. Expected returns are also provided on both an arithmetic basis (one-year average) and geometric basis (multi-year annualized). The standard deviations (volatilities) and correlations apply to both arithmetic and geometric expected returns.

Horizon Actuarial 2025 Survey of Capital Market Assumptions

Average Survey Assumptions

		Expected Returns					*Correlation Matrix*																
		10-Year Horizon		20-Year Horizon		Standard																	
	Asset Class	Arith.	Geom.	Arith.	Geom.	Deviation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	US Equity - Large Cap	7.67%	6.39%	8.29%	7.00%	16.54%	1.00																
2	US Equity - Small/Mid Cap	8.87%	6.92%	9.35%	7.38%	20.44%	0.89	1.00															
3	Non-US Equity - Developed	8.58%	7.03%	8.96%	7.35%	18.20%	0.82	0.77	1.00														
4	Non-US Equity - Emerging	9.96%	7.38%	10.63%	7.91%	23.43%	0.71	0.67	0.80	1.00													
5	US Corporate Bonds - Core	5.19%	5.00%	5.28%	5.10%	6.22%	0.32	0.28	0.32	0.29	1.00												
6	US Corporate Bonds - Long Duration	5.61%	5.04%	5.80%	5.28%	10.74%	0.29	0.27	0.28	0.25	0.89	1.00											
7	US Corporate Bonds - High Yield	6.44%	5.97%	6.82%	6.33%	9.77%	0.68	0.68	0.66	0.63	0.53	0.44	1.00										
8	Non-US Debt - Developed	4.19%	3.89%	4.29%	3.99%	7.48%	0.24	0.22	0.35	0.30	0.62	0.61	0.33	1.00									
9	Non-US Debt - Emerging	6.57%	6.03%	6.87%	6.30%	10.62%	0.54	0.51	0.57	0.63	0.60	0.53	0.67	0.50	1.00								
10	US Treasuries (Cash Equivalents)	3.60%	3.58%	3.61%	3.59%	1.47%	(0.01)	(0.04)	0.00	0.00	0.19	0.14	(0.00)	0.18	0.10	1.00							
11	TIPS (Inflation-Protected)	4.63%	4.44%	4.61%	4.41%	6.04%	0.18	0.14	0.19	0.20	0.66	0.61	0.34	0.51	0.43	0.22	1.00						
12	Real Estate	7.52%	6.21%	7.59%	6.38%	16.24%	0.55	0.55	0.48	0.42	0.27	0.23	0.47	0.20	0.39	0.03	0.24	1.00					
13	Hedge Funds	6.25%	5.92%	6.57%	6.24%	7.97%	0.71	0.70	0.69	0.67	0.29	0.24	0.63	0.20	0.51	0.02	0.19	0.42	1.00				
14	Commodities	6.20%	4.67%	6.37%	4.76%	17.83%	0.33	0.34	0.41	0.42	0.07	0.01	0.37	0.12	0.26	0.00	0.20	0.24	0.41	1.00			
15	Infrastructure	8.30%	7.22%	8.65%	7.52%	14.86%	0.65	0.64	0.67	0.61	0.34	0.35	0.59	0.36	0.54	0.04	0.26	0.48	0.57	0.42	1.00		
16	Private Equity	11.51%	9.13%	12.14%	9.63%	22.18%	0.76	0.74	0.68	0.64	0.21	0.19	0.57	0.16	0.45	(0.04)	0.12	0.48	0.64	0.31	0.57	1.00	
17	Private Debt	8.58%	7.91%	8.71%	8.08%	11.75%	0.58	0.58	0.57	0.54	0.22	0.17	0.68	0.12	0.44	(0.04)	0.11	0.41	0.61	0.38	0.51	0.63	1.00
	Inflation	2.39%	2.38%	2.41%	2.40%	1.90%																	

Expected returns over a 10-year horizon include all 41 survey participants.

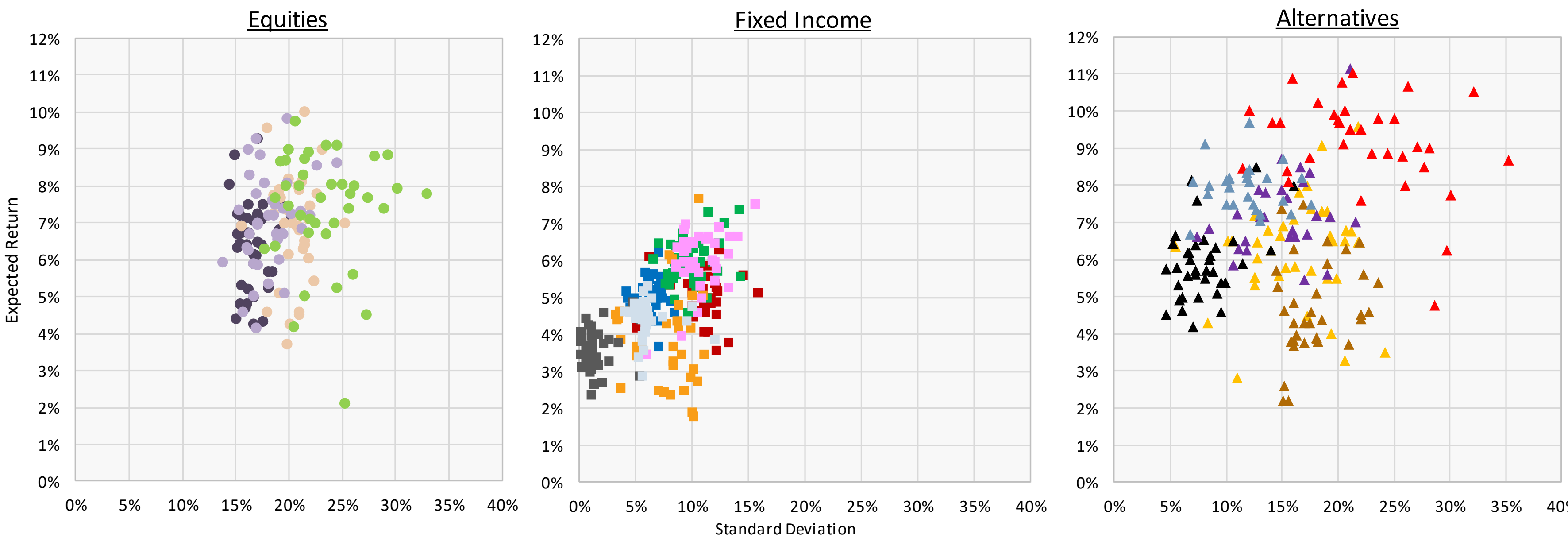
Expected returns over a 20-year horizon are based a subset of 27 survey participants who provided long-term assumptions.

Exhibit 18

Earlier in this report, Exhibit 5 showed the distribution of expected returns and standard deviations for all 41 advisors who provided short-term assumptions. The exhibit below shows the same distribution, broken out by asset type: equities, fixed income, and alternatives. Note that the average expected return and standard deviation from the survey are listed in brackets for each asset class. Also note that not every advisor provided expectations for every asset class.

2025 Survey: Distribution of Expected Returns and Standard Deviations

10-Year Horizon | Geometric Returns



Asset Class [Avg. Exp. Return | Avg. Std. Dev.]

- US Equity - Large Cap [6.4% | 16.5%]
- US Equity - Small/Mid Cap [6.9% | 20.4%]
- Non-US Equity - Developed [7.0% | 18.2%]
- Non-US Equity - Emerging [7.4% | 23.4%]

Asset Class [Avg. Exp. Return | Avg. Std. Dev.]

- US Corporate Bonds - Core [5.0% | 6.2%]
- US Corporate Bonds - Long Duration [5.0% | 10.7%]
- US Corporate Bonds - High Yield [6.0% | 9.8%]
- Non-US Debt - Developed [3.9% | 7.5%]
- Non-US Debt - Emerging [6.0% | 10.6%]
- US Treasuries (Cash Equivalents) [3.6% | 1.5%]
- TIPS (Inflation-Protected) [4.4% | 6.0%]

Asset Class [Avg. Exp. Return | Avg. Std. Dev.]

- Real Estate [6.2% | 16.2%]
- Hedge Funds [5.9% | 8.0%]
- Commodities [4.7% | 17.8%]
- Infrastructure [7.2% | 14.9%]
- Private Equity [9.1% | 22.2%]
- Private Debt [7.9% | 11.7%]

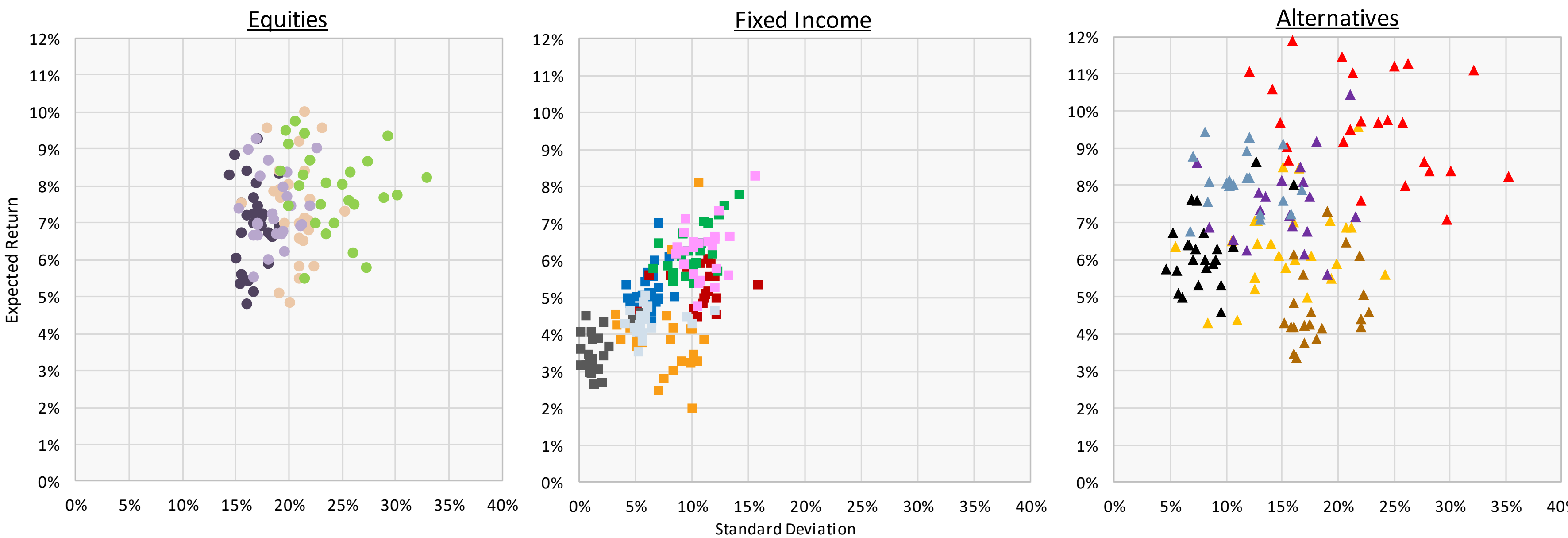
SOURCE: Horizon Actuarial 2025 Survey of Capital Market Assumptions
Expected returns over a 10-year horizon include all 41 survey participants.

Exhibit 19

Exhibit 18 showed the distribution of expected returns and standard deviations over an investment horizon of 10 years. The exhibit below shows the same distribution, but for a horizon of 20 years. Note that while Exhibit 18 included all 41 advisors in the survey, the exhibit below only includes assumptions for the 27 advisors who provided longer-term assumptions (horizons of 20 years or more). Also note that not every advisor provided expectations for every asset class.

2025 Survey: Distribution of Expected Returns and Standard Deviations

20-Year Horizon | Geometric Returns



Asset Class [Avg. Exp. Return | Avg. Std. Dev.]

- US Equity - Large Cap [7.0% | 16.6%]
- US Equity - Small/Mid Cap [7.4% | 20.6%]
- Non-US Equity - Developed [7.3% | 18.6%]
- Non-US Equity - Emerging [7.9% | 24.1%]

SOURCE: Horizon Actuarial 2025 Survey of Capital Market Assumptions
Expected returns over a 20-year horizon are based a subset of 27 survey participants who provided long-term assumptions.

Asset Class [Avg. Exp. Return | Avg. Std. Dev.]

- US Corporate Bonds - Core [5.1% | 6.0%]
- US Corporate Bonds - Long Duration [5.3% | 10.2%]
- US Corporate Bonds - High Yield [6.3% | 10.0%]
- Non-US Debt - Developed [4.0% | 7.5%]
- Non-US Debt - Emerging [6.3% | 10.9%]
- US Treasuries (Cash Equivalents) [3.6% | 1.6%]
- TIPS (Inflation-Protected) [4.4% | 6.2%]

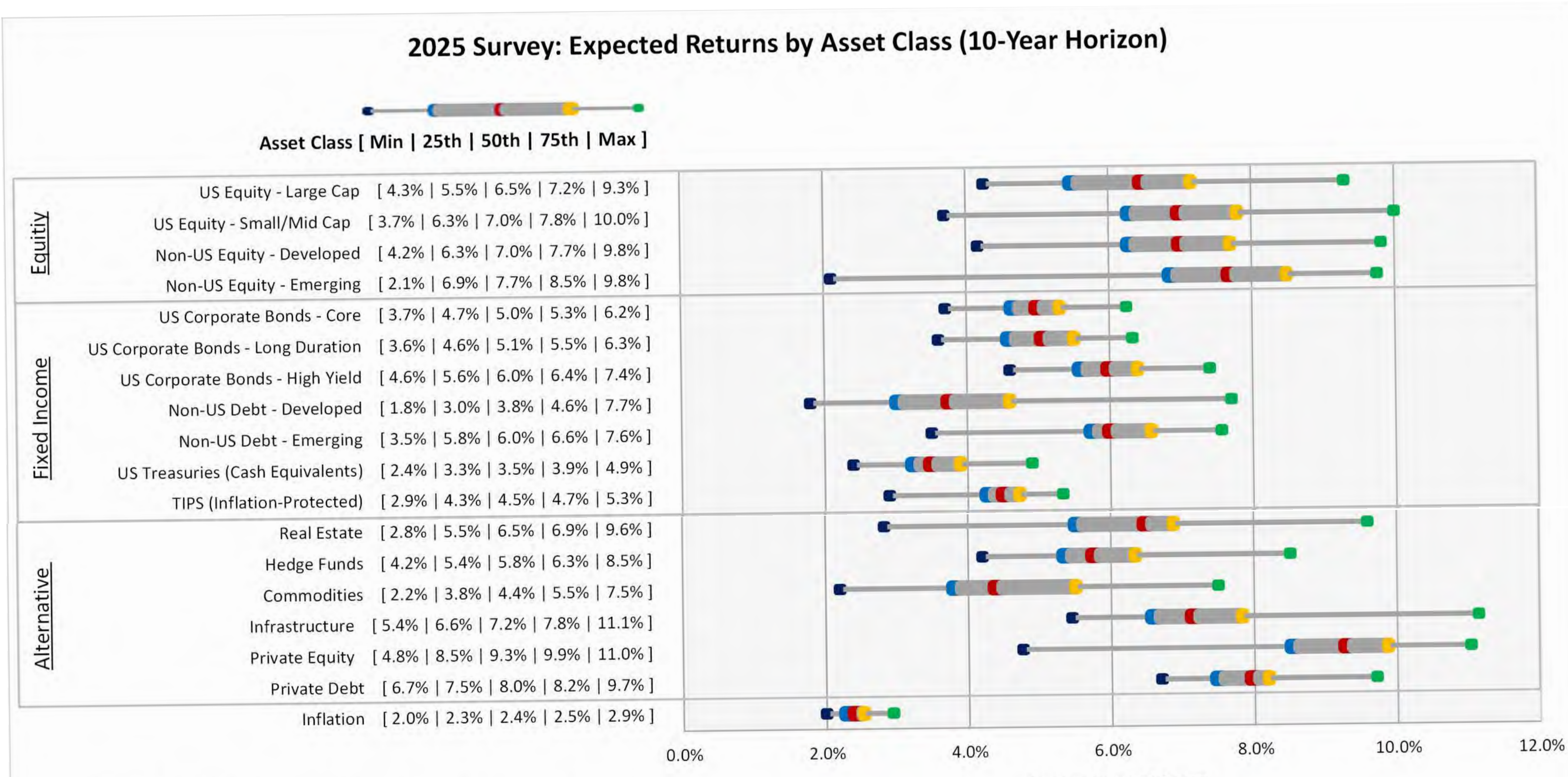
Asset Class [Avg. Exp. Return | Avg. Std. Dev.]

- Real Estate [6.4% | 15.5%]
- Hedge Funds [6.2% | 8.0%]
- Commodities [4.8% | 18.3%]
- Infrastructure [7.5% | 15.2%]
- Private Equity [9.6% | 22.8%]
- Private Debt [8.1% | 11.3%]

Exhibit 20

The exhibit below shows the ranges of expected annual returns for different asset classes over a 10-year investment horizon. The ranges shown below include assumptions for all 41 advisors in the survey. Expected returns shown below are annualized (geometric).

To illustrate the distribution of expected returns, the exhibit shows the range of the middle 50 percent of results: the range between the 25th and 75th percentiles. It also shows the median expected return for each asset class: the 50th percentile. Note that the expected returns for the *median* advisor shown below are not the same as the *average* expected returns shown elsewhere in the report. In most cases, however, the differences between median and average expected returns are relatively small.



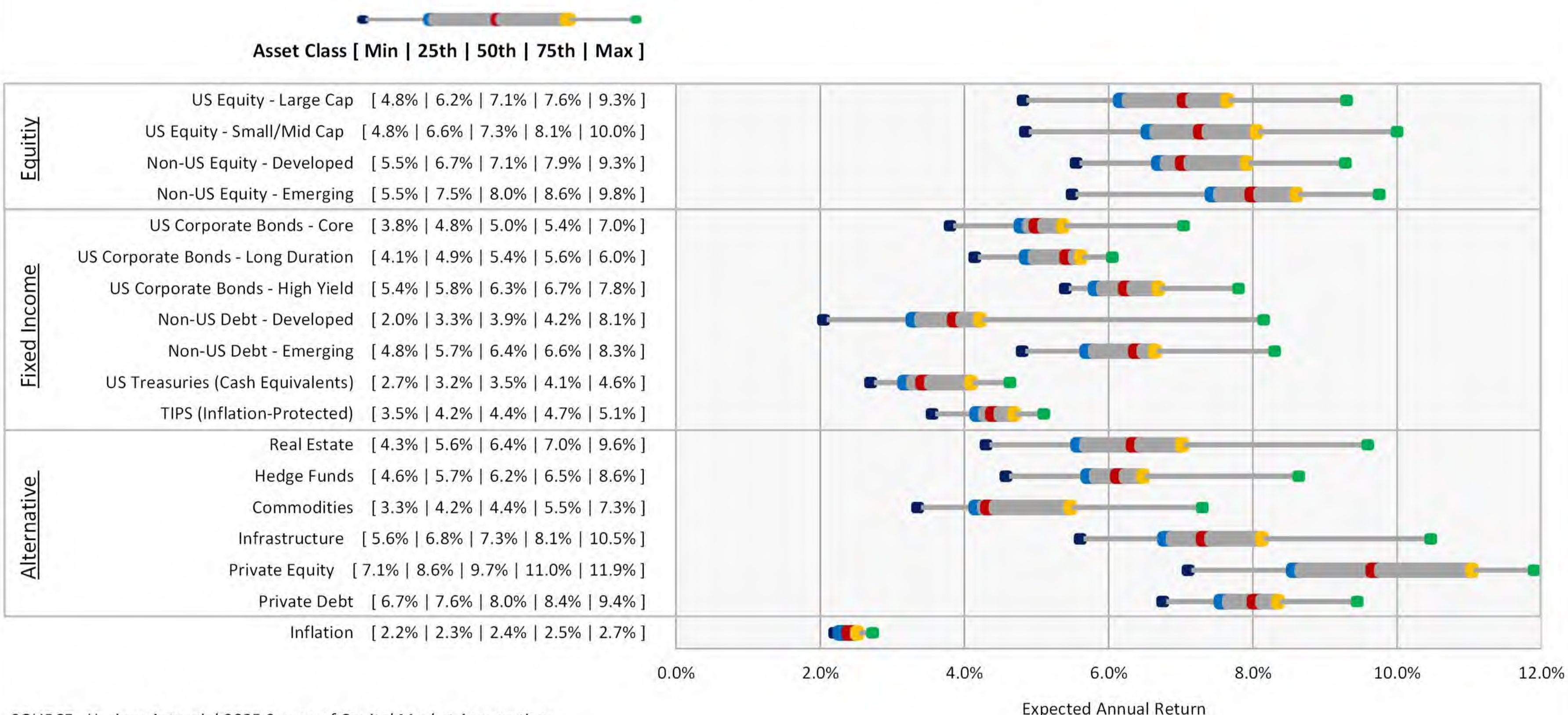
SOURCE: Horizon Actuarial 2025 Survey of Capital Market Assumptions
Expected returns are annualized over 10 years (geometric).

Exhibit 21

The exhibit below shows the ranges of expected annual returns for different asset classes over a 20-year investment horizon. The ranges shown below are based on the assumptions for 27 advisors who provided longer-term assumptions (horizons of 20 years or more). Expected returns shown below are annualized (geometric). Note that the ranges of expected returns are somewhat narrower when the investment horizon is longer.

To illustrate the distribution of expected returns, the exhibit shows the range of the middle 50 percent of results: the range between the 25th and 75th percentiles. It also shows the median expected return for each asset class: the 50th percentile. Note that the expected returns for the *median* advisor shown below are not the same as the *average* expected returns shown elsewhere in the report. In most cases, however, the differences between median and average expected returns are relatively small.

2025 Survey: Expected Returns by Asset Class (20-Year Horizon)



SOURCE: Horizon Actuarial 2025 Survey of Capital Market Assumptions

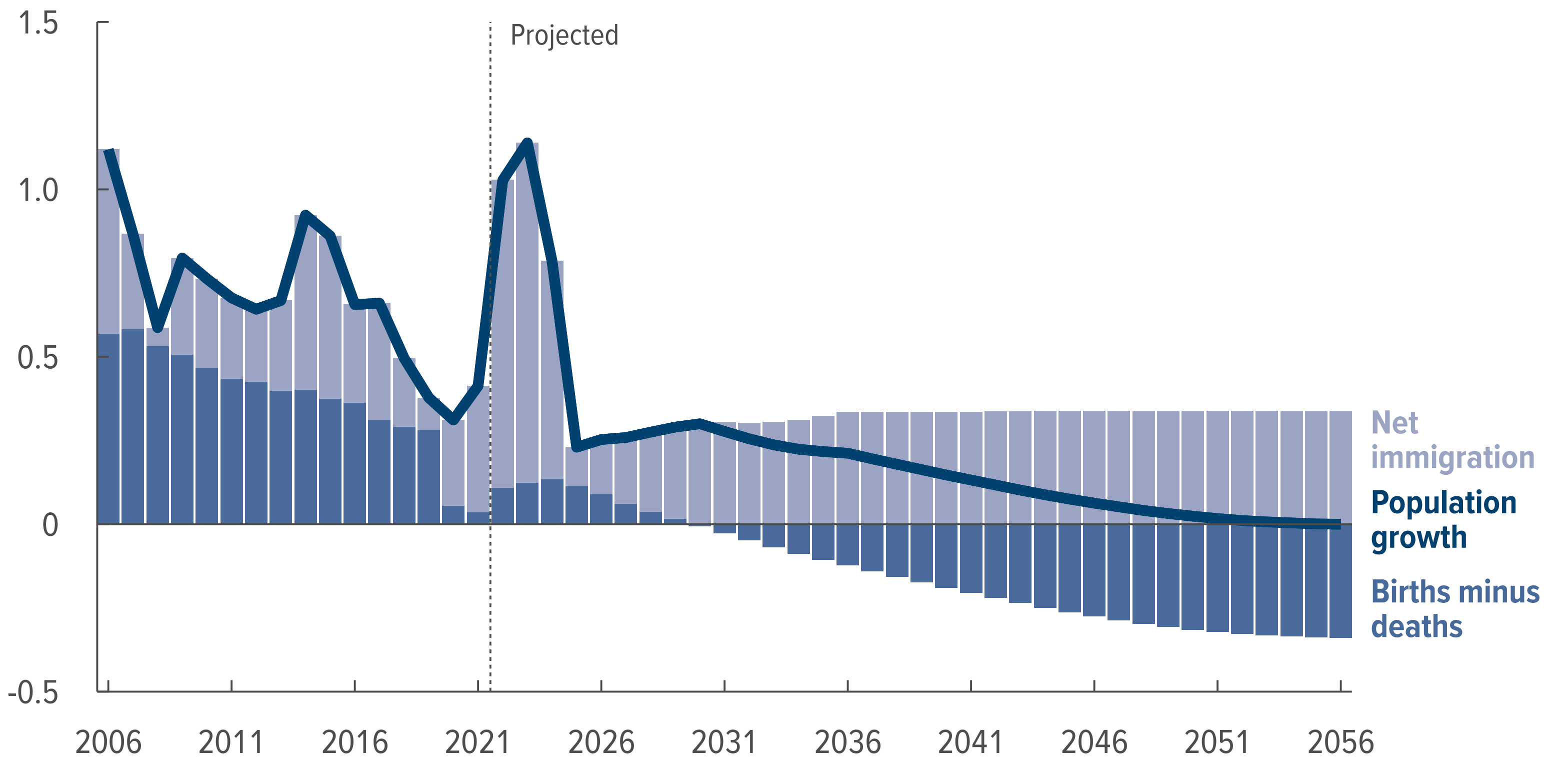
Expected returns are annualized over 20 years (geometric), based on a subset of 27 advisors who provided longer term assumptions.

Exhibit__(NYCRP-12)

Congressional Budget Office
Nonpartisan Analysis for the U.S. Congress

The Demographic Outlook: 2026 to 2056

Population Growth and Contributing Factors
Percent



JANUARY | 2026

At a Glance

The size of the U.S. population and its composition by age and sex have significant implications for the economy and the federal budget. For example, the number of people at the prime working ages of 25 to 54 affects the number of people who are employed, and the size of the population age 65 or older affects the number of Social Security and Medicare beneficiaries.

In this report, the Congressional Budget Office describes its population projections, which underlie the baseline budget projections and economic forecast that the agency will publish in February 2026. The population projections reflect laws and policies that were in place as of September 30, 2025.

- **Population.** The Social Security area population is projected to increase from 349 million people this year to 364 million in 2056. (That measure of the population, which is relevant for estimating payroll taxes and benefits for Social Security, includes residents of U.S. states and territories, as well as U.S. citizens, federal employees, and service members living abroad.) The segment of the population age 65 or older is projected to grow more quickly, on average, than younger groups, causing the average age of the population to rise.
- **Population Growth.** On the basis of recent laws, policies, and demographic trends, CBO projects that the rate of population growth will generally slow over the next 30 years, from an average of 0.3 percent a year in the next decade to an average of 0.1 percent a year from 2037 to 2056. The total population is projected to stop growing in 2056 and remain roughly the same size as in the previous year. Thereafter, the population is projected to shrink. Net immigration (the number of people who migrate to the United States minus the number who leave) is projected to become an increasingly important source of population growth in the coming years, as declining fertility rates cause the annual number of deaths to exceed the annual number of births starting in 2030. Without immigration, the population would begin to shrink in 2030.
- **Civilian Noninstitutionalized Population.** Some of CBO's economic projections (such as of gross domestic product and the labor force) depend on the number of people age 16 or older who are not on active duty with the armed forces or in institutions. CBO produces two projections of that civilian noninstitutionalized population using differing data from federal agencies. Each projection totals 301 million people in 2056, consistent with CBO's projection of overall population growth.
- **Changes Since January and September 2025.** CBO typically publishes updated demographic projections early in the calendar year. In 2025, it also released updated projections in September, which reflected laws and policies in place as of July 31. Compared with both of last year's projections, the Social Security area population is now projected to grow more slowly over the next 30 years and to be smaller in 2055 (2.1 percent smaller than projected last January and 0.7 percent smaller than projected last September). Since January 2025, CBO has reduced its projections of fertility rates because of new information and a change in its methods. CBO has also reduced its projections of net immigration from 2025 to 2029 because of administrative actions taken by the current Administration, enactment of the 2025 reconciliation act (Public Law 119-21), and updates to past population data.

CBO's projections of fertility, mortality, and net immigration rates are highly uncertain. Small differences between those projections and actual outcomes could compound over time and significantly alter the demographic picture by the end of the 30-year projection period.

www.cbo.gov/publication/61879

The Demographic Outlook: 2026 to 2056

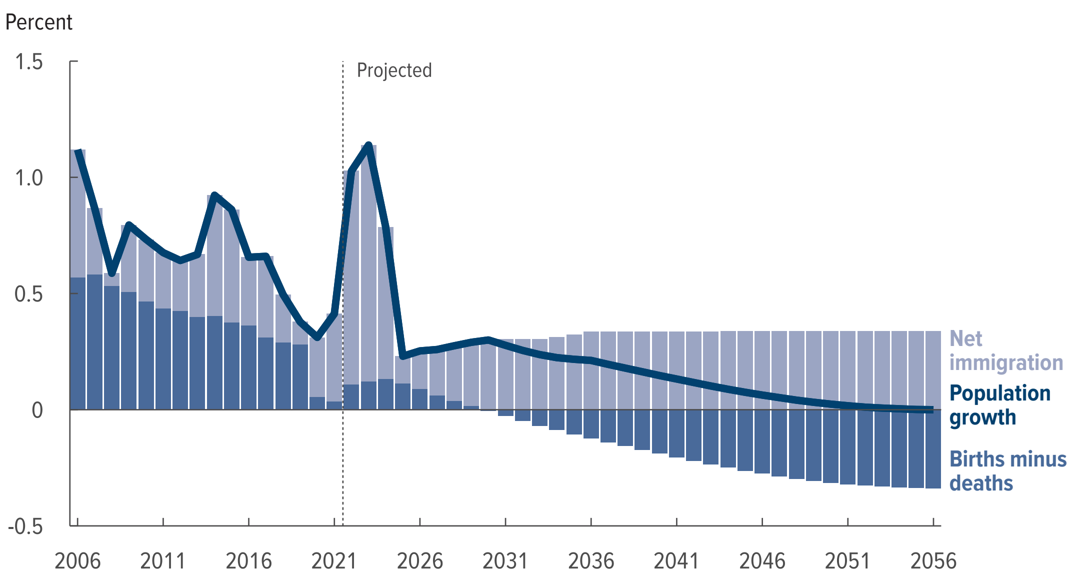
The outlook for the U.S. economy and the federal budget depends on projected changes in the size and composition of the population. Each year, the Congressional Budget Office produces 30-year population projections that are based on existing laws and policies—in this case, as of September 30, 2025—and recent demographic trends. The projections provide a benchmark for assessing how potential legislation, administrative actions, and judicial decisions would affect the size and structure of the U.S. population. This report explains how CBO's current population projections differ from the ones the agency released in January 2025 and then updated in September 2025 (to reflect laws and policies in place as of July 31, 2025).[1]

To project the U.S. population, CBO starts with recent data and then estimates future rates of fertility, mortality, and net immigration (the number of people who migrate to the United States minus the number who leave). In this report, the U.S. population is defined as the population used for estimating Social Security payroll taxes and benefits. (That measure, known as the Social Security area population, is described in Appendix C).

In CBO's projections, the population increases from 349 million people in 2026 to 364 million in 2056. Population growth slows during that period—from an average rate of 0.3 percent a year over the next decade to 0.1 percent a year thereafter. Through 2029, the population grows because more people are projected to migrate to the United States than to leave it (positive net immigration) and because the annual number of births is projected to exceed the annual number of deaths. Starting in 2030, declining fertility rates are projected to cause births to fall short of deaths. Over time, the negative net contribution of births and deaths increasingly offsets the positive contribution of net immigration, until population growth slows to zero in 2056. The population is projected to shrink thereafter. (For details about how CBO's projections differ from those of other government forecasters, see Appendix A.)

CBO's population projections are highly uncertain, especially in the later years of the 2026–2056 period. If rates of fertility, mortality, or net immigration were higher or lower than CBO projects, the resulting population would differ in size and composition from the one described in this report. The effects of such differences would be larger in later years because the differences would compound over time.

Population Growth and Contributing Factors



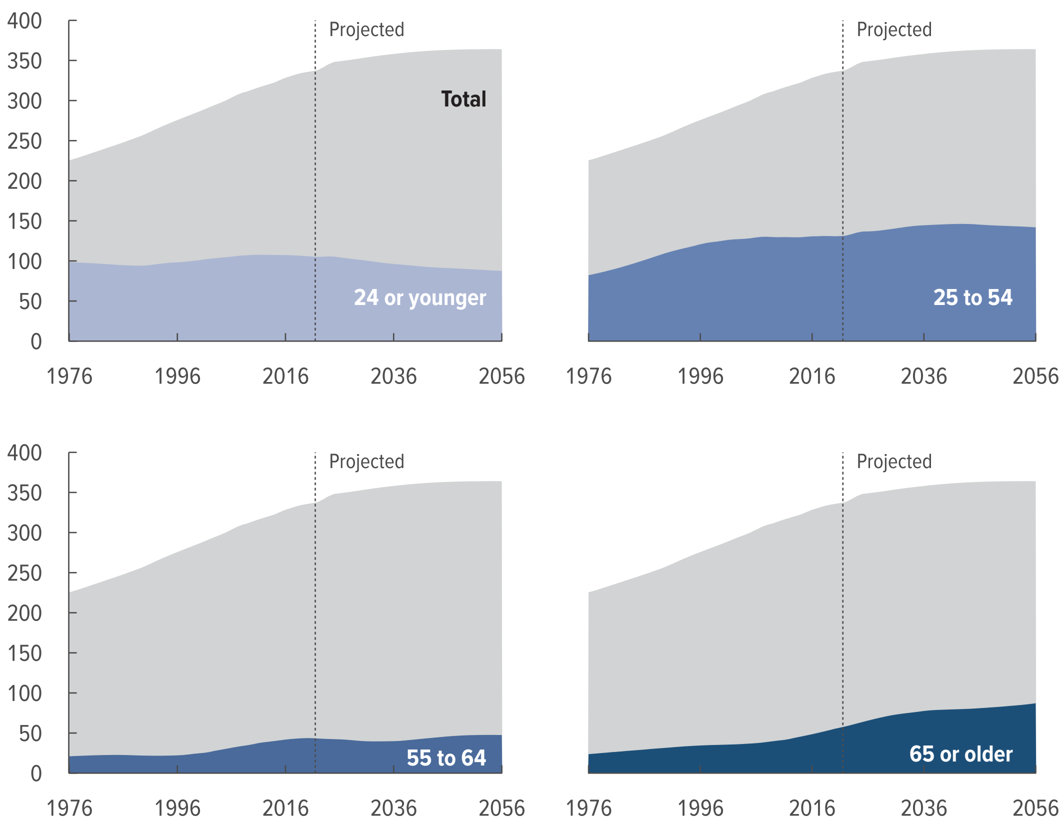
In CBO's projections, annual population growth generally slows over the next 30 years, reaching zero in 2056. Throughout that period, net immigration contributes to population growth but is increasingly offset by the effect of annual deaths' exceeding births.

The Size and Age Composition of the Population

CBO projects that the U.S. population will become older, on average, over the 2026–2056 period. The number of people age 65 or older is projected to rise through 2036, growing at an average annual rate of 1.6 percent. That rate is faster than the average growth rates projected for younger groups: –0.4 percent a year for people ages 55 to 64, 0.5 percent for people ages 25 to 54, and –0.8 percent for people age 24 or younger. After its initial rise, the growth of the population age 65 or older is projected to slow through 2056. The number of people ages 25 to 54 is projected to increase through 2042 and decrease thereafter. The population age 24 or younger is projected to decline in each of the next 30 years.

Population Size, by Age Group

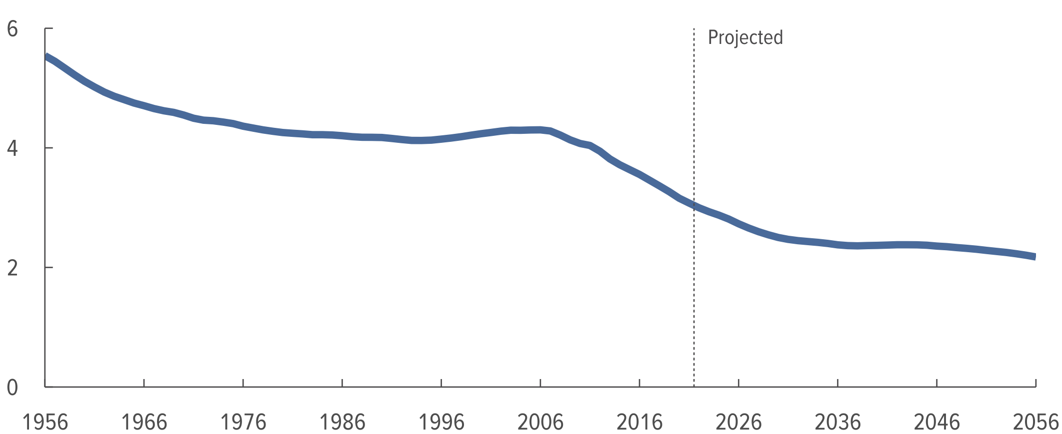
Millions of people



In CBO's projections, the number of people age 24 or younger declines for the next three decades. On average, the population age 65 or older grows more quickly than the population ages 25 to 54. That difference will affect the federal budget and the economy because people who are 65 or older are less likely to work and are generally eligible for Social Security and Medicare.

The Population Ages 25 to 64 Relative to the Population Age 65 or Older

Ratio



This year, there will be 2.7 people ages 25 to 64 for every person age 65 or older, CBO projects. Over the next three decades, that ratio is projected to decline to 2.2 to 1.

Components of Population Growth

Population growth is determined by births, deaths, and net immigration. In CBO's projections, fertility rates continue to be lower than the replacement rate (the fertility rate required for a generation to exactly replace itself in the absence of immigration), which is 2.1 births per woman. Mortality rates continue to decline over the next 30 years, and immigration becomes an increasingly important source of population growth.

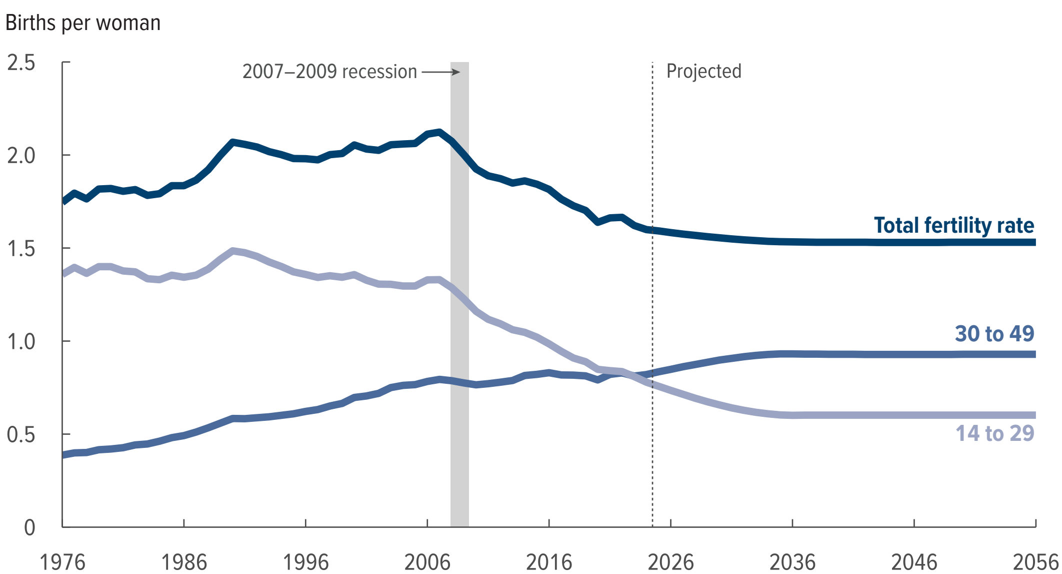
Fertility

CBO's projection of fertility rates is based on its assessment of past trends. For the 20 years before the 2007–2009 recession, the total fertility rate averaged 2.02 births per woman. After peaking in 2007 at 2.12, that rate has generally fallen, mainly because of lower fertility rates for women under age 25. The total fertility rate was 1.64 births per woman in 2020 and declined to 1.60 in 2024 (the most recent year for which data on fertility were available when these projections were made). CBO projects that the total fertility rate will equal 1.58 births per woman in 2026, decline to 1.53 in 2036, and remain at roughly that rate for the following 20 years.

The fertility rate for women under 30 is projected to fall over the next three decades: from 0.74 births per woman this year to 0.60 in 2056. The rate for women age 30 or older, by contrast, is projected to increase—from 0.85 births per woman in 2026 to 0.93 in 2056—partly because CBO expects women to delay bearing children until older ages.

CBO's projections of fertility rates are subject to considerable uncertainty. If future fertility rates differed from what CBO projects, the number of births and the age composition of mothers would look different from CBO's projections.

Fertility Rates, by Age Group



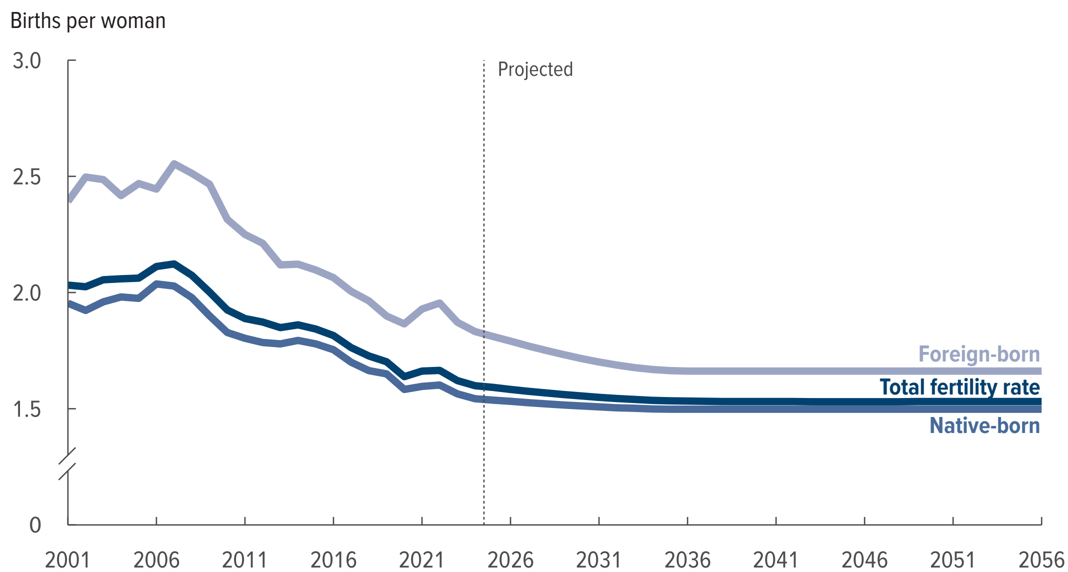
In CBO's projections, fertility rates rise for women of older childbearing ages and fall for women of younger childbearing ages. That pattern is consistent with the recent trend of delays in childbearing.

Fertility, by Mother's Place of Birth

CBO projects different fertility rates for women in the United States who were born in this country and those who were born elsewhere. The fertility rate for native-born women is projected to equal 1.53 births per woman in 2026, decline to 1.50 in 2032, and remain at that rate through 2056. The fertility rate for foreign-born women is projected to fall from 1.79 births per woman in 2026 to 1.66 in 2036 and then stay at that rate through 2056.

CBO projects separate fertility rates for foreign-born and native-born women using information on past fertility by age. That information comes mainly from the Centers for Disease Control and Prevention's National Center for Health Statistics and the Census Bureau's American Community Survey.[2] After projecting age-specific rates, CBO sums them to create total fertility rates for native-born and foreign-born women. The total fertility rate for women as a whole is the average of the total rates for native-born and foreign-born women, weighted by the projected size of the populations of native- and foreign-born women of childbearing age (which CBO defines as ages 14 to 49).

Fertility Rates, by Mother's Place of Birth



On the basis of past trends, CBO projects a higher fertility rate for foreign-born women than for women born in the United States. Because native-born women greatly outnumber women who immigrate to the United States, the total fertility rate (which includes both groups) is closer to the native-born rate than to the foreign-born rate.

Mortality

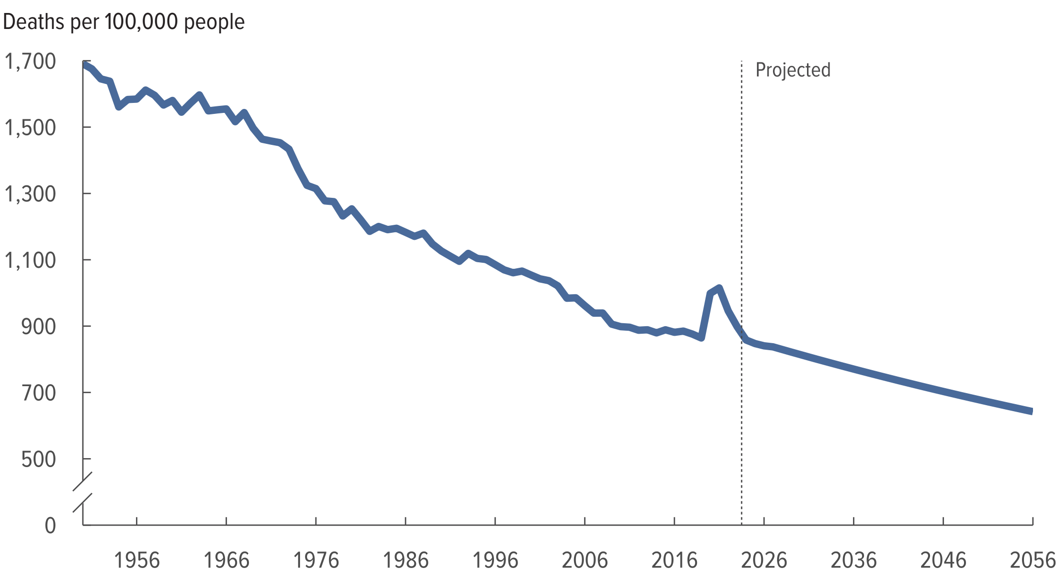
In CBO's projections, mortality rates decline, causing average life expectancy at birth to increase from 79.0 years in 2026 to 82.3 years in 2056.

CBO projects mortality rates on the basis of historical trends, with adjustments to account for the effects of COVID-19. (Those projections reflect data from Social Security's Board of Trustees through 2023.) Since at least the early 20th century, mortality rates in the United States have generally decreased (meaning that life expectancy has generally increased), and rates have fallen more quickly for younger adults than for older people. Since about 2010, however, the overall pace of decline has slowed, and mortality rates have risen for some groups—particularly young and middle-aged adults—because of such factors as drug overdoses, suicides, homicides, and transportation accidents.[3]

To account for those trends, CBO estimates that the mortality rate for each five-year age group will change at roughly the same average pace from 2024 to 2028 that it did from 2010 to 2019 (the last year before the COVID-19 pandemic). After 2028, mortality rates are projected to return to their more long-standing historical trends, declining at the average pace seen from 1950 to 2019. That time frame includes the period of faster decline before 2010 and the period of slower decline and reversal that some groups experienced from 2010 to 2019. The net effect is a continued decline in mortality rates beyond 2028.

Mortality rates are uncertain in the long term because factors such as advances in medical technology and changes in environmental conditions may have different effects in the future than they had in the past. Another area of uncertainty is whether the slowing of the decline in mortality rates for some groups from 2010 to 2019 will continue.

Mortality Rate, Adjusted for Age and Sex



In CBO's projections, mortality rates continue their long-standing trend by declining over the next 30 years. As a result, life expectancy at birth is projected to increase from 79.0 years to 82.3 years over that period, and life expectancy at age 65 is projected to increase from 19.8 years to 21.9 years.

Net Immigration

To develop its overall projections of net immigration, CBO groups people into three categories (described in more detail in Appendix C):

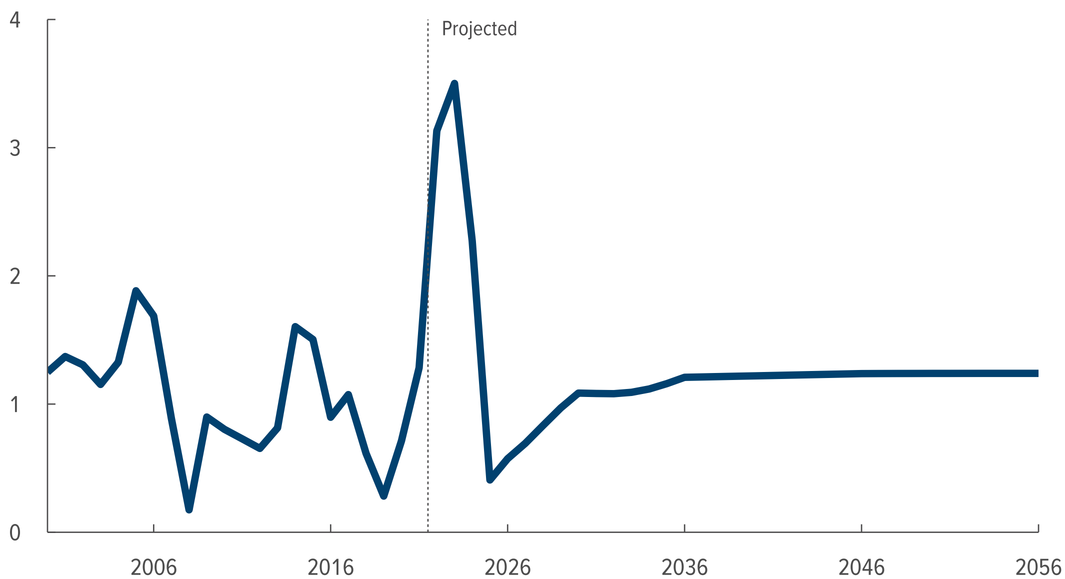
- LPR+, which consists of lawful permanent residents (LPRs) and people who are eligible to apply to become LPRs on the basis of their current immigration status, such as asylees (people granted asylum) and refugees.
- INA nonimmigrants, which consist of people admitted as nonimmigrants under the Immigration and Nationality Act (INA), such as students and temporary workers.
- Other foreign nationals, which consist of people in the United States who are not in the first two categories and who have not subsequently become U.S. citizens or received LPR, asylee, or nonimmigrant status. That category includes people who entered the United States illegally and people who were allowed to enter through the use of parole authority and who may be awaiting proceedings in immigration court.

CBO's projections of net immigration over the next two decades are based on its assessment of recent trends.[4] After 2046, net immigration is projected to grow each year at roughly the same rate as total population growth in the previous year (0.02 percent, on average).

CBO develops its projections of net immigration so they fall in the middle of the likely range of outcomes in the absence of new legislation or administrative or judicial changes. Several factors cause those projections to be uncertain. For example, changing conditions in immigrants' countries of origin could affect flows of immigration. Estimates of past immigration and projections of future immigration of people who enter the United States illegally are particularly uncertain because information about that group is hard to obtain. Estimates of how many people leave the country are also difficult to obtain. In addition, immigration could differ significantly from CBO's projections because of future legislative or administrative actions or changes to enforcement policies, which are not reflected in the current projections.

Net Immigration

Millions of people



CBO estimates that net immigration declined after 2023, to 410,000 people in 2025. In CBO's projections, net immigration rises steadily through 2030 and then grows more slowly through 2036 because of declining net immigration of INA nonimmigrants (such as students and temporary workers). From 2037 to 2056, net immigration is projected to average 1.2 million people per year (close to the average of 1.1 million people per year seen from 1990 to 2021).

Net Immigration, by Category

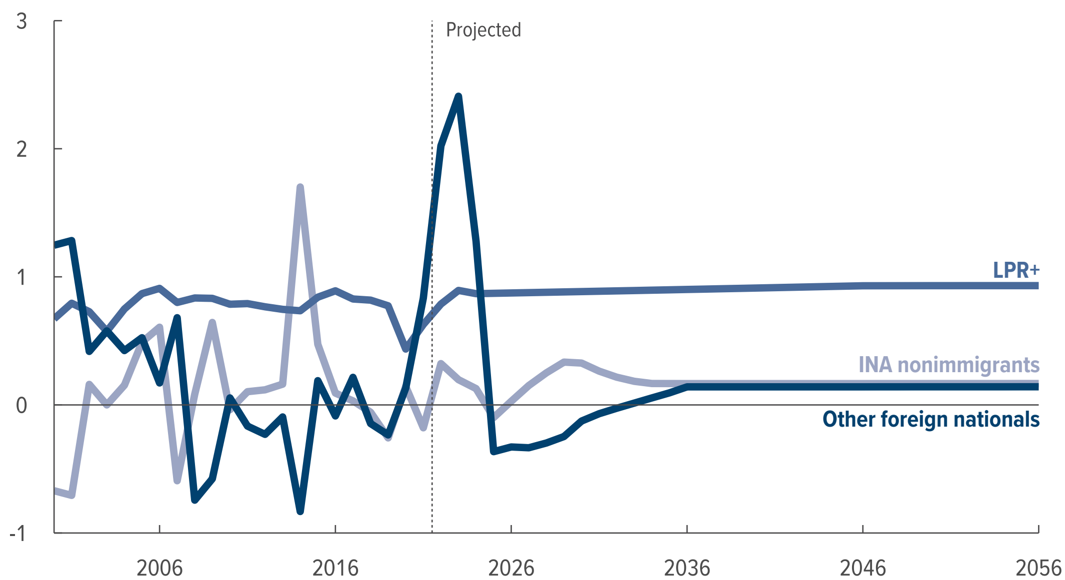
CBO projects that annual net immigration of lawful permanent residents and people eligible to apply for LPR status will grow slightly over the next 30 years (from 870,000 people in 2026 to 930,000 in 2056). On average, net immigration of people in that category averages 910,000 per year over the 2026–2056 period in CBO's projections.

Net immigration of students, temporary workers, and other people in the INA nonimmigrant category declined in 2025, CBO estimates, primarily because fewer students entered the United States. CBO projects that after 2025, the inflow of INA nonimmigrants will gradually return to the levels seen in the years shortly before the COVID-19 pandemic. The outflow of INA nonimmigrants will be reduced through 2029 by the smaller inflow of INA nonimmigrants in 2025, CBO projects. As a result of those factors, net immigration in the INA nonimmigrant category is projected to increase from 30,000 people in 2026 to 330,000 people in 2030. Such immigration is projected to fall after 2030 as INA nonimmigrants who arrived in previous years begin to leave. In CBO's projections, annual net immigration in the INA nonimmigrant category declines to 170,000 people in 2036 and remains near that number through 2056.

Net immigration of other foreign nationals was larger from 2021 to 2023 than it had been in recent decades, CBO estimates. Such immigration declined after a June 2024 executive order temporarily suspended most entries at the southern U.S. border, and it continued to decline in 2025 because of subsequent administrative actions. In 2025, net immigration of other foreign nationals turned negative, CBO estimates: 360,000 more people in that category left the country than arrived. CBO projects that net immigration of other foreign nationals will increase after 2025 as the number of immigrants joining that category each year returns to an amount consistent with its long-run historical average. Such immigration is projected to reach 140,000 people per year in 2036 and remain close to that number for the following two decades. (For more details, see Appendix B.)

Net Immigration, by Category

Millions of people



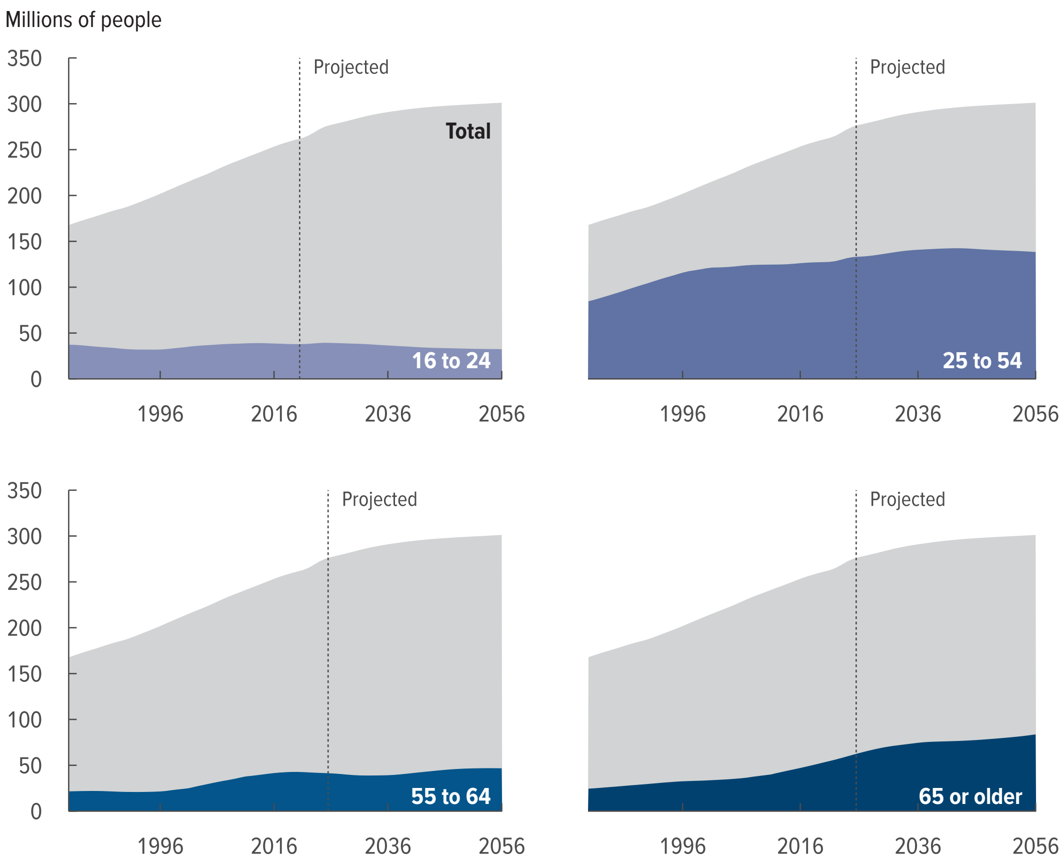
In CBO's projections, lawful permanent residents, asylees, and refugees represent the largest share of total net immigration each year from 2026 to 2056, averaging 910,000 people per year. INA nonimmigrants and other foreign nationals each average less than 200,000 people per year.

Civilian Noninstitutionalized Population

As an input to its economic forecast, CBO projects two measures of the civilian noninstitutionalized population age 16 or older, which consists of people who are not on active duty with the armed forces, in penal or mental institutions, in detention facilities, or in homes for the elderly or infirm. Both projections are generally consistent with CBO's projections of the growth of the Social Security area population.

- The first projection—which CBO calls Census Through 2020 Plus CBO Projection—incorporates population estimates made by the Census Bureau and researchers at the Federal Reserve Board through 2020. It reflects CBO's estimates of population growth thereafter, including the agency's estimates of net immigration after 2020. CBO uses that projection to estimate the size of the labor force and potential gross domestic product (the maximum sustainable output of the economy).
- The second projection—called BLS Through 2025 Plus CBO Projection—uses population data from the Bureau of Labor Statistics (BLS) through 2025 and then transitions to equal the Census Through 2020 Plus CBO Projection by 2031.[5] CBO uses that projection to estimate the unemployment rate and payroll employment numbers that will be reported by BLS.

Census Through 2020 Plus CBO Projection of the Civilian Noninstitutionalized Population, by Age Group



The number of people ages 25 to 54 in the civilian noninstitutionalized population—the group most likely to participate in the labor force—is projected to grow more slowly over the next 30 years than it did over the past 50 years.

The number of people age 65 or older in that population—who are generally eligible for Social Security and Medicare and are less likely to be employed than younger people—is projected to average 75 million over the next 30 years, about twice the average size over the past 50 years.

For Immediate Release: Thursday, November 09, 2023

U.S. Population Projected to Begin Declining in Second Half of Century

November 09, 2023
Press Release Number: CB23-189

NOV. 9, 2023 — The U.S. population is projected to reach a high of nearly 370 million in 2080 before edging downward to 366 million in 2100. By 2100, the total U.S. resident population is projected to increase by only 9.7% from 2022, according to the latest U.S. Census Bureau population projections released today. The projections provide possible scenarios of population change for the nation through the end of the century.

The 2023 National Population Projections is an update to the last series of projections, published in 2017, to account for the impact of COVID-19 and to reflect the results of the 2020 Census through its inclusion of the Vintage 2022 National Population Estimates [https://www2.census.gov/programs-surveys/popest/technical-documentation/methodology/2020-2022/methods-statement-v2022.pdf] as a base. It also extends the population projections to 2100, the first time since 2000 that the Census Bureau projections have stretched this far into the future. [https://www.census.gov/library/working-papers/2000/demo/POP-twps0038.html]

“In an ever-changing world, understanding population dynamics is crucial for shaping policies and planning resources,” stated Sandra Johnson, a demographer at the Census Bureau.

“The U.S. has experienced notable shifts in the components of population change over the last five years,” she explained. “Some of these, like the increases in mortality caused by the COVID-19 pandemic, are expected to be short-term while others, including the declines in fertility that have persisted for decades, are likely to continue into the future. Incorporating additional years of data on births, deaths and international migration into our projections process resulted in a slower pace of population growth through 2060 than was previously projected.”

Projections illustrate possible courses of population change based on assumptions about future births, deaths and net international migration. The 2023 projections include a main series (also known as the middle series) considered the most likely outcome of four assumptions, and three alternative immigration scenarios that show how the population might change under high, low and zero immigration assumptions.

Other highlights:

Total Population

- By 2100, the total population in the middle series is projected to reach 366 million compared to the projection for the high-immigration scenario, which puts the population at 435 million. The population for the middle series increases to a peak at 370 million in 2080 and then begins to decline, dropping to 366 million in 2100. The high-immigration scenario increases every year and is projected to reach 435 million by 2100.
- The low-immigration scenario is projected to peak at around 346 million in 2043 and decline thereafter, dropping to 319 million in 2100.
- Though largely illustrative, the zero-immigration scenario projects that population declines would start in 2024 in the complete absence of foreign-born immigration. The population in this scenario is projected to be 226 million in 2100, roughly 107 million lower than the 2022 estimate.

Drivers of Population Change

- In each of the projection scenarios except for the zero-immigration scenario, immigration is projected to become the largest contributor to population growth.
- In the middle series and the high-immigration scenario, net international migration is higher than natural increase (the difference between births and deaths) in all years of the time series. For the low-immigration scenario, this crossover happens in 2029.
- Reduced fertility and an aging population result in natural decrease — an excess of deaths relative to births — in all projection scenarios. This happens in 2038 in the main series, 2033 in the zero-immigration scenario, 2036 in the low-immigration scenario, and in 2042 in the high-immigration scenario.

Age and Sex

- Continued declines in fertility are projected to shift the age structure of the population so that there will be more adults age 65 or older compared to children under age 18.

- In the middle series, the share of the population in the older age group surpasses that of the younger age group in 2029 and, by 2100, 29.1% of the population is projected to be age 65 or older compared to 16.4% under age 18. This crossover happens in 2030 in the high-immigration scenario, 2029 in the low-immigration scenario, and 2028 in the zero-immigration scenario.
- The share of the population age 65 or older in 2100 ranges from 27.4% in the high-immigration scenario to 35.6% in the zero-immigration scenario.
- Similarly, the median age of the U.S. population, which represents the age at which half the population is older and half is younger, is projected to increase over time in all projection scenarios.
- In 2022, the median age for the total population was 38.9. In 2100, this is projected to increase to 47.9 in the middle series, 46.5 in the high-immigration scenario, 49.2 in the low-immigration scenario, and 53.6 in the zero-immigration scenario.
- Median age is currently higher for females, who tend to have longer life expectancies at birth compared to males, and this trend is projected to continue. In the middle series it is projected that in 2100, the median age for females will be 49.1 and the median age for males will be 46.8.
- Projected median age in 2100 for females ranges from 47.7 in the high-immigration scenario to 54.8 in the zero-immigration scenario.
- For males, the projected values in 2100 range from 45.4 in the high-immigration scenario to 52.5 in the zero-immigration scenario.

Race and Hispanic Origin

- Non-Hispanic White alone was the most prevalent race or ethnic group in the United States in 2022 (58.9%), followed by Hispanic (19.1%) and non-Hispanic Black alone (12.6%). Although the share of the population in each of these groups is projected to change over time, these three groups are projected to remain the most prevalent through 2060 in all immigration scenarios.
- In 2060, the non-Hispanic White alone population is projected to decline to 44.9% in the middle series, 42.7% in the high-immigration scenario, 46.6% in the low-immigration scenario, and to 50.7% in the zero-immigration scenario.
- At the same time, the Hispanic population is projected to increase to 26.9% in the middle series in 2060, 27.8% in the high-immigration scenario, 26.2% in the low-immigration scenario, and to 24.6% in the zero-immigration scenario.
- The non-Hispanic Black alone population is expected to remain at around 13% in 2060 in all of the immigration scenarios.

Nativity

- The projected share of the population that is foreign-born is highly influenced by assumptions regarding international migration.
- In 2022, 13.9% of the U.S. population was foreign-born. In the main series, this share is projected to increase to 19.5% in 2100, while the high-immigration scenario projects an increase to 24.4% and the low-immigration scenario projects an increase to 14.9%.
- The zero-immigration scenario projects a decline in the share of the population that is foreign-born to 0.3% in 2100.

Background on the 2023 Projections Series

The 2023 National Population Projections provide estimates of the future U.S. population by age, sex, race, Hispanic origin and nativity through 2060 and by age, sex and nativity only through 2100. These projections supersede the 2017 series and are the first set of projections based on the 2020 Census.

Different levels of immigration between the present and 2100 could change the projection of the population in that year by as much as 209 million people, with the projected total population ranging anywhere from 226 to 435 million. Varying assumptions about immigration also impact the projected composition of the population, with higher levels of immigration resulting in a projected population that is younger and more racially and ethnically diverse.

The Census Bureau regularly updates its population projections as new data on the components of change (births, deaths and migration) become available.

For more information, view population projections
[https://www.census.gov/programs-surveys/popproj.html]
or visit census.gov
[https://www.census.gov/en.html]
.

Contact

Public Information Office
301-763-3030 or
877-861-2010 (U.S. and Canada only)
pio@census.gov

Related Information

Press kit [https://www.census.gov/newsroom/press-kits/2023/population-projections.html]

These projections provide a comprehensive analysis of the nation’s projected population through 2100.

Page Last Revised - November 16, 2023

Technological Forecasting & Social Change 80 (2013) 1557–1562

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

Long-term GDP forecasts and the prospects for growth

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ARTICLE INFO

Article history:
Received 13 August 2012
Received in revised form 4 February 2013
Accepted 20 February 2013
Available online 13 March 2013

Keywords:
Logistic growth
Natural growth
S-curve
GDP
Inflation
Saturation
Logistic versus exponential

ABSTRACT

The growth of GDP is considered as a natural-growth process amenable to description by the logistic-growth equation. The S-shaped logistic pattern provides good descriptions and forecasts for both nominal and real GDP per capita in the US over the last 80 years. This enables the calculation of a long-term forecast for inflation, which is to enter a declining trend not so far in the future. The two logistics are well advanced, more so for nominal GDP. The assumption for logistic growth works even better for Japan whose nominal GDP per capita has already completed tracing out an entire logistic trajectory. The economic woes of industrialized countries could be attributed to the saturation of growth there, as if a niche in nature had been filled to capacity. In contrast, GDP growth in China and India is in the very early stages of logistic growth still indistinguishable from exponential patterns. The ceiling of these logistics can be anywhere between 5 and 10 times today's levels.

1. Introduction

The growth of Gross Domestic Product (GDP) is considered to be an essential ingredient of a healthy economy. A plethora of near-future forecasts typically projects a constant percentage over several years in the future invariably promising growth [1]. But longer-range forecasts are also often based on more or less exponentially growing patterns [2]. And yet there have been voices advocating that days of diminishing growth are approaching. These voices began in 1972 with the publication of *The Limits to Growth* by the Club of Rome [3]. But they increased in numbers recently with such works as Tim Jackson's *Prosperity Without Growth* [4], Serge Latouche's *Farewell to Growth* [5], and Peter Victor's *Managing Without Growth: Slower by Design, Not Disaster* [6]. Richard Heinberg has a rather extensive compilation of publications on this subject in his book *The End of Growth* [7].

Complementary to the works mentioned, which are generally based on economic arguments, I want to address in this article the growth of GDP as a natural-growth process. Growth in competition is an appropriate eyepiece here because there is abundant competition in the processes that contribute to the formation of GDP and the issue of limited resources cannot be denied. Competition and limited resources are the ingredients of logistic growth that describes growth in competition of species populating ecological niches. But my ultimate argument for using a logistic approach is an a posteriori one, namely the goodness of the way logistic growth describes the evolution of GDP over almost a century.

Logistic growth implies a cap, a final ceiling, in sharp contradiction to forecasts based on linear and exponential patterns, which are unlimited. I will present actual data on GDP growth demonstrating that such a cap is altogether realistic. Once at the ceiling there can be no more growth, none unless catastrophes and disasters of unseen-before magnitude create new niches for growth or the "species" undergoes a major mutation effectively transforming itself into a different species, e.g. through war and conquest of new territory.

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0040-1625/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.techfore.2013.02.010

2. Logistic-growth fits on the US GDP

The historical data on the US GDP per capita come from the US Department of Commerce, Bureau of Economic Analysis, and the US Census Bureau [8]. They consist of yearly data points up to and including reliable estimates for year 2012. The logistic equation used is Eq. (1). The fitting procedure involved the minimization of a Chi Square using EXCEL's solver.

$$X(t) = \frac{M}{1 + e^{-\alpha(t - t_o)}} + C \quad (1)$$

where M is the ceiling level of the logistic S-shaped pattern, α the steepness of the curve, t_o the midpoint of the entire growth process, and C an eventual pedestal (positive or negative) on which the logistic may be sitting, often associated with missing early data.

Faced with the dilemma of studying the nominal GDP expressed in current dollars or the real GDP – i.e. corrected for inflation – expressed in constant (chained) dollars, I decided to study them both. Furthermore, I chose to look at GDP *per capita*, because the growth of population may mask or modulate the growth of GDP. To my surprise both sets of data resulted in excellent logistic fits. Fig. 1 shows nominal GDP per capita and Fig. 2 shows real GDP per capita. The lower graphs show the rate of change in annual increments, i.e. the life cycle of each process; they are derived from the curves at the top of Figs. 1 and 2. The emerging images indicate that the inflection points – centers of the life-cycle curves – are behind us, particularly for nominal, and that there is about a 7-year lead by nominal GDP.

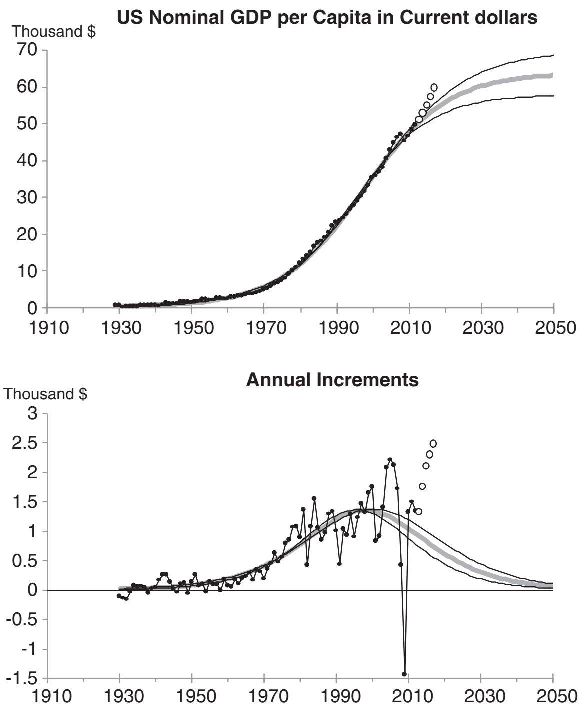


Fig. 1. Above, nominal GDP per capita (black dots) and logistic fit (thick gray line). Below, the rate of growth in annual increments. The open circles are IMF forecasts. The thin black lines delimit 90% confidence-level bands.

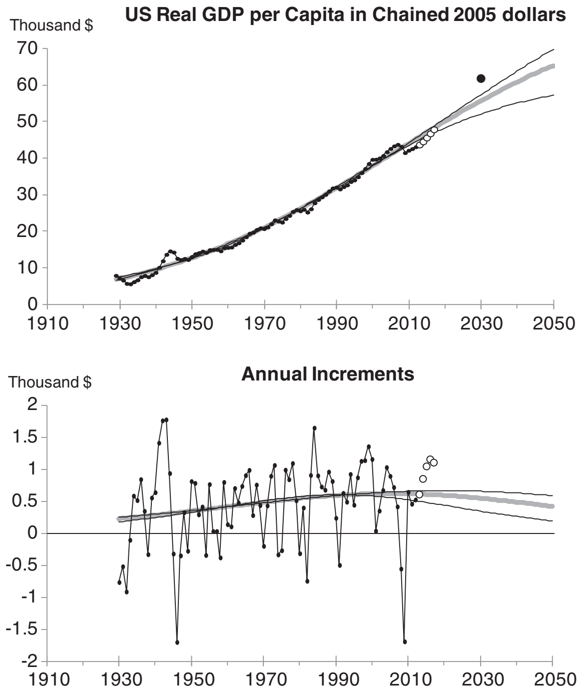


Fig. 2. Above, real GDP per capita (black dots) and logistic fit (thick gray line). Below, the rate of growth in annual increments. The open circles are IMF forecasts. The thin black lines delimit 90% confidence-level bands. The big black dot is a long-term forecast by Agnus Maddison [11].

The goodness of the fits can be visually appreciated by the way the data points closely follow the logistic patterns (thick gray lines) over 80 years despite many world-shaking events and varying inflation over this period of time. The fit parameters are tabulated in Table 1.

A further surprise was that whereas the nominal GDP nears completion of the growth process, the curve was 77.6% completed by the end of 2012, the real GDP has still considerable remaining growth potential, its curve was only 55.2% completed. The respective midpoints – inflection points of the logistics – were in mid 1998 for nominal GDP and late 2005 for real GDP. Thin black lines delimit 90% confidence-level bands, in other words, where we should expect future GDP values to fall nine times out of ten. Such bands were established using look-up tables in Reference [9] and taking into account the error per data point (approximated here by the mean absolute deviation). The 90% confidence-level intervals for the two inflection points are 1995–2000 and 1991–2020 respectively.

Table 1
Results for the logistic fits on nominal and real US GDP per capita.

	M	α	t_o	C	Mean abs. dev.
Nominal	63.40584	0.085912	1997.522	0.430336	7.9%
Real	85.00400	0.029035	2004.832	−1.63077	2.9%

The open circles shown for the period 2013–2017 are forecasts by the International Monetary Fund (IMF) made in traditional economists' ways, most frequently consisting of linear and exponential extrapolations [10]. For nominal GDP they indicate a more optimistic trend progressively deviating from the logistic course (outside the 90% confidence-level band). The big black dot in Fig. 2 is a long-term forecast by Agnus Maddison [11].

There is a rather limited amount of growth potential ahead of us in nominal GDP but a significant amount of growth potential in real GDP, which economists prefer to talk about more often than not. But what good is it for us to know that "somewhere" there is much growth while all we see in everyday life in current dollars is little growth? The real GDP seems to have little relevance to the people on the streets. Apparently inflation has "eaten up" all our growth potential. But given that both nominal and real GDP constitute natural-growth processes – i.e. follow logistic trajectories – inflation, which is linking these two must also have some *natural* origin rather than its usual attribution to frivolous human behavior!

In fact, the decline of nominal GDP's rate of growth in *percentage terms* began already in the late 1970s, as can be seen in Fig. 3. The data fluctuate considerably particularly during early 20th century because of the small absolute values of GDP (which is in the denominator). Nevertheless, the thick gray line, derived from the logistic curve in Fig. 1, provides a good description for what happened during the last 80 years. The trend indicated by the IMF forecasts seems to be in sharp disagreement.

3. Inflation

From the logistic curves for nominal and real GDP we can extract an overall trend for inflation, shown in Fig. 4. The thick gray line is not a fit to the data here. It is calculated from the ratio of the gray logistic curves in Figs. 1 and 2, and seems to be a fair description of the trend of the consumer price index over the past 80 years. It provides a long-term forecast for inflation — something of a Holy Grail quest for economists. It heralds deflationary times in the future.

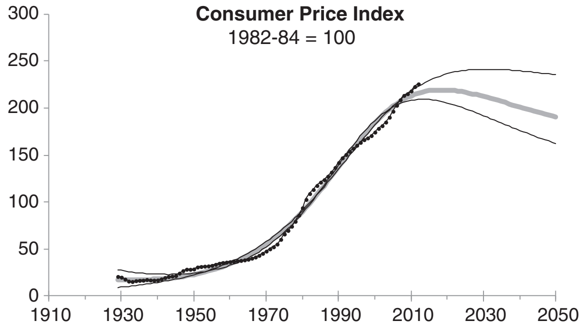


Fig. 4. The black dots are the actual numbers for the consumer price index (1982–84 = 100). The thick gray line indicating the inflation trend is not a fit to the data. It is calculated from the logistic curves in Figs. 1 and 2. The thin black lines delimit an uncertainty range resulting from the bands defined by the thin black lines in Figs. 1 and 2.

4. GDP growth in other parts of the world

It is of interest to also examine the long-term prospects of GDP growth from a logistic point of view in other parts of the world. Fig. 5 shows that the nominal GDP per capita in Japan has completed its logistic curve twenty years ago! No uncertainties around this logistic fit. The fit parameters are given in Table 2.

There has been no growth in Japan for twenty years and the traditional forecast from IMF for years 2013–2017 – shown here with the open circles – does not contradict our logistic description unless its rising trend continues well beyond 2017.

However in developing countries the story is different. Figs. 6 and 7 show the nominal GDP per capita and logistic fits for China and India respectively. The data come from EconStats [12]. Both growth processes are in the very early stages of logistic growth, a region where it is difficult to

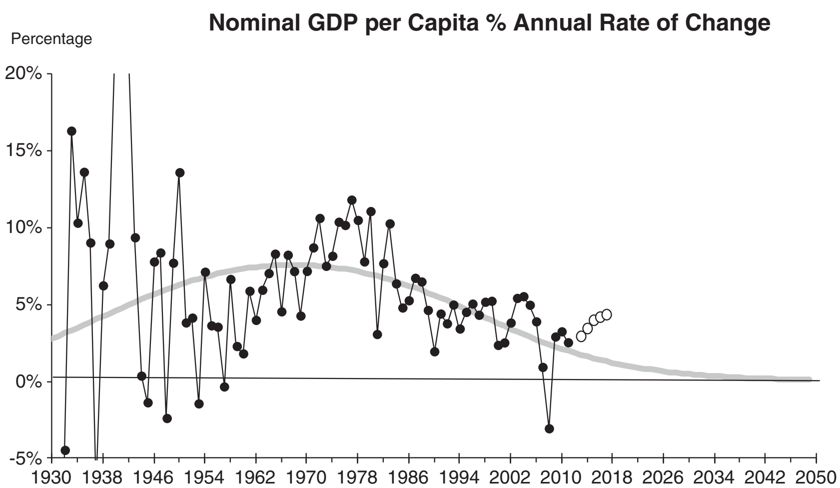


Fig. 3. Annual percent rate of growth of nominal GDP per capita (black dots) and of the logistic fit (thick gray line). The open circles are IMF forecasts.

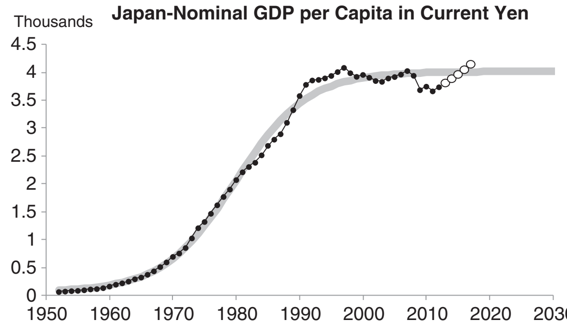


Fig. 5. Japanese nominal GDP per capita (black dots), IMF forecast (open circles) and logistic fit (thick gray line).

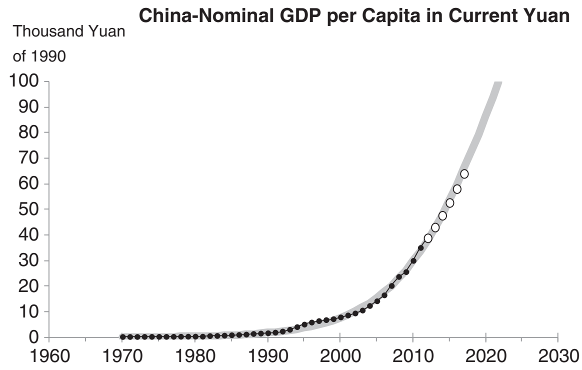


Fig. 6. Chinese nominal GDP per capita (black dots), IMF forecast (open circles) and logistic fit (thick gray line).

distinguish a logistic pattern from a simple exponential pattern. It is not realistic to try and establish uncertainties for the ceilings of the logistics in Figs. 6 and 7 because the patterns are still exponential for all practical purposes. Instead we can try to establish upper and lower limits for the ceilings of eventual logistics. The table in the Appendix A sets a lower limit as a factor of 5 on today's levels. Infant mortality and common sense can help us establish an upper limit. Infant mortality is usually taken between 5% and 10% of the final ceiling. A tree or a sunflower seedling of height less than 5% of its final size is vulnerable to herbivores or simply to be stepped on by a bigger animal. Assuming China's and India's natural-growth curves have advanced to at least beyond infant-mortality levels, their remaining growth potential should be at most about 10 times today's GDP levels.

5. Discussion

One cannot assume that a country's economy, its wealth, its prosperity, or the productivity of its people will be growing indefinitely. These are natural-growth processes and will eventually reach ceilings. This article focuses on GDP as a metric for economic growth because it is the most frequently quoted metric and data are readily available worldwide. Analyzing other indexes of national progress, such as GPI (General Progress Indicator), would probably lead to similar conclusions. In Japan the nominal GDP per capita has already reached its ceiling in the early 1990s and the country has had rates of growth around null ever since. In the US the annual GDP increments have already entered diminishing trends for both nominal and real GDP per capita, more evidently for the former; in percentage terms its rate of growth is expected to progressively diminish to 1.1% by 2020 and to 0.5% by 2030, see Fig. 3. All this should happen on the average, of course, as recessions and periods of growth come and go.

Considering that inflation is calculated from two natural-growth curves, it must also have a *natural* course to follow. In fact the CPI is forecasted to shortly enter a gentle downward trend, again on the average.

In view of a logistic analysis, as a niche becomes full the rate of growth progressively drops to zero. This is in general the case with the evolution of GDP in industrialized countries. Barring catastrophes and disasters of unseen magnitude one should not expect renewed growth rates in the industrialized world. In contrast, developing countries like China and India, where the logistic-growth process is still in its very early stages, should be expected to experience accelerating growth for decades.

A logistic description may not be appropriate for the evolution of GDP in some situations. For example, one could have thought that undergoing such major "mutations" as Germany's reunification in 1991 and the European monetary union in 1992 would invalidate a logistic description for the evolution of GDP in the countries involved. But apparently these mutations were not important enough. Most EU countries – including Germany – show only a minor glitch on the evolution of their GDP pattern around 1992; others like Belgium show no deviation whatsoever. Even Germany's reunification shows up as a minor deviation. In contrast, World War II breaks up the evolution of Germany's real-GDP-per-capita curve in order to place the country on an entirely different logistic curve after the war, see Fig. 8.

Table 2
Results for the logistic fit on nominal GDP in Japan.

M	α	t_o	*C*	Mean abs. deviation
3.947866	0.1753931	1979.87	0.0665637	5.8%

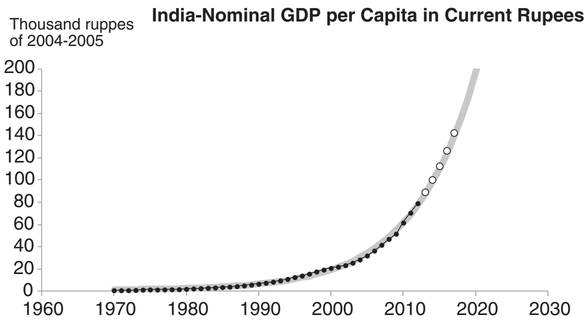


Fig. 7. Indian nominal GDP per capita (black dots), IMF forecast (open circles) and logistic fit (thick gray line).

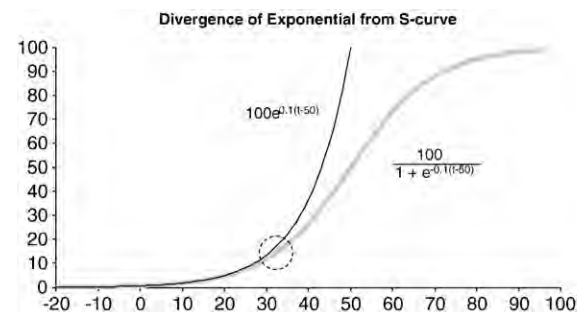
Fig. 8. German real GDP per capita (black dots) and logistic fits (thick gray lines). Data source: Agnus Maddison [11].

Most countries in the European Union are experiencing a saturation – i.e. they are approaching the ceiling of a logistic – comparable to that of the US and Japan and this could be one explanation of the West's lingering economic malaise. For these countries to find themselves back on steeply rising growth patterns a very fundamental change must take place. Probably nothing lesser than the acquisition of new territory or the complete revamping of their economy the way it happened in the US with the crash of 1929 would do the job. After all, as we can see in Fig. 1, events as important as World War II, which had such a profound effect on the evolution of Germany's GDP, produced only an insignificant glitch on the smooth evolution of America's GDP.

Appendix A. Distinguishing a logistic from an exponential

A logistic curve is indistinguishable from a simple exponential pattern in its very early stages. There has been controversy about the timing when a logistic curve unambiguously distinguishes itself from a simple exponential pattern [13]. In this appendix there is a quantification of this phenomenon.

Let us try to see at what time the S-curve deviates from the exponential pattern in a significant way, see Appendix Fig. 1. Appendix Table 1 quantifies the deviation between a logistic and the corresponding exponential pattern as a fraction of the Logistic's penetration level. By "corresponding" exponential I mean the limit of Eq. (1) as $t \to -\infty$ (with $C = 0$).



Appendix Fig. 1. The construction of a theoretical S-curve (gray line) and the exponential (thin black line) it reduces to as time goes backward. The big dotted circle points out the time when the deviation becomes important. The formulae used are shown in the graph.

Appendix Table 1
The deviation between exponential and logistic patterns as a function of how much the logistic has proceeded to completion.

Deviation	Penetration
11.1%	10.0%
12.2%	10.9%
13.5%	11.9%
15.0%	13.0%
16.5%	14.2%
18.3%	15.4%
20.2%	16.8%
22.3%	18.2%
24.7%	19.8%
27.3%	21.4%
30.1%	23.1%
33.3%	25.0%
36.8%	26.9%
40.7%	28.9%
44.9%	31.0%
49.7%	33.2%
54.9%	35.4%
60.7%	37.8%
67.0%	40.1%
74.1%	42.6%
81.9%	45.0%
90.5%	47.5%
100.0%	50.0%

In Appendix Table 1 we appreciate the size of the deviation between exponential and logistic patterns as a function of how much the logistic has proceeded to completion. Obviously beyond a certain point the difference becomes flagrant. When exactly this happens maybe subject to judgment so Appendix Table 1 is there to quantitatively help readers make up their mind. Most readers will agree that a 25% deviation between exponential and S-curve patterns is significant because it makes it clear that the two processes can no longer be confused. This happens when the logistic that corresponds to the exponential has reached about 20% of its ceiling level. In other words, the future ceiling that caps a growth process that just begins deviating from an exponential pattern in an unambiguous way is about 5 times this level.

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Review of Income and Wealth
Series 71, Number 1, February 2025; e12690
DOI: 10.1111/roiw.12690

THE PRODUCTIVITY SLOWDOWN IN ADVANCED ECONOMIES: COMMON SHOCKS OR COMMON TRENDS?

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INSEAD

This paper reviews advanced-economy productivity developments in recent decades. We focus primarily on the facts about, and explanations for, the mid-2000s labor-productivity slowdown in large European countries and the United States. Slower total factor productivity (TFP) growth was the proximate cause of the slowdown. This conclusion is robust to measurement challenges including the role of intangible assets, rankings of productivity levels, and data revisions. We contrast two main narratives for the stagnating TFP frontier: The shock of the Global Financial Crisis; and a common slowdown in TFP trends. Distinguishing these two empirically is hard, but the pre-recession timing of the U.S. slowdown suggests an important role for the common-trend explanation. We also discuss the unusual pattern of labor productivity growth since the start of the Covid-19 pandemic. Although it is early, there is little evidence so far that the large pandemic shock has changed the slow pre-pandemic trajectory of labor-productivity growth.

JEL Codes: D24, E23, E44, F45, O47

Keywords: convergence, great recession, productivity growth

1. INTRODUCTION

Why has productivity growth been so slow across advanced economies since the mid-2000s? We attribute the proximate cause of the growth slowdown to a mid-2000s slowdown in total factor productivity (TFP) growth. We discuss some

Prepared for the 2022 Ruggles Lecture at the International Association for Research in Income and Wealth conference in Luxembourg. A package with data and code to replicate the tables and figures in this paper, can be downloaded from https://doi.org/10.34894/RCIQ6B. We thank Antonio Fatas, Bart van Ark, conference participants, and several anonymous referees for helpful comments. We also thank Stephanie Stewart for excellent research assistance. The views in this paper are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of San Francisco or anyone else associated with the Federal Reserve System.
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key uncertainties regarding measurement, which point to priorities for data collection and release. We contrast two competing narratives for the slowdown. One is the common shock of the Great Recession, which hit all major advanced economies after 2007; the other is a common slowdown in trend, plausibly linked to a reduced contribution from information and communications technology (ICT). We find that the timing supports the common-trend slowdown, largely independent of the Great Recession. Finally, we discuss the pandemic experience. Although it is early, there is little evidence so far that the large pandemic shock has changed the slow pre-pandemic trajectory for productivity growth.

Figure 1 shows the data that motivate this paper. The figure shows the level of market-economy labor productivity for selected economies (normalized to one in 1985). After rising essentially in parallel prior to 1995, the U.S. pulled ahead, and Spain and Italy slowed dramatically. Since the mid-2000s, productivity growth in all major economies has been slow.

This slow-productivity growth trajectory is a crucial macroeconomic issue. It contributes to slow growth in GDP overall and in average incomes. It raises budget challenges for governments. Pre-pandemic, it was an important contributor to the widespread sense of economic stagnation.

In Section 2, we find that the slowdown after 2007 reflects a slowdown in TFP growth. This conclusion is based on growth accounting, in which the contribution of TFP is in labor-augmenting terms and the contribution of capital-deepening is in terms of the capital-output ratio; we prefer this accounting to the "standard" Solow (1957) accounting because it better accounts for the endogeneity of capital. The standard accounting, in the Solow (1956) model or other neoclassical growth models, attributes some of the contribution of TFP growth to the endogenous response of capital accumulation. Hence, we focus most of our subsequent analysis and discussion of the productivity slowdown on TFP growth.

Indeed, over time, TFP is the most important factor explaining patterns in labor productivity. Capital deepening (in terms of the capital-output ratio) sometimes makes a difference—helping explain, for example, why France and

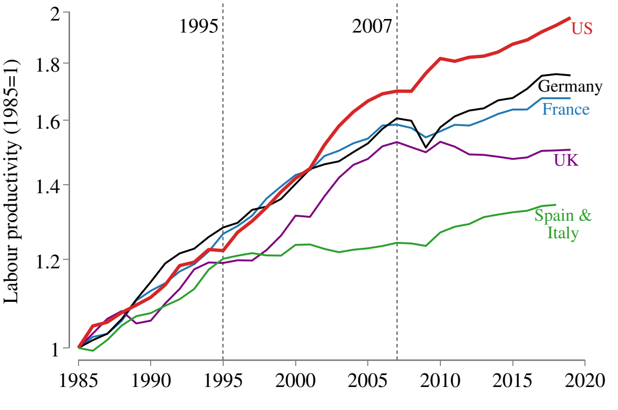

Figure 1. Market economy labor productivity in selected major economies.
Notes: Market economy value added per hour. *Sources*: EU KLEMS (2012, 2021), ONS, and BEA-BLS. Spain & Italy is an unweighted average.

Germany saw slower labor productivity growth in the 1995–2007 period than in the preceding years, despite—in contrast to much of the literature—an apparent *pickup* in TFP growth. Capital deepening also matters for understanding relative labor-productivity levels. But with our preferred growth accounting, capital deepening does not contribute to the post-2007 slowdown in labor productivity growth.

In Section 3, we delve into some challenges in terms of data measurement and data inconsistencies. These data issues potentially affect interpretation and policymaking; they highlight the importance of having long, consistent, high-quality datasets. Some of the facts we identify appear more robust and reliable than others.

For example, was the mid-1990s pickup in TFP growth widely shared across countries? Our baseline estimates suggest that it was. But the current vintage of EU KLEMS data goes back only to 1995 and UK industry data have a major methodological break in 1998. Hence, conclusions for countries outside the U.S. (which has long, consistent time series data) requires comparing the pre-96 period and the post-95 period using data constructed with different methodologies. More broadly, different vintages of EU KLEMS give different answers regarding the 1995–2007 period.

Another example of a data challenge involves levels accounting. Such TFP levels require that output and inputs be adjusted for purchasing power parity (PPP). And, since we focus on the market economy, the adjustments need to be done at the industry level (including for intermediate inputs). Unfortunately, inconsistencies in the PPPs and price indices over time mean that the choice of base year for a constant PPP series substantial affect the results.

These data uncertainties mean it is challenging to have complete confidence in the answers to key questions for policymakers who seek to improve productivity performance. Appropriate policies require a view on questions such as, how do your growth rates compare with those in other countries? How far is your country from the overall frontier? And which sectors are leaders, and which are laggards? Reducing the uncertainties requires much more focus on collecting and publishing high-quality data within and across countries. There is a need for consistent long-term data series, as well as for quality control for tracking changes between vintages of data.

Still, though data uncertainty clouds some facts, the slowdown in TFP growth since the mid-2000s does appear robust. And it appears relatively robust that the U.S. was the overall market-economy leader in terms of TFP levels (though not necessarily in all sectors). So in Section 4, we compare two competing narratives about the mid-2000s TFP slowdown.

One view is that the Great Recession was a large common shock that hit everyone, more or less contemporaneously, and which knocked productivity growth off course. The Great Recession started at the end of 2007 as a modest U.S. recession; but it intensified and spread after Lehman's failure in September 2008. Financial constraints or other factors might have then led firms to invest less in R&D and other innovation spending.

However, as we discuss, the evidence from deep recessions or from banking/financial crises is mixed in terms of whether they persistently harm the level or growth rate of productivity; the evidence is stronger that deep recessions persistently harm labor markets. Still, the biggest challenge to the Great Recession-shock narrative is that the U.S. slowdown predated the Great Recession. So in our view, although we cannot rule out that the Great Recession might have played a role in some countries, it did not appear to play a primary role.

The second explanation, which is where we put most of the weight, is that the slowdown reflected a common slowdown in trend TFP growth that started in the mid-2000s. This slowdown followed the (in current data vintages) widely shared mid-1990s pickup in TFP growth. One interpretation consistent with the data and the literature is that information and communications technology (ICT) was a general-purpose technology (GPT) that boosted growth for a time—ex ante, one didn't know how long the growth-boost would last (Basu et al., 2004), but it came to an end in the mid-2000s (Fernald, 2015). The backdrop to this GPT boost was that ideas were getting harder to find (Bloom et al., 2023; Bloom et al., 2020). Indeed, the ICT boost may have sown the seeds of its own demise (Aghion et al., 2023; De Ridder, 2024) by, eventually, reducing incentives to innovate.

If frontier growth slowed, how does this transmit across countries? The slowing-trend narrative should apply broadly to countries close to the frontier. Ideas, after all, flow across borders. The growth-theory logic of conditional convergence implies that, though countries may have different steady-state levels of output per hour—where differences depend on structural aspects of the economy such as government policies (e.g., labor and product-market institutions), rule of law, education, population growth, and so forth—steady-state growth rates should roughly equal the growth rate of the frontier.[1] Hence, a slowdown in frontier growth naturally implies that other countries with the same steady-state growth rates should see a similar slowdown. As we discuss in Section 4, if the U.S. slowed several years before the Great Recession (as the time series evidence suggests), then the European slowdown might have been visible only with a lag. Thus, the two narratives both have similar implications for the timing of the European slowdown.

Finally, in Section 5, we discuss the pandemic period. COVID-19 was another big shock. Labor productivity growth in the U.S., EU, and UK all initially rose strongly in 2020. But by mid-2022, as cyclical influences on labor productivity unwound, the level of productivity seemed broadly consistent with its slow pre-pandemic trend.

Our analysis builds on our earlier work, including Fernald (2015), Cette et al. (2016), Fernald et al. (2017), Fernald et al. (2020) and Fernald and Inklaar (2022). Chadha and Samiri (2022) and Goldin et al. (2024) provide recent surveys with broader references to the literature.

[1] For our purposes, so-called club convergence has the same implications. Conditional convergence implies that countries with the same structural features will have the same steady-state level and growth rates. Club convergence implies that countries with the same structural features, *and* the same initial level of GDP per capita, will have the same steady-state level and growth rates (Galor, 1996). Most of the empirical growth literature is in terms of per capita quantities; but the mechanisms should apply to TFP and labor productivity.

TFP initially fell sharply, consistent with its typical recession pattern. But the economic recovery was rapid, and so was the rebound in TFP. In fact, TFP rose substantially above its pre-pandemic trend through 2021. But the spike in TFP has since reversed, and by the third quarter of 2022 it was back roughly to its pre-pandemic trend.

How do we make sense of these TFP movements? Fernald and Li (2022) argue that there were substantial movements in factor utilization. A decline in utilization during the worst of the pandemic (in the second quarter of 2022) quickly reversed. When the economy rebounded, firms reported difficulty filling positions; qualitatively, workers reported putting in exceptional effort as well as longer hours. By 2022, however, stories increasingly emphasized "burnout" and "quiet quitting," suggesting that workers were reducing their exceptional efforts. By mid- to late-2022, the TFP contribution had returned most of the way towards its pre-pandemic trend.[28]

The UK also provides quarterly growth accounting. Figure 9 shows the UK productivity growth decomposition. Qualitatively, the UK experience in the pandemic was somewhat similar to the US case. The countercyclicality of labor composition and capital deepening was even more pronounced in the UK. TFP collapsed during the depths of the pandemic in early 2020 and then bounced back. The TFP contribution doesn't overshoot its pre-pandemic trend the way it does in the U.S. This could reflect the stronger US economic recovery, where GDP reached its 2019Q4 peak in the first quarter of 2021—a time when UK GDP remained more than 10 percent below its pre-pandemic peak. (As of the end of 2022, the UK had still not reached that peak.) Hence, factor utilization plausibly didn't spike as strongly in the UK as the data suggest.

Still, by the end of the sample (end of 2021 for the UK, third quarter of 2022 for the U.S.), the level of TFP in both countries looked roughly consistent with pre-pandemic trends. And so, while it is still early and even the data in hand are subject to revision, our tentative interpretation is that the U.S. and UK data do not so far suggest strong reasons for thinking that even the major shock of the pandemic provided either a sizeable boost or a restraint to the level or growth of TFP.

Hence, as all of the data in this paper make clear, that underlying trend appears slow.

6. DISCUSSION AND IMPLICATIONS FOR THE FUTURE

Across advanced economies, growth in labor productivity and total factor productivity is notably lower than it was 20 to 30 years ago. We compare the two primary narratives for this slowdown. The first emphasizes the common shock of the Great Recession. The second emphasizes a common trend slowdown. The two explanations are not mutually exclusive; we don't know the counterfactual in the absence of the Great Recession. But in our view, the weight of the evidence

[28] The Fernald (2014) dataset includes a model-based utilization adjustment which, while subject to considerable measurement error, is broadly consistent with the qualitative stories.

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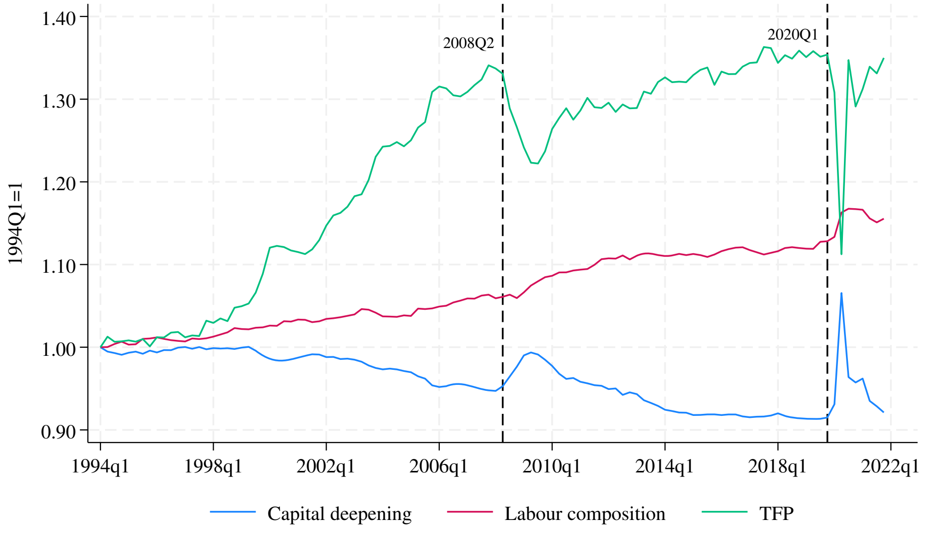


Figure 9. UK growth accounting. Contributions to UK market-economy output per hour (percent change, annual rate).

Notes: Source is UK Office of National Statistics (ONS, 2022). Quarterly data from 1994Q2 through 2021Q4. Capital deepening is the contribution of capital relative to output. Contribution of TFP is in labor-augmenting form (so it is $\Delta lnTFP_t / (1 - \alpha_t)$).

favors the common-trends explanation. We discuss several plausible driving forces, including a continuing decline in research productivity, how ICT technology may lead to increased competition and lower returns from innovation and how intangible assets can serve as an anti-competitive barrier to entry. This list may not be exhaustive; for example, Vollrath (2020) argues for the role of demographics and a shift towards non-material forms of welfare. But that is all the more reason to strive for better understanding of what drives the common trend. Even the large shock of the COVID-19 pandemic does not, so far, appear to have knocked the pre-pandemic trend off course.

Which narrative fits the facts matters for the design of economic policy. If deep downturns such as the Great Recession cause persistent harm to the level or growth rate of productivity, then the policy prescription is to do everything you can to maintain aggregate demand (Cerra et al., 2023). (Of course, even if productivity were only marginally affected, the same advice may be needed to avoid labor-market damage.) If the issue is that the trend growth has slowed for reasons unrelated to the recession, then what is mainly called for is growth policies (e.g., Aghion et al., 2021).

As we note, there are a number of data challenges and uncertainties. It appears robust that a TFP slowdown drove the mid-2000s labor-productivity slowdown. But not all of the apparent facts that we discuss in Section 2 are as clearcut. For example, did France and Germany see a TFP pickup in the mid-1990s akin to what was seen in the U.S. and UK? Current vintages of EU KLEMS suggest they probably did. But the current vintage goes back only to 1995, complicating time series comparisons. This example and others point to the need for considerably more resources to be devoted to developing and maintaining long time series of consistent, high-quality data.

MORNINGSTAR

US Economic Outlook: Q4 2025

The labor market is drifting further away from full employment.

Table of Contents

Morningstar Asset Class Research

Preston Caldwell
Chief US Economist

Forecast Update

Still expecting growth to slow and inflation to increase.

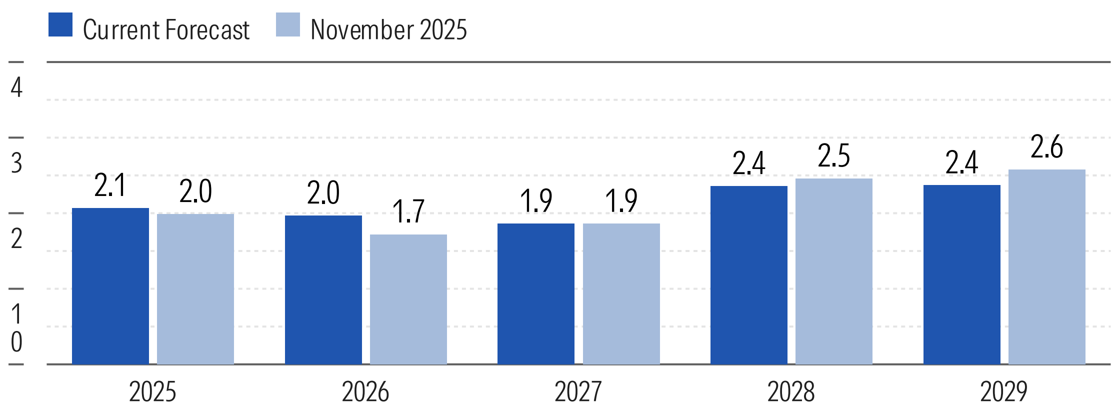
Tariffs Still to Weigh on GDP Growth and Push Up Inflation

We Expect Growth to Trough in 2025-26 but Rebound Thereafter

We've upped our near-term growth figures. Continued momentum around artificial intelligence spending should support investment growth more than originally anticipated in 2026. And the AI uplift to equity prices also supports consumption via the wealth effect.

We expect gross domestic product growth to trough in late 2026 or early 2027, owing to the impact of tariffs, along with a separate downward impulse to consumption growth from more-cautious households. Starting in 2027, we expect growth to improve as the tariff impact fades and the economy responds to monetary loosening.

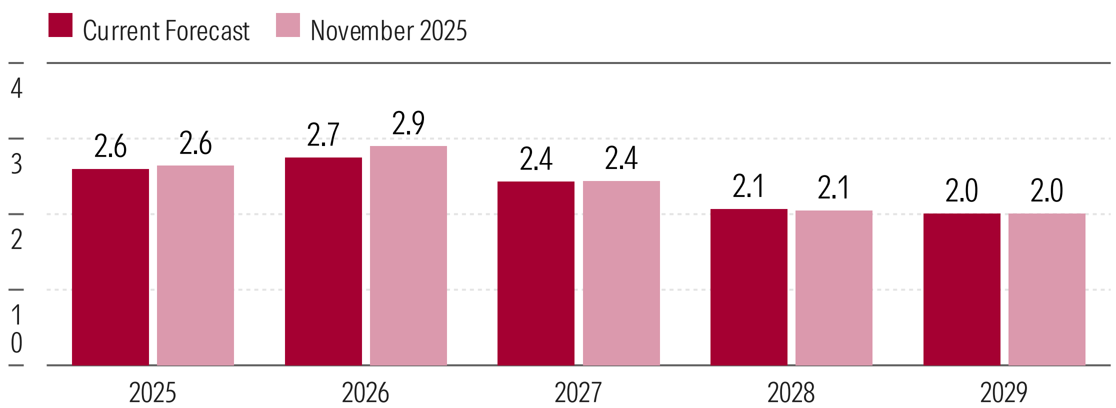
Real GDP Growth (%): Forecast Revisions Annual Averages



Inflation to Rise Again on Tariffs

The US had nearly beaten back inflation, which dropped from 6.6% in 2022 to 2.6% in 2024. But tariffs are breathing new life into inflation. Businesses are not yet done passing tariff costs on to consumers. As such, we expect inflation to peak in 2026. After that, inflation is expected to drop off as the slack created by weak GDP growth generates disinflationary pressure. We have trimmed our inflation expectations slightly, as we expect businesses to retain more of the tariff cost than they did previously. This also reflects the downward inflation surprise in the November 2025 data.

Inflation (%, PCE): Forecast Revisions[1] Annual Averages



[1] Our inflation measure is the Personal Consumption Expenditures Price Index, which has several advantages over the Consumer Price Index and is preferred by the Fed.

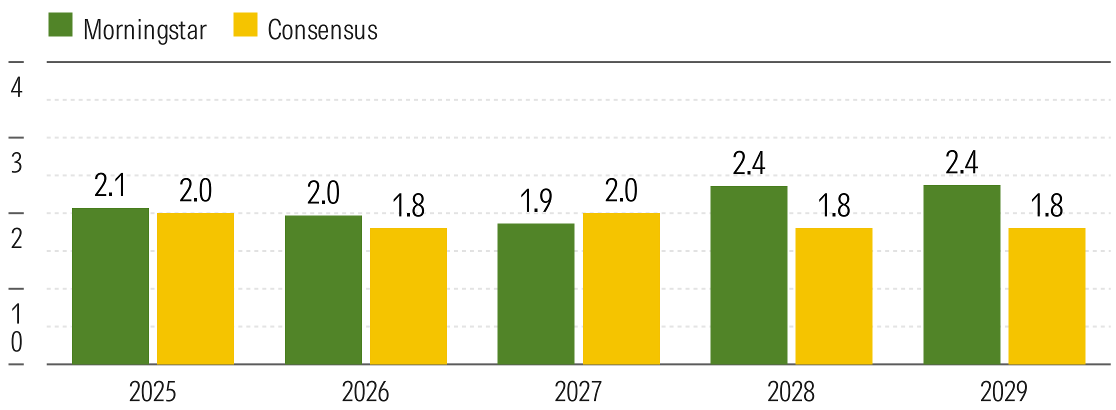
Source: Morningstar.

Our Views on Tariff Economic Impact Align With Consensus

We Remain More Optimistic Than Consensus on Longer-Run Growth

Our GDP growth forecasts are fairly close to consensus in the near term. As had been the case before tariffs, we're a little more upbeat on longer-run growth than consensus—we expect about a cumulative 1.4 percentage points more real GDP growth through 2029. This is mainly because of our optimism about labor supply growth, including labor force participation rates, where we expect solid job availability to draw in more people to the workforce.

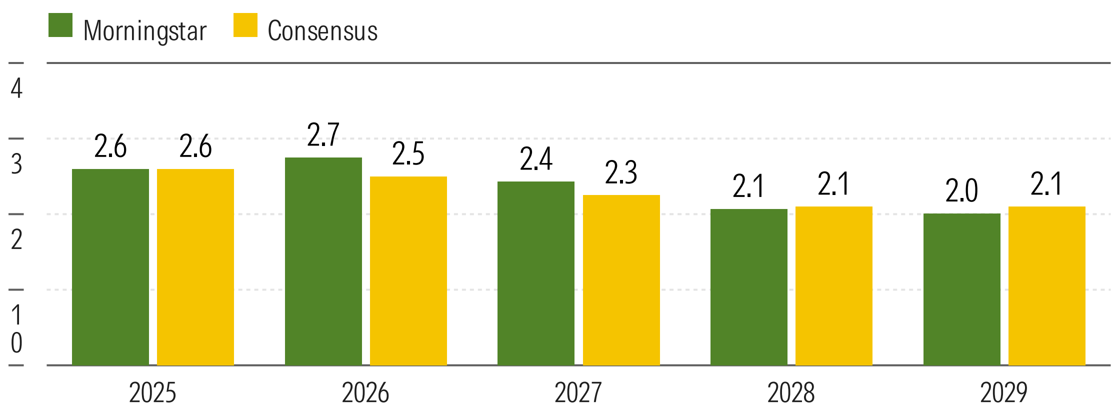
Real GDP Growth (%): Consensus Comparison Annual Averages



We Expect Inflation to Fall a Bit More Than Consensus Does

On inflation, our views track moderately close to consensus, although we expect the inflationary impact of tariffs to be a bit higher, at the peak, in 2026. The cost of tariffs will take time to percolate through the economy, and consensus may be too easily assuaged by inflation data so far, which has come in milder than initially feared.

Inflation (%, PCE): Consensus Comparison Annual Averages



Source: Survey of Professional Forecasters, Morningstar.

Our Supply Side Views Drive Our Longer-Run GDP Forecast

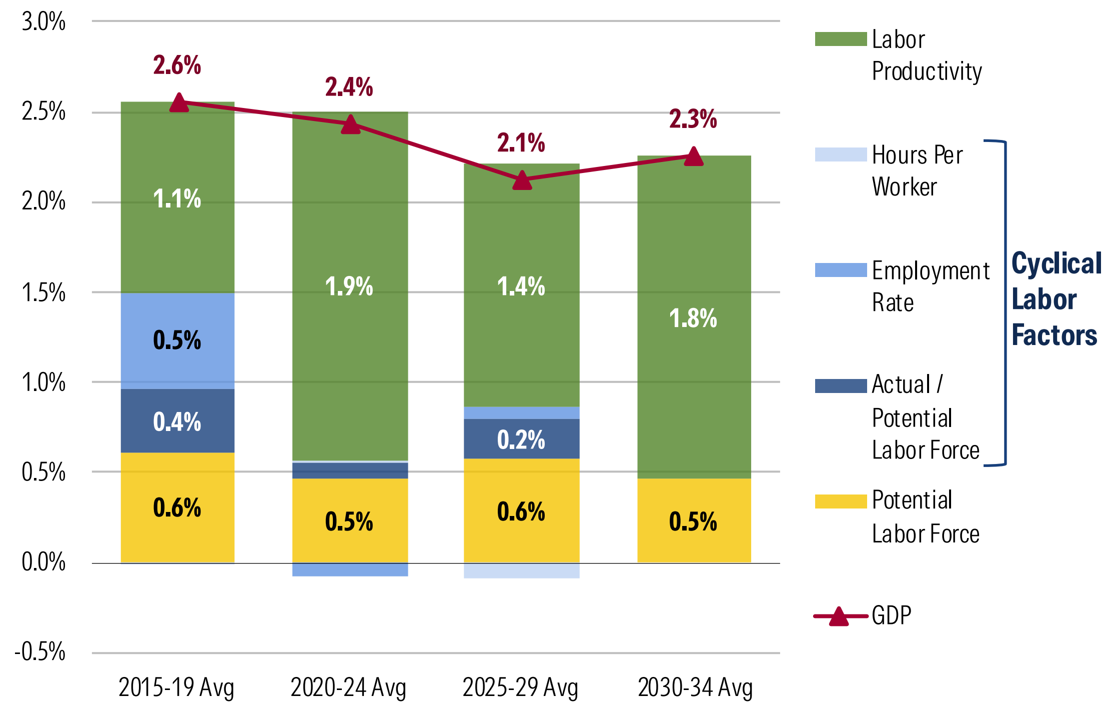
We Expect More Labor Force Expansion Than Consensus

Our longer-run GDP forecast (five-plus years) is determined solely by our projections for the supply side of the economy, as we expect the Federal Reserve to calibrate aggregate demand so that the economy is operating at full capacity. GDP growth in the prepandemic years was fueled heavily by cyclical labor market expansion (the long recovery from the Great Recession). Therefore, we can't take for granted that prepandemic growth rates represent a good benchmark for long-term growth.

We expect labor force participation (adjusted for demographics) to recover ahead of prepandemic rates as solid job availability pulls in formerly discouraged workers. The influx of immigration over 2023-24 has also yet to be fully integrated into the workforce.

Since the start of the pandemic, productivity growth has averaged about 1.9%. We expect about 1.4% growth over 2024-29, with a negative 0.1%-0.2% annual impact from tariff hikes. Productivity growth should accelerate over 2030-34 as the tariff impact fades and AI starts to play out in the broader economy.

US-Weighted Average Tariff Rate, %



Real GDP = Potential Labor Force x $\frac{\text{Actual LFP}}{\text{Potential LFP}}$ x $\frac{\text{Employees}}{\text{Labor Force}}$ x $\frac{\text{Hours}}{\text{Worker}}$ x $\frac{\text{Output}}{\text{Hours Worked}}$

(1 - unemployment rate) ↑ Labor Force

"labor productivity" ↑ Hours Worked

Source: Bureau of Economic Analysis, Bureau of Labor Statistics, Morningstar.

Equity Risk Premiums (ERP): Determinants, Estimation, and Implications – The 2026 Edition

Updated: March 5, 2026

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Equity Risk Premiums (ERP): Determinants, Estimation and Implications – The 2026 Edition

The equity risk premium is the price of risk in equity markets, and it is not only a key input in estimating costs of equity and capital in both corporate finance and valuation, but it is also a key metric in assessing the overall market. Given its centrality, it is surprising how haphazard the estimation of equity risk premiums remains in practice. We begin this paper by looking at the economic determinants of equity risk premiums, including investor risk aversion, uncertainty about information and perceptions of macroeconomic risk. In the standard approach to estimating the equity risk premium, historical returns are used, with the difference in annual returns on stocks versus bonds, over a long period, comprising the expected risk premium. We note the limitations of this approach, even in markets with an abundance of data, like the United States, and its complete failure in emerging markets, where the historical data tends to be limited and volatile. We look at two other approaches to estimating equity risk premiums – the survey approach, where investors and managers are asked to assess the risk premium and the implied premium approach, where a forward-looking estimate of the premium is estimated using either current equity prices or risk premiums in other markets. In the next section, we look at the relationship between the equity risk premium and risk premiums in the bond market (default spreads) and in real estate (cap rates) and how that relationship can be mined to generate expected equity risk premiums. We close the paper by examining why different approaches yield different values for the equity risk premium, and how to choose the "right" number to use in analysis.

(This is the seventeenth update of this paper. The first update was during the financial crisis in 2008 and there have been annual updates at the start of each year from 2009 through 2025)

work, Shiller has adapted his widely used CAPE ratio to reflect an implied equity risk premium, by inverting the CAPE and netting out a real riskfree rate from it.[130]

A Generalized Model: Implied Equity Risk Premium

To expand the model to fit more general specifications, we would make the following changes: Instead of looking at the actual dividends paid as the only cash flow to equity, we would consider potential dividends instead of actual dividends. In my earlier work (2002, 2006), the free cash flow to equity (FCFE), i.e, the cash flow left over after taxes, reinvestment needs and debt repayments, was offered as a measure of potential dividends.[131] Over the last decade, for instance, firms have paid out only about half their FCFE as dividends. If this poses too much of an estimation challenge, there is a simpler alternative. Firms that hold back cash build up large cash balances that they use over time to fund stock buybacks. Adding stock buybacks to aggregate dividends paid should give us a better measure of total cash flows to equity. The model can also be expanded to allow for a high growth phase, where aggregate earnings and dividends can grow at rates that are very different (usually higher, but not always) than stable growth values. With these changes, the value of equity can be written as follows:

$$\text{Value of Equity} = \sum_{t=1}^{t=N} \frac{E(FCFE_t)}{(1+k_e)^t} + \frac{E(FCFE_{N+1})}{(k_e - g_N)\,(1+k_e)^N}$$

In this equation, there are N years of high growth, $E(FCFE_t)$ is the expected free cash flow to equity (potential dividend) in year t, k_e is the rate of return expected by equity investors and g_N is the stable growth rate (after year N). We can solve for the rate of return equity investors need, given the expected potential dividends and prices today, as an internal rate of return. Subtracting out the riskfree rate should generate a more realistic equity risk premium.

In a variant of this approach, the implied equity risk premium can be computed from excess return or residual earnings models. In these models, the value of equity today

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130 The CAPE is computed using average earnings over ten years and adjusting these earnings for inflation. To be honest, this modified version seems like a belated and incomplete attempt to fix the CAPE, as a market timing tool.

131 Damodaran, A., 2025, *Investment Valuation*, John Wiley and Sons; Damodaran, A., 2006, *Damodaran on Valuation*, John Wiley and Sons.

can be written as the sum of capital invested in assets in place and the present value of future excess returns:[132]

$$\text{Value of Equity} = \text{Book Equity today} + \sum_{t=1}^{t=\infty} \frac{\text{Net Income}_t - k_e(\text{Book Equity}_{t-1})}{(1+k_e)^t}$$

If we can make estimates of the book equity and net income in future periods, we can then solve for the cost of equity and use that number to back into an implied equity risk premium. Claus and Thomas (2001) use this approach, in conjunction with analyst forecasts of earnings growth, to estimate implied equity risk premiums of about 3% for the market in 2000.[133] Easton (2007) provides a summary of possible limitations of models that attempt to extract costs of equity from accounting data including the unreliability of book value numbers and the use of optimistic estimates of growth from analysts.[134]

Implied Equity Risk Premium in Practice

In this section, we will begin by laying out the process of estimating implied equity risk premiums and then use that approach to compute the current implied equity risk premium for the S&P 500.

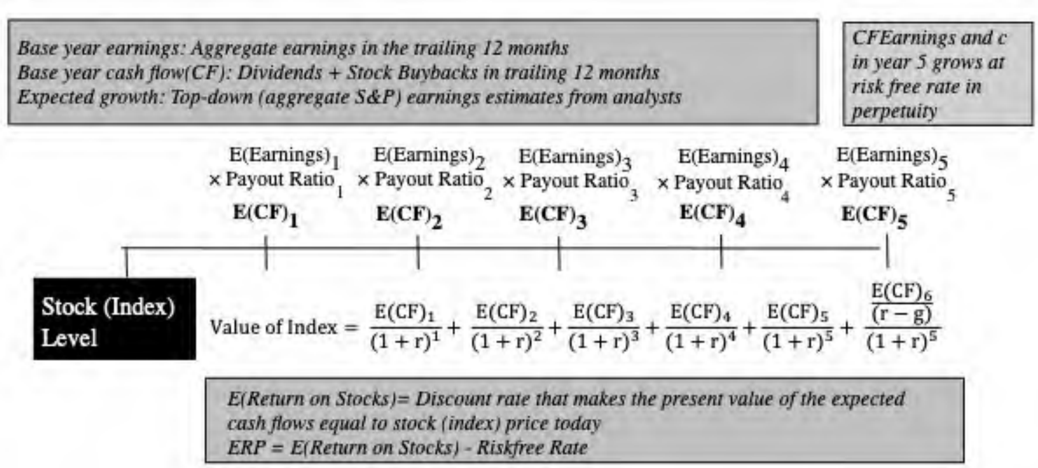
Implied Equity Risk Premiums: An Augmented Dividend Discount Model

The FCFE approach to estimating equity risk premiums, described in the last section, works for firms where free cashflows can be estimated, but can falter when applied to indices, where some of the companies are financial service firms. Consequently, we adopt a variant, albeit an imperfect one, where we assume that sum of dividends and stock buybacks across all stocks in the S&P 500 is roughly equivalent to the free cash flows to equity of the stocks in the index. With that as a starting point, we then use analyst forecasts of future growth to estimate future earnings and cash return (dividends + buybacks), and assume that growth rate will converge over time to the growth rate of the economy in the

[132] For more on excess return models, see Damodaran, A, 2006, *Valuation Approaches and Metrics: A Survey of the Theory and Evidence,* Working Paper, www.damodaran.com.
[133] Claus, J. and J. Thomas, 2001,'*Equity premia as low as three percent? Evidence from analysts' earnings forecasts for domestic and international stock markets*, Journal of Finance 56(5), 1629–1666.
[134] Easton, P., 2007, *Estimating the cost of equity using market prices and accounting data*, Foundations and Trends in Accounting, v2, 241-364.

future (after year 5), with the treasury bond rate operating as a proxy for the nominal growth rate of the economy. Figure 9a illustrates the inputs into this process:

Figure 9a: The Implied Equity Risk Premium Process



Put simply, the implied equity risk premium is an equity market analog for the yield-to-maturity computation for a bond, with the index level replacing the bond, the expected cash flows from dividends and buybacks supplanting coupons and the terminal value of equities (captured in the last term) taking the place of the face value of the bond. As with bonds, if index levels rise (fall) without a corresponding increase (drop) in earnings, the expected return on stocks will decrease (increase).

If the biggest drawbacks with using historical equity risk premiums are that they are backward-looking, static, and noisy, it is worth putting implied equity risk premiums under the lens to see their limitations.

1. Implied ERP is forward-looking: The implied ERP is computed by using expected cash flows in the future, and what investors are paying for those cash flows today, making them forward looking.
2. Implied ERP is dynamic: The implied ERP will change as the index level changes, and in periods of market volatility, the equity risk premium will also be volatile. While that may trouble practitioners who value stability, it reflects the reality of markets, which is that fear and greed are constantly competing for attention.
3. Implied ERP is less noisy: Historical risk premiums are noisy because they are based upon annual returns on stocks, which are highly volatile on a year-to-year basis. It is true that implied equity risk premiums are noisy too, with the noise coming from

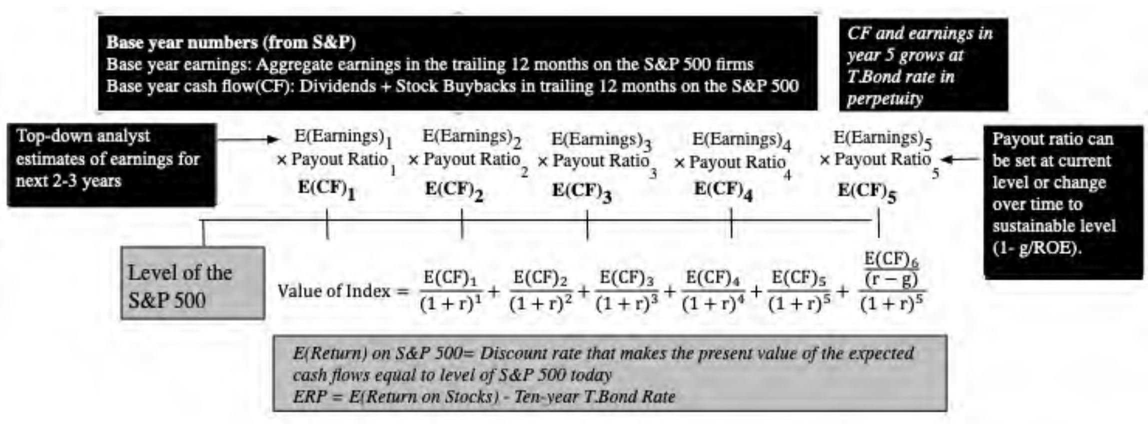
errors in forecasted earnings growth and cash flows, but that error is small, relative to that in historical equity risk premiums.

As a bonus, note that, unlike the historical risk premium, the implied equity risk premium can be computed for markets with little or no history, since all that is required is an index level and expected cash flows.

Implied Equity Risk Premiums for the S&P 500: Estimation Process

We will use the S&P 500 as the base index to both illustrate the implied equity risk premium approach for three reasons. First, unlike most other indices of long standing, which are composed of thirty or forty stocks, the S&P 500 is composed of not just 500 companies, but the 500 largest companies in the US, in terms of market capitalization. Second, the S&P 500 index is the most-widely followed index in the world, making it easier to get expected earnings and growth numbers. Third, it is the index that we have been computing the equity risk premium since the early nineties, thus allowing for an assessment of how equity risk premiums have changed over time. Figure 9b summarizes the input choices that we use to compute the implied ERP for the S&P 500:

Figure 9b: Estimation Choices for S&P 500 Implied Equity Risk Premium



The index level and ERP are market numbers, leaving no room for subjectivity, but depending on analyst estimates for expected earnings growth may strike some as imprudent, given evidence that analysts bias growth estimates for individual companies. To counter that, we use estimates of earnings on the S&P 500 from market strategists and analysts who track the market, rather than aggregating company-specific earnings forecasts for individual companies. To back up the proposition that these top-down forecasts of

2. Survey premiums reflect historical data more than expectations. When stocks are going up, investors tend to become more optimistic about future returns and survey premiums reflect this optimism. In fact, the evidence that human beings overweight recent history (when making judgments) and overreact to information can lead to survey premiums overshooting historical premiums in both good and bad times. In good times, survey premiums are even higher than historical premiums, which, in turn, are higher than implied premiums; in bad times, the reverse occurs.
3. When the fundamentals of a market change, either because the economy becomes more volatile, or investors get more risk averse, historical risk premiums will not change but implied premiums will. Shocks to the market are likely to cause the two numbers to deviate. After the attack on the World Trade Center in September 2001, for instance, implied equity risk premiums jumped almost 0.50% but historical premiums were unchanged (at least until the next update).

In summary, we should not be surprised to see large differences in equity risk premiums as we move from one approach to another, and even within an approach, as we change estimation parameters.

Which approach is the "best" approach?

If the approaches yield different numbers for the equity risk premium, and we have to choose one of these numbers, how do we decide which one is the "best" estimate? The answer to this question will depend upon several factors:

a. Predictive Power: In corporate finance and valuation, what we ultimately care about is the equity risk premium for the future. Consequently, the approach that has the best predictive power, i.e., it yields forecasts of the risk premium that are closer to realized premiums, should be given more weight. So, which of the approaches does best on this count? Campbell and Shiller (1988) suggested that the dividend yield, a simplistic measure of the implied equity risk premium, had significant predictive power for future returns.[157] However, Goyal and Welch (2007) examined many of the measures suggested as predictors of the equity risk premium in the literature, including the

[157] Campbell, J. Y. and R. J. Shiller. 1988, *The Dividend-Price Ratio And Expectations Of Future Dividends And Discount Factors*, Review of Financial Studies, v1(3), 195-228.

dividend yield and the earnings to price ratio, and find them all wanting.[158] Using data from 1926 to 2005, they conclude that while the measures do reasonably well in sample, they perform poorly out of sample, suggesting that the relationships in the literature are either spurious or unstable. Campbell and Thompson (2008) disagree, noting that putting simple restrictions on the predictive regressions improve out of sample performance for many predictive variables.[159] Jagannathan and Liu (2019) also dissent, noting that using a latent model for dividends not only helps forecast future dividend growth, but that the learning from dividend dynamics can help predict future stock returns.[160]

To answer this question, we looked at the actual excess returns[161] earned by stocks over bonds from 1960 to 2025 and considered six predictors of this premium – the dividend yield, the earnings yield, the historical risk premium through the end of the prior year, the implied equity risk premium at the end of the prior year, the average implied equity risk premium over the previous five years and the premium implied by the Baa default spread. Since the survey data does not go back very far, we could not test the efficacy of the survey premium. Our results are summarized in table 28:

Table 28: Predictive Power of different estimates- 1960 – 2025

Predictor	*Correlation with actual excess return next year*	*Correlation with actual excess return- next 5 years*	*Correlation with actual excess return – next 10 years*
Earnings Yield	0.135	-0.086	-0.008
Dividend Yield	0.148	-0.094	-0.118
Current implied premium	0.052	0.403**	0.489**
Average implied premium: Last 5 years	0.135	0.334**	0.405**
Historical Premium	-0.107	-0.366**	-0.461**

158 Goyal, A. and I. Welch, 2007, *A Comprehensive Look at the Empirical Performance of Equity Premium Prediction,* Review of Financial Studies, v21, 1455-1508.
159 Campbell, J.Y., and S.B. Thompson, 2008, *Predictive Excess Stock Returns Out of Sample: Can Anything Beat the Historical Average?* Review of Financial Studies, v21, 150-9-1531.
160 Jagannathan, R. and B. Liu, 2019, *Dividend Dynamics, Learning and Expected Stock Returns*, Journal of Finance v74, pg 401-448.
161 WE computed the average return on stocks in the following five (ten) years and netted out the average return earned on T.Bonds over the following five (ten) years.

Default Spread based premium	0.275**	0.005	0.038

** Significant at 5% level

Over this period, the only approach that provided any predictive value for actual risk premium in the next period was the default spread based approach. If we extend our analysis to make forecasts of the actual return premium earned by stocks over bonds for the next five or ten years, the current implied premium is the best predictor, followed by the average implied equity risk premium and historical risk premiums perform the worst; in fact, they operate as good contra indicators, with a high historical risk premium forecasting lowered actual returns in the future. If predictive power were the only test, historical premiums clearly fail the test.

b. Beliefs about markets: Implicit in the use of each approach are assumptions about market efficiency or lack thereof. If you believe that markets are efficient in the aggregate, or at least that you cannot forecast the direction of overall market movements, the current implied equity premium is the most logical choice, since it is estimated from the current level of the index. If you believe that markets, in the aggregate, can be significantly overvalued or undervalued, the historical risk premium or the average implied equity risk premium over long periods becomes a better choice. If you have absolutely no faith in markets, survey premiums will be the choice.

c. Purpose of the analysis: Notwithstanding your beliefs about market efficiency, the task for which you are using equity risk premiums may determine the right risk premium to use. In acquisition valuations and equity research, for instance, you are asked to assess the value of an individual company and not take a view on the level of the overall market. This will require you to use the current implied equity risk premium, since using any other number will bring your market views into the valuation. To see why, assume that the current implied premium is 4% and you decide to use a historical premium of 6% in your company valuation. Odds are that you will find the company to be overvalued, but a big reason for your conclusion is that you started off with the assumption that the market itself is over valued by about 25-30%.[162] To make yourself

[162] If the current implied premium is 4%, using a 6% premium on the market will reduce the value of the index by about 25-30%.

market neutral, you will have to stick with the current implied premium. In corporate finance, where the equity risk premium is used to come up with a cost of capital, which in turn determines the long-term investments of the company, it may be more prudent to build in a long-term average (historical or implied) premium.

In conclusion, there is no one approach to estimating equity risk premiums that will work for all analyses. If predictive power is critical or if market neutrality is a pre-requisite, the current implied equity risk premium is the best choice. For those more skeptical about markets, the choices are broader, with the average implied equity risk premium over a long period having the strongest predictive power. Historical risk premiums are very poor predictors of both short-term movements in implied premiums or long-term returns on stocks.

As a final note, there are papers that report consensus premiums, often estimated by averaging across approaches. I remain skeptical about these estimates since the approaches vary not only in terms of accuracy and predictive power but also in their philosophy. Averaging a historical risk premium with an implied premium may give an analyst a false sense of security but it really makes no sense since they represent different views of the world and push in different directions.

Five myths about equity risk premiums

There are widely held misconceptions about equity risk premiums that we would like to dispel in this section.

1. Estimation services "know" the risk premium: When Ibbotson and Sinquefield put together the first database of historical returns on stocks, bonds and bills in the 1970s, the data that they used was unique and not easily replicable, even for professional money managers. The niche they created, based on proprietary data, has led some to believe that Ibbotson Associates, and data services like them, have the capacity to read the historical data better than the rest of us, and therefore come up with better estimates. Now that the access to data has been democratized, and we face a much more even playing field, there is no reason to believe that any service has an advantage over any other, when it comes to historical premiums. Analysts should no longer be allowed to

hide behind the defense that the equity risk premiums they use come from a reputable service and are thus beyond questioning.

2. There is no right risk premium: The flip side of the "services know it best" argument is that the data is so noisy that no one knows what the right risk premium is, and that any risk premium within a wide range is therefore defensible. As we have noted in this paper, it is indeed possible to arrive at outlandishly high or low premiums, but only if you use estimation approaches that do not hold up to scrutiny. The arithmetic average premium from 2015 to 2025 for stocks over treasury bonds is an equity risk premium estimate, but it is not a good one.
3. The equity risk premium does not change much over time: Equity risk premiums reflect both economic fundamentals and investor risk aversion and they do change over time, sometimes over very short intervals, as evidenced by what happened in the last quarter of 2008. Shocks to the system – a collapse of a large company or sovereign entity or a terrorist attack – can cause premiums to shoot up overnight. A failure to recognize this reality will lead to analyses that lag reality.
4. Using the same premium is more important than using the right premium: Within many investment banks, corporations and consulting firms, the view seems to be that getting all analysts to use the same number as the risk premium is more important than testing to see whether that number makes sense. Thus, if all equity research analysts use 5% as the equity risk premium, the argument is that they are all being consistent. There are two problems with this argument. The first is that using a premium that is too high or low will lead to systematic errors in valuation. For instance, using a 5% risk premium across the board, when the implied premium is 4%, will lead you to find that most stocks are overvalued. The second is that the impact of using too high a premium can vary across stocks, with growth stocks being affected more negatively than mature companies. A portfolio manager who followed the recommendations of these analysts would then be over invested in mature companies and under invested in growth companies.
5. If you adjust the cash flows for risk, there is no need for a risk premium: While statement is technically correct, adjusting cash flows for risk has to go beyond reflecting the likelihood of negative scenarios in the expected cash flow. The risk

adjustment to expected cash flows to make them certainty equivalent cash flows requires us to answer exactly the same questions that we deal with when adjusting discount rates for risk.

Summary

The risk premium is a fundamental and critical component in portfolio management, corporate finance, and valuation. Given its importance, it is surprising that more attention has not been paid in practical terms to estimation issues. In this paper, we began by looking at the determinants of equity risk premiums including macroeconomic volatility, investor risk aversion and behavioral components. We then looked at the three basic approaches used to estimate equity risk premiums – the survey approach, where investors or managers are asked to provide estimates of the equity risk premium for the future, the historical return approach, where the premium is based upon how well equities have done in the past and the implied approach, where we use future cash flows or observed bond default spreads to estimate the current equity risk premium.

The premiums that we estimate can vary widely across approaches, and we considered two questions towards the end of the paper. The first is why the numbers vary across approaches and the second is how to choose the "right" number to use in analysis. For the latter question, we argued that the choice of a premium will depend upon the forecast period, whether you believe markets are efficient and whether you are required to be market neutral in your analysis.

Journal of
Risk and Financial Management

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Time Dependence of CAPM Betas on the Choice of Interval Frequency and Return Timeframes: Is There an Optimum?

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Abstract: AbstractsThe traditional CAPM beta is almost exclusively calculated over a return period that spans a window length of 60-months, at one-month return frequencies. It is one of the most utilized models in the asset management industry to assess systematic risk. Yet there is limited evidence to suggest that these estimation parameters are optimal. Utilizing data between January 2000 and December 2021 for the Russell 1000 index, we test daily, weekly, and monthly beta estimations to calculate tracking errors (TE) for the use of these betas in predicting subsequent performance over daily, weekly, and monthly timeframes. We identify that daily CAPM betas are best for predicting subsequent period daily returns and that weekly CAPM betas are strongly correlated with forward weekly and monthly period returns. Leveraging the significant advances in computing resources and the increasing utilization of high frequency trading strategies, we argue that additional window length and return interval-based CAPM betas should be calculated for estimating the systematic risk embedded in diversified portfolios.

Keywords: CAPM; beta; estimation; intervalling; intervaling; frequency; window-length; timeframes; beta drift; stationarity; tracking error; portfolio beta hedging; multi-asset investing; systematic risk; fintech

JEL Classification: G11; G17; C10; C18; B41

check for updates

Citation: Agrrawal, Pankaj, Faye W. Gilbert, and Jason Harkins. 2022. Time Dependence of CAPM Betas on the Choice of Interval Frequency and Return Timeframes: Is There an Optimum? *Journal of Risk and Financial Management* 15: 520. https://doi.org/10.3390/jrfm15110520

Academic Editors: W. Brent Lindquist and Svetlozar (Zari) Rachev

Received: 12 October 2022
Accepted: 1 November 2022
Published: 7 November 2022

1. Introduction

The assertion that there is a relation between portfolio beta and the market return has been analyzed and debated for decades. The Sharpe-Linter-Black CAPM model (1964) supports this theory and states that the expected return is a positive linear function of beta, the risk free rate and the expected market return, while other researchers question the usefulness of the beta in predicting the expected return. More recently, Lin (2021) tested the consistency of a five-factor process as applied to an intertemporal CAPM model. Fama and French (1992) asserted that there is no systematic relationship between beta and security returns. Some others agree on the relationship but introduce non-linearity in the relationship (Carroll and Wei 1988). Chen et al. (1986) argued in favor of measuring the relationship between security expected returns using several macroeconomic variables. Lakonishok and Shapiro (1986) presented the case that there is empirical evidence that security returns are affected by an unsystematic risk component. Hollstein et al. (2020), in a recent study, find that intra-day high frequency return-based betas explain the size anomaly better than the conditional betas based on daily returns.

With all these differing and evolving views on the validity of the CAPM beta, a practitioner still cannot look beyond the fact that the traditional CAPM beta remains one of the most widely used factors in the capital markets. According to Graham and Harvey (2001) in a survey of industry participants, over seventy percent of respondents always or almost always look at the traditional CAPM beta, especially when it comes to assessing the extent of systematic risk in the portfolio.

The CAPM model, however, does not give any guidance into whether the beta should be measured daily, weekly, monthly, quarterly, or annually (Roman and Terraza 2018). The beta coefficient of a security will vary across different return frequencies. The phenomenon is referred to as the intervalling (or intervaling) effect bias in beta (Hawawini 1980; Fung et al. 1985; Corhay 1992). CAPM modeling also does not indicate the optimal regression window length that should be utilized to estimate betas. With a longer estimation window (greater than, say, 24 or 60 months) there are more observations in the regression; however, going much further back could introduce issues related to a transformed company with a different set of characteristics, even though it remains under the same company name (or CUSIP number as in the CRSP Pricing database 2022); this can happen when a larger company merges with others over time.

The purpose of this study is not to argue the validity of the CAPM model or its linearity, it is rather to answer the question of what is the optimal interval period (of returns) and window-length of estimation that would yield a beta estimate, whose utilization would make the daily, weekly, or monthly estimation and forecast of systematic portfolio risk more robust. The quantitative community in the US asset management industry primarily uses vendor-supplied betas, which are based on a 60-month return calculation (monthly interval frequency combined with a 60-month window-length of estimation period). We think that there is a legacy issue here, borne out of computational and data limitations years ago (Sharpe 1964) when beta first started getting deployed en masse in industrial portfolio evaluation.[1] These considerations do not exist at the time of writing of this research. The impact of in-the-money vested options, warrants or other convertible securities on EPS dilution was first systematically documented by Goldsticker and Agrrawal (1999), subsequently Akono et al. (2019) found that Regulation FD was partially successful at curbing the influence of management incentives on analysts' research when signaling expected underperformance by way of rounding to zero the EPS estimates; nonetheless such EPS volatility then feeds into stock valuation volatility, eventually resulting in unstable betas. As will be shown in the results, stocks with higher volatility are increasingly sensitive to varying frequency and estimation window lengths.

A survey of literature did not turn up any substantial/formalized insights into what is the effect of changing the interval of returns (monthly, weekly, and daily frequency of returns) on the traditional CAPM beta calculation, or the impact of altering the window-length (apart from the traditional 60-month window) on the accuracy/stability of the CAPM beta's prediction of the forward one-day return. In particular, there appears to be no justification to employing a 60-month beta, based on monthly return intervals to indicate/estimate a one-day or one-week portfolio systematic risk. We also think that with the growth of the market-neutral hedge fund industry, the need for daily portfolio rebalancing may necessitate the use of differing interval betas, with a drift towards higher frequency information (Hollstein et al. 2020), and thus shorter intervals.

2. Literature Review

The literature on the impact of 'intervalling' and window length variation on CAPM beta estimation is somewhat intermittent, though deep. Most of the work discusses the effect of different intervals on the return distributions and dispersion of residuals. Hollstein et al. (2020), find that intra-day high frequency return-based betas explain the size anomaly better than the conditional betas based on daily returns. Hawawini (1980), in his seminal paper on the intervalling effect, demonstrated "mathematically that the skewness of securities' returns—the ratio of the third moment to the standard deviation cubed—is sensitive to the length of the differencing interval over which returns are measured." In his paper, he demonstrates that "the higher the moment's order, the more sensitive it is to the length of the differencing interval over which securities' returns are measured." Smith (1978) estimated the "characteristic lines of 200 common stocks (are examined) over the period 1950–1969. With respect to measurement, geometric mean return decreased slightly and predictably with intervalling. The dispersion of return distribuweighted returns. Hence, the sub-portfolio returns in this study are value weighted-based, based on the prior period capitalization. The beta-based fraciles are EW (CRSP via WRDS 2022). The actual portfolio returns for the subsequent period (t + 1) were then compared to the expected returns based on the portfolio betas and actual returns of the market. This was conducted for daily (D), weekly (W) and monthly (M) forecast lengths. Then, new betas were calculated with a window estimation period ending one month later; and new portfolio combinations formed. The interval and window-length combinations that yielded the lowest tracking error would provide the preferred beta estimate for each portfolio combination and forecast length (forward 1 day, 1 week or 1 year).

Since the CAPM is more relevant for portfolios, where unsystematic risk has been diversified away and beta is the only relevant measure of the risk in security, the analysis was conducted on a portfolio level rather than an individual security level. We formed various portfolio combinations from the Russell 1000 universe based on market capitalization, beta, as calculated above, and a combination of market capitalization and beta (Table 1 (A, B, C)).

We use the annualized tracking error of forward-looking portfolio return estimates as our measure of the explanatory power of the various beta coefficients. The annualized tracking error, TE, is derived from the standard deviation of differences between the actual and expected portfolio returns, as demonstrated below:

$$TE = \sqrt{\lambda \sum_{t=1}^{N} (r_{P,t+1} - \beta_P r_{M,t+1})} \tag{5}$$

where:

N = The total number of periods examined (our current sample has 186 periods);
λ = The number of return periods per year (when forecasting daily returns, λ = 252; for weekly returns, λ = 52; and for monthly returns, λ = 12);
β_P = The equal-weighted portfolio beta based on a given interval and estimation window;
$r_{p,t+1}$ = The actual portfolio return for the period immediately following the beta calculations and portfolio formation;
$r_{m,t+1}$ = The actual return of the Market, as proxied by the total return of the Russell 1000, for the period immediately following the beta calculations and portfolio formation.

5. Further Research

To identify and isolate any effect of market directionality on the relationship between interval type, window-length and subsequent period TE, this analysis could be divided into conditional dual periods based on the up and down markets (Pettengill et al. 1995; Cooper 2009).

A. Some preliminary work indicates that, in down markets, it appears that weekly betas accomplish lower TE's than daily betas. It would be interesting to explore this further, though we do think that the increased volatility witnessed during down-markets may have an association with this observation and that the use of daily betas during bear markets may be too unstable for next day forecasting (Alexeev et al. 2016). With r_i and r_{mD} as the excess returns to security i and down market excess returns, respectively, where r_m is the full market excess return, then the downside dual beta (Chong 2022) is:

$$\beta^{-} = \frac{Cov(r_i, r_{mD} | r_{mD} < r_m)}{Var(r_{mD} | r_{mD} < r_m)}$$

The upside dual beta would be of a similar construct but with the inequalities reversed.

B. Given the extensive amount of computational time it took to analyze the time series of returns in their various permutations and combinations, additional work could be undertaken to design an appropriate and efficient scanning mechanism to identify the optimal combinations of interval, window-lengths and the beta-size dimension.

C. The impact of varying intervals and window-lengths on the one-period ahead predictability of systematic risk can alternatively (to the tracking error, TE) be assessed by the Information Coefficient (IC); stable and robust betas will likely result in higher IC's, but the formal assessment could be a future research item (Appendix B).

6. Conclusions

In this paper, we have empirically considered whether the standard 60-month window length for calculating CAPM betas for portfolios is optimal for all trading interval lengths. Considering the condensed output of 540 cells (of portfolios TE's) from this study, over the period 2000 to 2021 (three rectangular matrices of 180 cells), we find that forecast interval lengths matched to daily or weekly return-based betas are more likely to lead to the lowest tracking errors. When considering the plurality of options for all types of market capitalizations (large, mid and small), the weekly return frequency performs best in producing the lowest TE for 1-period forward returns. Large Cap stocks have the highest occurrence of the lowest observed tracking errors, especially for the weekly return series. The 1-year and 2-year window length estimation period yields the most unstable betas, particularly for the daily and monthly return frequencies (they have the lowest occurrence of low TE's). Mid Cap stocks have the lowest tracking errors associated with daily or weekly intervals and estimation window lengths of four and five years. Thus, while there is no optimal combination, the analysis leans towards shorter return intervals (daily or weekly but not monthly) *and* longer estimation periods (four or five years of returns). This combination can be very intense on computing time, but is nothing compared to the scale of crypto mining and blockchain authentication (Lei et al. 2021; Verhoeven et al. 2018). Results indicate that the generally witnessed practice of utilizing monthly interval betas (over a 60-month estimation period) to estimate next day or next week portfolio returns, or to control for portfolio risk in a market-neutral setting, may not be optimal and is likely a vestige of legacy issues that are no longer relevant (in an era of cloud computing, high frequency data, machine readable data and AI). Agrrawal (2009) demonstrated that pricing data for new firms could be programmatically harvested from the web much before they get archived in a machine-readable format from the larger data providers (WRDS 2022).

A non-overlapping series of betas will result in a more robust tracking error estimation resulting from a matching interval frequency with the forecast period, eventually resulting in greater portfolio stability (less churn, less portfolio turnover and fewer expenses, the benefits of which will eventually percolate to the investor). Given the advent of HFT strategies and also high-volume IPOs, many newly floated companies just do not have 60 months of inception-to-date pricing data. As such, a shorter estimation window but higher frequency (e.g., 18 months of weekly return-based betas, instead of 5-year monthly return-based betas), would still meet the Central Limit Theorem caveats and have sufficient return observations to have usable betas for portfolio risk estimation. Stable and robust betas can result in higher IC's (information coefficients) and is demonstrated in the Appendix A. That is also a future research item.

Considering the findings herein, and given how common it is for industry participants to consider CAPM betas for portfolio risk estimation, we think that additional research is needed to understand how the interplay between interval frequency and estimation period length impacts the CAPM betas and the resulting tracking errors for investment portfolios. In the age of Fintech and cloud computing, the market participants do not have to have their portfolio risk calibrated by a metric that has mostly served well, but was derived over fifty years ago (Sharpe 1964; Lintner 1965; Black 1972).

Author Contributions: Conceptualization: P.A.; methodology: P.A.; software, MATLAB code and user written VBA, P.A.; validation, P.A.; formal analysis, P.A., F.W.G. and J.H.; investigation, P.A., F.W.G. and J.H.; resources, P.A., F.W.G. and J.H.; data curation, P.A.; writing—original draft preparation, P.A.; writing—review and editing, P.A., F.W.G. and J.H.; visualization, P.A.; supervision, joint F.W.G., J.H. and P.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding. No APC was applied to the paper.

Data Availability Statement: Pricing data on stocks. Is via the *Wharton Research Data Services*. Available online: https://wrds-www.wharton.upenn.edu/ (accessed on 1 March 2022).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

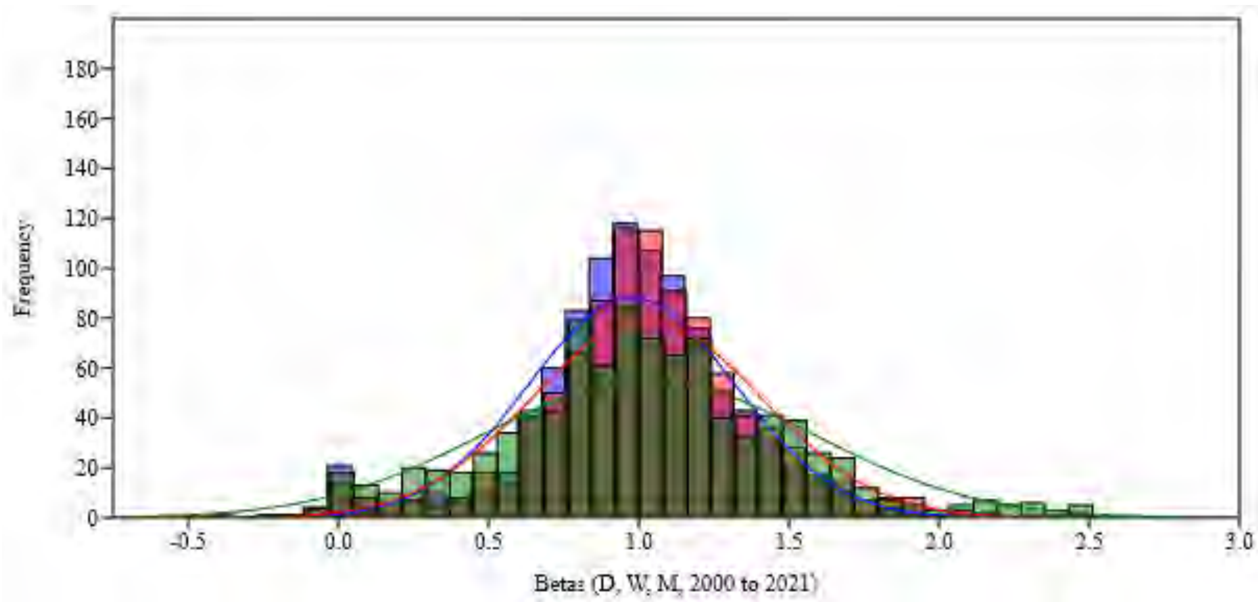

Figure A1. Histograms of betas (daily, weekly and monthly return series, 2000–2021).

The monthly betas have the relatively largest variance (flattest histogram, in green hue), while the daily betas have the lowest variance (blue histogram). A total of 99% of betas are in the [−1, +3] range. Conducting the Jarque-Bera test (Jarque and Bera 1980) for

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This article has benefitted from participant comments at the Rutgers University Center for Research in Regulated Industries Eastern Conference in May 2011. The authors would also acknowledge the Whitcomb Center for Financial Research for funding the data acquisition from the WRDS database.

Public Utility Beta Adjustment and Biased Costs of Capital in Public Utility Rate Proceedings

The Capital Asset Pricing Model (CAPM) is commonly used in public utility rate proceedings to estimate the cost of capital and allowed rate of return. The beta in the CAPM associates risk with estimated return. However, an empirical analysis suggests that the commonly used Blume CAPM beta adjustment is not appropriate for electric and electric and gas public utility betas, and may bias the cost of common equity capital in public utility rate proceedings.

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I. Introduction

Regulators, public utilities, and other financial practitioners of utility rate setting in the United States and other countries often use the Capital Asset Pricing Model (CAPM) to estimate the rate of return on common equity (cost of common equity).[1] Typically, the ordinary least squares method (OLS) is the preferred estimation method for the CAPM betas of public utilities. Although the CAPM model has been widely criticized regarding its validity and predictability in the literature, as summarized by Professors Fama and French in 2005,[2] many firms and practitioners extensively use it to obtain cost of common equity estimates; e.g., such as shown by Bruser et al. in 1998, Graham and Harvey in 2001, and Gray, et al. in 2005.[3] Michelfelder, et al. in 2013[4] in this

 1040-6190/$–see front matter http://dx.doi.org/10.1016/j.tej.2013.09.017

journal presents a new model, i.e., the Predictive Risk Premium Model, to estimate the cost of common equity capital and compare and contrast the poor results of the CAPM to that model and the discounted cash flow model.

Major vendors of betas include, but are not limited to, Merrill Lynch, Value Line Investment Services (Value Line), and Bloomberg. These companies use Blume's 1971 and 1975[5] beta adjustment equation to adjust OLS betas to be used in the estimation of the cost of common equity for public utilities and other companies.

The premise behind the Blume adjustment is that estimated betas exhibit mean reversion toward one over time; that is, betas greater or less than 1 are expected to revert to 1. There are various explanations for the phenomenon first discussed in Blume's pioneering papers. One explanation is that the tendency of betas toward one is a by-product of management's efforts to keep the level of firm's systematic risk close to that of the market. Another explanation relates to the diversification effect of projects undertaken by a firm.[6]

While this may be the case for non-regulated stocks, regulation affects the risk of public utility stocks and therefore the risk reflected in beta may not follow a time path toward one as suggested by Peltzman in 1976, Binder and Norton in 1999, Kolbe and Tye in 1990, Davidson, Rangan, and Rosenstein in 1997, and Nwaeze in 2000.[7] Being natural monopolies in their own geographic areas, public utilities have more influence on the prices of their product (gas and electricity) than other firms. The rate setting process provides public utilities with the opportunity to adjust prices of gas and electricity to recover the rising costs of fuel and other materials used in the transmission and distribution of electricity and gas. Companies operating in competitive markets

The premise behind the Blume adjustment is that estimated betas exhibit mean reversion toward one over time.

do not have this ability. In this respect, the perceived systematic risk associated with the common stock of a public utility may be lower than that of a non-public utility. Therefore, forcing the beta of a utility stock toward one may not be appropriate, at least on a conceptual basis.

The explanations provided by Blume and others to justify the latter tendency are hardly applicable to public utilities. Unlike other companies, utilities can and do possess monopolistic power over the markets for their products. This power impacts the ''negotiation process'' for setting electric and gas prices. Furthermore, it provides them with the opportunity to raise prices to recover increases in operating costs without regard to competitive market pressure. Such price influence is rarely available to companies operating in competitive market environments for their products. In that respect, macroeconomic factors will have a greater impact on the earnings and stock prices of the non-utility companies resulting in larger systematic risk or betas.

The application of Blume's equation to public utility stocks generally results in larger betas, since most raw utility betas are less than 1. Therefore, applications of these betas to estimate the cost of capital and an allowed rate of return on common equity possibly biases the required rate of return or cost of common equity, leading to an over-investment of capital as predicted by Averch and Johnson in 1962,[8] which preceded the trend in prudency reviews that began to occur in the 1980s. Although reported public utility betas may have been biased upward by the vendors of beta that applied Blume's adjustment to public utility betas, ex post prudency reviews of ''used and useful'' assets defined and supported by the Duquesne 1989 US Supreme Court decision[9] resulted in an underinvestment of capital in generation and transmission assets, leading to electric brownouts and blackouts. This article examines the behavior of the betas of the population of publicly traded U.S. energy utilities. In

 1040-6190/$–see front matter http://dx.doi.org/10.1016/j.tej.2013.09.017

addition to evaluating the stability of these betas over the period from the January 1962 to December 2007, we also test whether or not public utility betas are stationary or mean reverting toward 1 or perhaps a different level.

II. Background

Investor-owned public utility regulatory proceedings to change rates for service almost always involve contentious litigation on the fair rate of return or cost of common equity. Since the cost of common equity is not observable, it must be inferred from market valuation models of common equity. The differences in the recommended allowed rates of return resulting from necessary subjective judgments in the application of cost of common equity models can easily mean 500 basis points or more in the estimate. Therefore, both the impact on customer rates for utility service and the profits of the utilities are very sensitive to the methods used to estimate the cost of common equity and allowed rate of return. The two most commonly used models are the Dividend Discount Model (DDM) and the CAPM. We discuss the use of CAPM for estimating the cost of common equity for public utilities. Our focus is on the use of market-influential betas from the major vendors of betas: Merrill Lynch, Value Line, and Bloomberg. These vendors apply Blume's adjustment to raw betas to estimate forward-looking betas. Blume[10] performed an empirical investigation, finding that beta is non-stationary and has a tendency to converge to 1. Bey in 1983 and Gombola and Kahl in 1990[11] found that utility betas are non-stationary and concluded that each utility beta's non-stationarity must be viewed on an individual stock basis, unlike the recommendation of Blume which adjusts all betas for their tendency to approach 1. Similarly with

Investor-owned public utility regulatory proceedings to change rates for service almost always involve contentious litigation on the fair rate of return or cost of common equity.

Gombola and Kahl, we find that public utility betas have a tendency to be less than 1. They investigated the time series properties of public utility betas for their ability to be forecasted whereas we are concerned with the institutional reasons for the trends in beta, the bias instilled in cost of capital estimates assuming that utility betas converge to one and the widespread use and applicability of the Blume adjustment to public utility betas. McDonald, Michelfelder and Theodossiou in 2010[12] show that use of OLS is problematic itself for estimating betas as the nonnormal nature of stock returns result in beta estimates that are statistically inefficient and possibly biased.

Blume's equation is:

$$\beta_{t+1} = 0.343 + 0.677\beta_t \quad (1)$$

where β_{t+1} is the foreasted or projected beta for stock i based on the most recent OLS estimate of firm's beta β_t. For example if β_t is estimated using historical returns from the most recent five years, then the projected β_{t+1} may be viewed as a forecast of the beta to prevail during the next five years. As mentioned earlier, Blume's equation implies a long-run mean reversion of betas toward 1. The long-run tendency of betas implied by Blume's equation can be computed using the equation:

$$\overline{\beta} = \frac{0.343}{1-0.677} = 1.0619 \approx 1 \quad (2)$$

The same result can be obtained by recursively predicting beta until it converges to a final value. This can only be appropriate for stocks with average betas, as a group, close to one. This is, however, hardly the case for public utility betas that are generally less than 1 (as discussed in detail below).

The magnitude of adjustment for Blume's beta equation is initially large and declines dramatically as the adjusted beta approaches 1 either from below (for betas lower than 1) or from above (for betas greater than 1). In this respect, the beta adjustment step (size) will be larger for betas further away from 1.

As we will see in the next section, the median beta of the public utilities studied ranges between 0.08 and 0.74 over time,

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depending upon the period used. Under the assumption that betas for public utilities are consistent with Blume's equation, the next period beta for a stock with a current beta of 0.5, will be $\beta_{t+1} = 0.343 + 0.677\ (0.5) = 0.6815$, implying a 36.3 percent (0.6815/0.5) upward adjustment. On the other hand a beta of 0.4 will be adjusted to $\beta_{t+1} = 0.343 + 0.677\ (0.4) = 0.6138$ which constitutes a 53.5 percent upward adjustment and a beta of 0.3 will be adjusted to 0.5461 or by 82.0 percent.

The beta adjustment method most widely disseminated by the major beta vendors is the Blume adjustment. Therefore, our focus is on the Blume adjustment for public utility betas and the public utility cost of common equity capital. Occasionally, an expert witness in a public utility rate case estimates their own betas, but they are quickly repudiated in rate proceedings since these betas are not disseminated by influential stock analysts and presumed not to be reflected in the stock price. Section III discusses the data and empirical analysis of the Blume adjustment and its impact on the cost of common equity for public utilities.

III. Data and Empirical Analysis

The data include monthly holding period total returns for 57 publicly traded U.S. public utilities for the period from January 1962 to December 2007 obtained from the University of Chicago's Center for Research in Security Prices (CRSP) database. The sample includes all publicly traded electric and electric and gas combination public utilities with SIC codes 4911 and 4931 listed in the CRSP database. All non-U.S. public utilities traded in the U.S. and non-utility stocks were not included in the dataset. The monthly holding period total returns for each stock as calculated in the CRSP database were used for estimating betas of varying periods. The monthly market total return is the CRSP value-weighted total return.

Occasionally, an expert witness in a public utility rate case estimates their own betas, but they are quickly repudiated in rate proceedings.

The computation of the betas is based on the single index model, also used in Blume:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + e_{i,t}, \quad (3)$$

where $R_{i,t}$ and $R_{m,t}$ are total returns for stock i and the market during month t, α_i, and β_i are the intercept and beta for stock i and $e_{i,t}$ is a regression error term for stock i. As previously mentioned, OLS is the typical estimation method used by many vendors of beta and is used in this investigation.

Table 1 presents the mean and median OLS beta estimates for the 57 utilities using 60, 84, 96, and 108 monthly returns respectively over five different non-lapping periods between December 1962 and December 2007. We also performed the same empirical analysis for periods of 4, 6, 10, 11, 12 and 13 years and the results were similar; the results are not shown for brevity but available upon request. We used non-overlapping periods to avoid serial correlation and unit roots. If we take, for example, 360 months of time series of returns for a stock and estimate 60-month rolling betas moving one month forward for each beta, this would result in 300 betas. Since only two of 60 observations would be unique due to overlapping periods, the error term would be highly serially correlated. A Blume-type regression of these betas would have a unit root, a coefficient of one and an intercept near 0, and therefore appear to follow a random walk. Therefore, the empirical nature of beta requires that lags in the Blume equation involve no overlapping time periods.

The mean and median betas in Table 1 not only do not rise toward 1 as the time period moves forward; the betas generally decline. Table 2 includes OLS regressions of the Blume equation for the 5-, 7-, 8-, and 9-year betas. We estimated five sets of 4- through 13-year betas inclusively for each public utility then

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Table 1: Mean and Median Betas for Varying Time Periods.

9-Year Periods	12/62–12/71	12/71–12/80	12/80–12/89	12/89–12/98	12/98–12/07
Mean	0.69	0.60	0.41	0.40	0.27
Median	0.68	0.57	0.40	0.36	0.22

8-Year Periods	12/67–12/75	12/75–12/83	12/83–12/91	12/91–12/99	12/99–12/07
Mean	0.76	0.39	0.45	0.27	0.33
Median	0.74	0.37	0.43	0.23	0.27

7-Year Periods	12/72–12/79	12/79–12/86	12/86–12/93	12/93–12/00	12/00–12/07
Mean	0.68	0.40	0.40	0.09	0.50
Median	0.65	0.39	0.38	0.06	0.47

5-Year Periods	12/77–12/82	12/82–12/87	12/87–12/92	12/92–12/97	12/97–12/02
Mean	0.36	0.38	0.53	0.49	0.12
Median	0.35	0.38	0.50	0.45	0.08

The following model was estimated for the sample of public utility stocks for five 60-, 84-, 96-, and 108-month non-overlapping periods. The ordinary least squares method was used to estimate the parameters of the single index model: $R_{i,t} = \alpha_i + \beta_i R_{m,t} + e_{i,t}$
where $R_{i,t}$ and $R_{m,t}$ are total returns for stock i and the market during month t, α_i, and β_i is the intercept and capital asset pricing model beta for stock i, respectively, and $e_{i,t}$ is a regression error term for stock i. The entire data series ranges from December 1962 to December 2007. The stock returns are the monthly holding period total returns from the CRSP database. The market returns are the CRSP market value-weighted total returns.

regressed the latter beta on the previous period betas. The 5-, 7-, 8-, and 9-year equations are shown for brevity. The diagnostic statistics strongly refute the validity of the Blume equation for public utility stocks. Most of the R^2's are equal to or close to 0.00 and the largest is 0.09. Only one F-statistic (tests the significance of the equation estimation) is significant and all but two slopes are insignificant. Also shown is the long-run beta implied from each Blume model as shown in equation (2). They range from 0.08 to 0.59. Only one estimate, the first-period 9-year Blume equation, includes a positive and statistically significant slope and intercept. The implied long-term beta of that equation is 0.59, which is substantially below one and the largest value of all estimates. As a final and visual review of the trends in betas, we developed and plotted probability distribution box plots developed by Tukey in 1977[13] for the 4- through 13-year public utility betas. We have shown only the 4- and 5-year beta box plots as shown in Figures 1 and 2 for brevity (the 6- to 13-year plots are available upon request). Tukey box plots show the 25th and 75th percentiles (the box height), the 10th and 90th percentiles (the whiskers), the median (the line inside the box), and the dispersion of the outlying betas. The box plots should be viewed as looking down on the distributions of the betas. We developed 4- through 13-year beta box plots to review the trend in shorter-term versus longer-term betas. None of the 51 beta probability distributions display any tendency for betas to drift toward one. The 5-, 6- and 7-year betas have higher variances in the last period relative to all other periods. A few outlying betas are greater than 2.0. This pattern is consistent with the notion that utility holding companies are investing in risky ventures of affiliates that can retain excess returns should they be realized. Note that the mean beta in Figures 1 and 2 show the cyclical nature of short-term utility betas with a severe downturn in the late 1990s and a severe upswing in the early 2000s. Generally, the box plots show a long-term downward trend in public utility betas.

It is interesting to note that the drop in beta occurred just after

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Table 2: Public Utility Blume Equation Estimates.

9-Year Betas	$\beta_2 = f(\beta_1)$	$\beta_3 = f(\beta_2)$	$\beta_4 = f(\beta_3)$	$\beta_5 = f(\beta_4)$
γ_0	0.463***	0.318***	0.480***	0.235***
	(0.074)	(0.062)	(0.096)	(0.080)
γ_1	0.214**	0.153	−0.186	0.800
	(0.102)	(0.099)	(0.227)	(0.179)
Long Run β	0.59	0.38	0.41	0.26
R^2	0.09	0.04	0.01	0.00
F-Statistic	4.43**	2.36	0.67	0.20
p-Value	0.04	0.13	0.42	0.65
8-Year Betas	$\beta_2 = f(\beta_1)$	$\beta_3 = f(\beta_2)$	$\beta_4 = f(\beta_3)$	$\beta_5 = f(\beta_4)$
γ_0	0.341***	0.464***	0.184**	0.321***
	(0.083)	(0.047)	(0.088)	(0.070)
γ_1	0.058	−0.034	0.193	0.035
	(0.106)	(0.115)	(0.189)	(0.220)
Long Run β	0.36	0.45	0.23	0.33
R^2	0.01	0.00	0.02	0.00
F-Statistic	0.30	0.09	1.04	0.02
p-Value	0.58	0.76	0.31	0.88
7-Year Betas	$\beta_2 = f(\beta_1)$	$\beta_3 = f(\beta_2)$	$\beta_4 = f(\beta_3)$	$\beta_5 = f(\beta_4)$
γ_0	0.370***	0.375***	0.074	0.491***
	(0.081)	(0.052)	(0.075)	(0.049)
γ_1	0.048	0.059	0.036	0.128
	(0.115)	(0.122)	(0.179)	(0.259)
Long Run β	0.39	0.40	0.08	0.56
R^2	0.00	0.00	0.00	0.00
F-Statistic	0.17	0.23	0.04	0.24
p-Value	0.68	0.63	0.84	0.62
5-Year Betas	$\beta_2 = f(\beta_1)$	$\beta_3 = f(\beta_2)$	$\beta_4 = f(\beta_3)$	$\beta_5 = f(\beta_4)$
γ_0	0.329***	0.474***	0.321***	0.106*
	(0.047)	(0.086)	(0.088)	(0.061)
γ_1	0.151	0.137	0.316**	0.019
	(0.119)	(0.213)	(0.157)	(0.111)
Long Run β	0.39	0.55	0.47	0.11
R^2	0.03	0.01	0.07	0.00
F-Statistic				
p-Value	1.62	0.41	4.07	0.03
	0.21	0.52	0.05	0.87

The following Blume equation was estimated using the betas of public utility stocks for five 60-, 84-, 96-, and 108-month non-overlapping periods. The ordinary least squares method was used to estimate the parameters of the following model: $\beta_{i,t+1} = \gamma_0 + \gamma_1\beta_{i,t} + \varepsilon_{i,t}$.
where $\beta_{i,t+1}$ is the OLS estimated CAPM beta for stock *i*, $\beta_{i,t}$ is the previous period beta for stock *i*, γ_0 and γ_1 are the intercept and slope of the Blume equation, and ε_t is the regression error term. The time subscripts on the betas refer to the time periods of estimation from Table 1. For example, β_5 in the 9 year panel refers to the beta estimated for each stock using the returns data from December 1998 to December 2007. The long-run $\beta = \gamma_0/(1 - \gamma_1)$; it can also be found by solving recursively for the next period beta until it converges on a final value. Newey-West autocorrelation and heteroskedasticity consistent standard errors are in parentheses.
* Significance at 0.10 level.
** Significance at 0.05 level.
*** Significance at 0.01 level.

deregulation of the wholesale electricity market in April 1996. This is inconsistent with the buffering theory of Peltzman and Binder and Norton[14] who found that regulation buffers the volatility of cash flows of public utilities from the vicissitudes of competition and business cycles and therefore reduces their systematic risk. However, this is consistent with Koble and Tye's 1990[15] theory of asymmetric regulation and the empirical findings of Michelfelder and Theodossiou in 2008,[16] who found that asymmetric regulation is associated with down-market public utility betas greater than their up-market betas. Adverse asymmetric regulation began in the 1980s and resulted in an upper boundary for public utilities' allowed rates of return equal to the cost of capital. If public utilities were granted an opportunity to earn their cost of common equity, regulators frequently would disallow specific investments *ex post* from earning the allowed rate of return if they were deemed ''not used and useful,'' even though they were deemed to be prudent when the decision was made to make these investments. The result was that utilities were not truly granted the opportunity to earn their allowed rate of return. If they happened to over-earn their allowed rate of return due to higher than anticipated demand forecasts, ''excess'' returns were taken away. This became known as regulatory risk, quantified as a risk premium in the cost of

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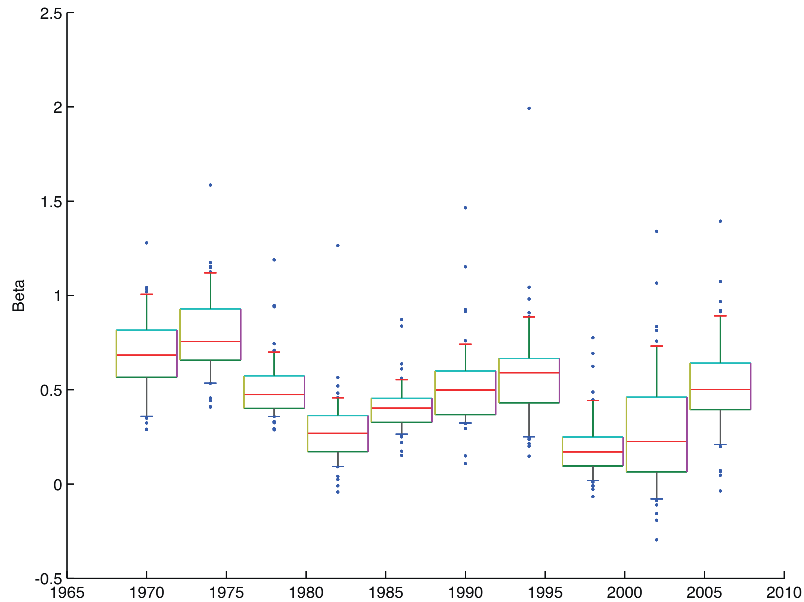


Boxes give the 25th and 75th percentiles; line in the boxes is for the median; whiskers give the 10th and 90th Percentiles

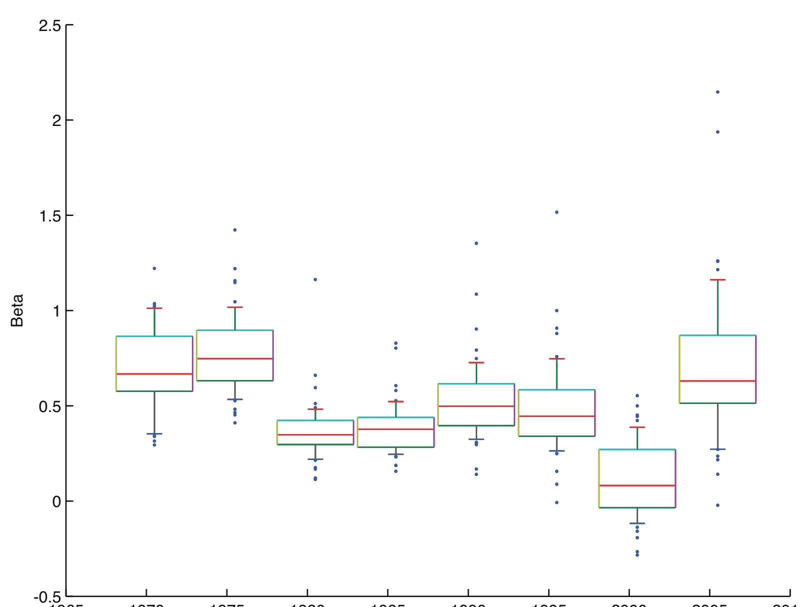
Figure 1: Boxplots of Utility Stock Betas Using 4 Year Periods Data

common equity. Michelfelder and Theodossiou in 2008[17] also concluded that public utility stocks are no longer defensive stocks dampening the downward behavior of otherwise less diversified portfolio returns in down markets.

Therefore, some suggest that *de*regulation may have ''buffered'' utility cash flows from regulatory risk, i.e., the chance that regulation would impose disappointing allowed rates of return in the manner described above. The advent of generation deregulation caused electric utilities with generating plants to no longer face regulatory risk on over 50 percent of their asset base. This is consistent with falling betas after deregulation of electric generation. The Brattle Group in 2004[18] found the same result in a research project for the Edison Electric Institute, an electric utility trade and lobbying organization. They found that electric utility betas fell after deregulation.

We suggest that it may be due to the relief of deregulation from asymmetric regulation. In any case, we find that the Blume adjustment toward 1 is not supported by our empirical results. This adjustment suggests that in the long run, all public utilities (and all firms) would gravitate toward the same risk and return. Our results herein suggest that the Blume adjustment is inappropriate for public utilities as it assumes that public utility betas are moving toward one in the long run as are non-utility company betas.

We perform a simple calculation to show the impact of a biased beta on public utility revenues. We calculate the common equity risk premium on the market as the annual total return for the CRSP market return from 1926 to 2007 to be approximately 12 percent and the average return on a three-month T-Bill to be about 4 percent. The long-term common equity risk premium is 8 percent. The difference between a beta of 0.50 and a Blume adjusted beta of .67 would result in a difference in cost of common equity



Boxes give the 25th and 75th percentiles; line in the boxes is for the median; whiskers give the 10th and 90th Percentiles.

Figure 2: Boxplots of Utility Stock Betas Using 5 Year Periods Data

  http://dx.doi.org/10.1016/j.tej.2013.09.017

of 136 basis points. Using a common equity ratio of 0.50, this would impact the weighted average rate of return by 68 points. Assuming a rate base of $5 billion (the level for a moderately large electric utility), the difference in ''allowed'' net income would be 0.0068 × $5 billion, or, $34 million. Assuming a 37.5 percent income tax rate, the increase in revenues required to earn the additional $34 million would be $54 million. This is obviously a substantial difference. It is important for us to stress in this example that we do not necessarily advocate these inputs for the recommended cost of common equity for a utility with a raw beta of 0.50. The deliberation in recommending the cost of common equity is performed with a careful and detailed analysis of the company and stock, referral to more than one valuation model of the cost of common equity estimation and expert judgment.

IV. Conclusion

Major vendors of CAPM betas such as Merrill Lynch, Value Line, and Bloomberg distribute Blume-adjusted betas to investors. We have shown empirically that public utility betas do not have a tendency to converge to 1. Short-term betas of public utilities follow a cyclical pattern with recent downward trends, then upward structural breaks with long-term betas following a downward trend. We estimate the Blume equation for electric and gas public utilities, finding that all but one equation is statistically insignificant. The single significant equation implies a long-term convergence of beta to approximately 0.59. During our nearly 45-year study period, the median beta ranged from 0.08 to 0.74. Therefore the Blume equation overpredicts utility betas and Blume-adjustments

of utility betas are not appropriate.

We are not suggesting that betas should not be adjusted for prediction. Rather, the measurement period and subjective adjustment to beta should be based upon the likely future trend in peer group or *public utility betas*, or the specific utility's beta, not the trend in betas for all stocks in general. The time pattern of utility betas is obviously more complex than a smooth curvilinear adjustment, or for that matter, any adjustment toward one. Nor do we suggest as an alternative the use of raw or unadjusted betas in an application of the CAPM to estimate a public utility's cost of common equity.■

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Exhibit__(NYCRP-13)

The following table shows annual and monthly values for average dividend per share in the utility sector, for the value-weighted average.

Source: Data are processed from the Fama French Data Library, accessed at https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html on March 24, 2026

Dividend per share is calculated by first calculating dividend yield as difference between utility sector returns with and without dividends, then multiplying by the average sector price (normalized so that 1929=1).

Annual average dividend per share equals the average of monthly dividend per share, from all 12 months.

Year	Annual Avg. Div. per Share	Month 1: Div. per Share	Month 2: Div. per Share	Month 3: Div. per Share	Month 4: Div. per Share	Month 5: Div. per Share	Month 6: Div. per Share	Month 7: Div. per Share	Month 8: Div. per Share	Month 9: Div. per Share	Month 10: Div. per Share	Month 11: Div. per Share	Month 12: Div. per Share
1926	0.34							0.15	0.36	0.4	0.24	0.41	0.49
1927	0.38	0.19	0.42	0.44	0.26	0.45	0.41	0.39	0.41	0.45	0.3	0.43	0.37
1928	0.45	0.41	0.4	0.39	0.51	0.4	0.33	0.49	0.58	0.35	0.36	0.74	0.44
1929	0.57	0.57	0.45	0.39	0.59	0.5	0.47	0.45	1.42	0.35	0.2	0.68	0.76
1930	0.56	0.39	1.09	0.26	0.44	0.96	0.23	0.66	0.86	0.34	0.32	0.7	0.52
1931	0.51	0.38	1	0.4	0.35	0.62	0.57	0.3	0.76	0.27	0.42	0.65	0.44
1932	0.48	0.2	1.03	0.43	0.17	0.43	0.47	0.25	1.1	0.39	0.13	0.66	0.46
1933	0.35	0.12	0.51	0.28	0.19	0.78	0.39	0.1	0.65	0.23	0.09	0.73	0.14
1934	0.31	0.15	0.71	0.16	0.1	0.6	0.17	0.07	0.67	0.17	0.1	0.64	0.2
1935	0.29	0.09	0.44	0.24	0.1	0.58	0.23	0.09	0.55	0.2	0.21	0.49	0.28
1936	0.32	0.09	0.44	0.22	0.17	0.48	0.29	0.09	0.6	0.2	0.19	0.73	0.35
1937	0.34	0.13	0.54	0.23	0.18	0.51	0.27	0.15	0.49	0.22	0.29	0.66	0.37
1938	0.3	0.12	0.55	0.19	0.13	0.49	0.38	0.18	0.44	0.24	0.25	0.49	0.2
1939	0.33	0.25	0.51	0.18	0.22	0.49	0.27	0.25	0.42	0.25	0.23	0.46	0.4
1940	0.33	0.26	0.45	0.25	0.32	0.33	0.39	0.25	0.44	0.27	0.3	0.38	0.29
1941	0.29	0.33	0.32	0.33	0.19	0.31	0.43	0.27	0.35	0.29	0.19	0.24	0.27
1942	0.25	0.25	0.26	0.23	0.22	0.24	0.25	0.2	0.2	0.32	0.26	0.23	0.31
1943	0.24	0.24	0.27	0.31	0.22	0.25	0.28	0.19	0.18	0.41	0.12	0.15	0.31
1944	0.28	0.21	0.17	0.31	0.2	0.61	0.29	0.2	0.35	0.17	0.31	0.25	0.28

Year	Annual Avg. Div. per Share	Month 1: Div. per Share	Month 2: Div. per Share	Month 3: Div. per Share	Month 4: Div. per Share	Month 5: Div. per Share	Month 6: Div. per Share	Month 7: Div. per Share	Month 8: Div. per Share	Month 9: Div. per Share	Month 10: Div. per Share	Month 11: Div. per Share	Month 12: Div. per Share
1945	0.27	0.24	0.19	0.34	0.32	0.36	0.18	0.19	0.34	0.2	0.33	0.41	0.18
1946	0.28	0.21	0.24	0.37	0.29	0.43	0.2	0.2	0.31	0.16	0.35	0.4	0.2
1947	0.31	0.23	0.35	0.19	0.38	0.39	0.19	0.4	0.31	0.29	0.38	0.35	0.3
1948	0.35	0.29	0.29	0.45	0.28	0.36	0.38	0.18	0.31	0.33	0.69	0.32	0.34
1949	0.38	0.33	0.29	0.53	0.29	0.35	0.47	0.24	0.38	0.51	0.34	0.42	0.44
1950	0.43	0.43	0.26	0.63	0.34	0.46	0.48	0.26	0.48	0.54	0.34	0.47	0.48
1951	0.47	0.4	0.52	0.5	0.35	0.41	0.63	0.34	0.56	0.47	0.42	0.48	0.53
1952	0.5	0.51	0.46	0.51	0.42	0.46	0.58	0.43	0.42	0.61	0.44	0.5	0.61
1953	0.5	0.38	0.5	0.56	0.37	0.53	0.54	0.43	0.47	0.65	0.4	0.61	0.61
1954	0.56	0.43	0.46	0.7	0.44	0.55	0.79	0.44	0.57	0.61	0.43	0.7	0.6
1955	0.58	0.41	0.52	0.67	0.57	0.68	0.62	0.45	0.63	0.59	0.49	0.77	0.58
1956	0.62	0.45	0.79	0.57	0.48	0.71	0.69	0.51	0.67	0.52	0.65	0.74	0.63
1957	0.66	0.57	0.75	0.66	0.47	0.86	0.57	0.59	0.71	0.66	0.5	0.9	0.68
1958	0.7	0.6	0.74	0.72	0.62	0.7	0.77	0.57	0.77	0.74	0.5	0.93	0.74
1959	0.71	0.57	0.8	0.81	0.53	0.76	0.75	0.6	0.78	0.76	0.6	0.87	0.72
1960	0.76	0.57	0.76	0.9	0.62	0.9	0.78	0.61	0.97	0.63	0.58	1.09	0.71
1961	0.8	0.74	0.93	0.78	0.68	0.98	0.7	0.61	1.11	0.67	0.83	0.98	0.66
1962	0.82	0.73	0.97	0.7	0.62	0.91	0.73	0.78	1.06	0.64	0.85	1.11	0.73
1963	0.88	0.83	0.97	0.73	0.87	1.04	0.68	0.94	1.07	0.69	0.94	1.02	0.81
1964	0.94	0.76	1.13	0.82	0.79	1.13	0.88	0.85	1.1	0.93	0.8	1.21	0.92
1965	1.01	0.84	1.1	1.02	0.83	1.2	0.94	0.83	1.31	0.96	0.86	1.32	0.91
1966	1.07	0.74	1.21	1.11	0.88	1.28	0.96	0.86	1.19	1	0.99	1.5	1.06
1967	1.13	0.92	1.26	1.11	0.89	1.44	1.03	0.89	1.49	0.97	1.04	1.59	1
1968	1.23	1.09	1.36	0.91	1.32	1.35	1.26	1.03	1.44	1.11	1.15	1.67	1.03
1969	1.22	1.02	1.46	1.11	1.19	1.48	1.05	1.04	1.43	1.09	1.32	1.31	1.18
1970	1.32	0.94	1.7	1.33	0.89	1.5	1.16	1.13	1.8	1.16	1.09	1.88	1.24
1971	1.32	1.08	1.42	1.44	0.99	1.59	1.35	1.02	1.73	1.09	1.27	1.58	1.32
1972	1.39	1.13	1.61	1.2	0.94	1.84	1.27	1.07	1.87	1.21	1.35	1.9	1.24
1973	1.36	0.98	1.85	1.01	1.12	1.89	1.27	1.02	1.91	1.1	1.37	1.52	1.28
1974	1.41	1.31	1.87	1.06	1.09	1.74	1.14	1.12	1.68	1.24	1.54	1.8	1.31

Year	Annual Avg. Div. per Share	Month 1: Div. per Share	Month 2: Div. per Share	Month 3: Div. per Share	Month 4: Div. per Share	Month 5: Div. per Share	Month 6: Div. per Share	Month 7: Div. per Share	Month 8: Div. per Share	Month 9: Div. per Share	Month 10: Div. per Share	Month 11: Div. per Share	Month 12: Div. per Share
1975	1.56	1.34	1.87	1.35	1.16	2.08	1.59	1.17	1.95	1.34	1.44	1.89	1.51
1976	1.64	1.3	1.7	1.74	1.28	1.94	1.61	1.3	2.3	1.45	1.33	2.11	1.64
1977	1.73	1.22	2.15	1.49	1.43	2.22	1.63	1.32	2.19	1.6	1.24	2.73	1.6
1978	1.82	1.26	2.24	1.67	1.5	2.38	1.82	1.12	2.56	1.65	1.6	2.22	1.82
1979	1.97	1.59	2.29	1.81	1.24	2.77	2.09	1.45	2.69	1.4	1.78	2.74	1.81
1980	2.09	1.54	2.55	1.69	1.68	2.91	2.11	1.51	2.53	2.01	1.84	2.66	2
1981	2.22	1.42	2.58	2.47	1.42	2.81	2.45	1.58	2.57	2.25	1.89	3.04	2.19
1982	2.44	1.47	2.84	2.57	1.78	3.15	2.09	1.64	3.88	2.27	1.98	2.86	2.78
1983	2.55	1.85	3.28	2.31	1.92	3.42	2.28	1.87	3.25	2.73	2.07	3.16	2.51
1984	2.65	2.07	3.01	2.48	1.55	3.28	2.84	1.65	3.74	2.55	2.55	3.25	2.82
1985	2.8	2.13	2.96	3.3	1.78	3.77	2.98	1.82	3.6	2.39	2.41	3.65	2.76
1986	2.85	2.03	3.93	2.83	1.9	3.72	3.01	2.23	3.81	2.41	2.17	3.25	2.97
1987	2.8	2.26	3.09	3.07	2.05	3.38	3.08	2.15	3.69	2.77	1.91	2.92	3.25
1988	2.92	2.38	3.29	2.99	2.05	3.86	2.99	2.1	3.62	2.87	1.93	4	2.99
1989	2.98	2.15	3.49	2.93	2.31	3.82	2.95	2.07	4.03	2.79	2.27	3.82	3.12
1990	2.92	2.07	3.52	2.94	1.66	4.37	2.69	2.39	3.29	2.41	2.88	3.62	3.2
1991	3.04	2.2	3.82	2.65	2.69	3.61	2.82	2.31	3.96	3.09	2.18	3.94	3.24
1992	3.01	2.01	3.26	3.45	2.35	3.6	3.3	2.49	3.22	3.36	2.2	3.37	3.5
1993	3.04	2.15	3.58	3.55	2.15	3.45	3.47	2.37	4.01	2.94	2.08	3.84	2.93
1994	3	1.61	3.68	3.21	2.22	3.37	3.02	2.46	3.69	3.34	1.72	4.17	3.47
1995	3.21	2.47	3.62	3.3	2.47	4	3.33	1.87	4.19	3.57	2.08	4.12	3.54
1996	3.13	1.87	3.96	3.03	2	4.24	3.38	1.99	4.2	3.19	2.66	3.93	3.06
1997	3.24	2.29	3.54	2.95	2.16	4.1	3.28	2.78	3.38	3.52	2.86	4.02	3.97
1998	3.21	2.31	3.53	3.58	2.87	3.51	3.34	2.24	3.87	3.54	2.84	3.32	3.58
1999	3.05	2.4	3.13	3.15	3.11	3.67	3.15	2.69	3.38	2.9	2.78	3.03	3.25
2000	3.23	2.15	3.46	3.57	2.82	3.95	3.02	2.03	4.98	2.86	2.4	4.21	3.38
2001	3.04	1.56	5.05	2.81	1.86	5.36	2.25	1.77	4.82	2.2	1.58	4.2	3.03
2002	2.85	2.08	4.21	2.66	1.76	4.09	2.56	1.49	4.84	1.84	2.43	3.89	2.33
2003	2.68	1.84	3.58	2.03	1.59	4.68	2.24	2.26	3.75	1.82	2.17	3.79	2.38
2004	2.88	2.34	3.96	2.22	2.05	3.62	2.54	2.12	4.01	2.3	2.4	4.31	2.76

Year	Annual Avg. Div. per Share	Month 1: Div. per Share	Month 2: Div. per Share	Month 3: Div. per Share	Month 4: Div. per Share	Month 5: Div. per Share	Month 6: Div. per Share	Month 7: Div. per Share	Month 8: Div. per Share	Month 9: Div. per Share	Month 10: Div. per Share	Month 11: Div. per Share	Month 12: Div. per Share
2005	3.24	1.66	4.56	3.4	2.28	3.84	3.58	2.49	4.67	2.74	1.62	4.84	3.14
2006	3.43	1.8	4.9	3.44	2.22	4.84	3.37	1.64	5.91	2.63	1.72	5.83	2.86
2007	3.61	1.5	6.38	3.1	1.69	5.87	3.08	1.41	6.01	3.4	1.26	6.38	3.29
2008	3.74	1.89	5.34	3.39	1.5	6.51	3.85	1.86	6.09	2.74	1.77	6.34	3.58
2009	3.91	1.94	4.77	3.83	2.05	5.99	4.23	2.1	6.48	3.36	1.85	6.68	3.7
2010	3.97	1.82	6.43	3.6	2.02	5.44	3.84	2.22	6.54	3.62	2.09	6.27	3.72
2011	4.39	1.27	6.45	5.06	2.16	6.39	4.45	2.55	7.23	3.41	1.68	7.59	4.47
2012	4.64	0.98	8.33	4.43	1.45	7.87	4.43	1.22	8.78	3.88	1.36	8.64	4.31
2013	4.91	2.56	8.12	4.85	1.53	6.9	5.36	1.98	7.2	5.52	3.09	6.36	5.48
2014	5.4	2.81	8.47	4.68	2.16	8.78	5.28	3.17	8.12	4.8	3.41	7.76	5.38
2015	5.47	2.14	9.06	5.15	2.21	9.12	5	3.53	7.58	5.18	3.58	8.18	4.94
2016	5.4	1.67	8.76	6.52	1.79	8.4	6.65	1.56	8.59	5.12	1.88	8.57	5.27
2017	5.59	1.71	9.44	6.3	1.97	9.65	4.72	2.23	9.68	5.24	1.87	9.72	4.61
2018	5.72	1.94	8.13	6.46	2.54	9.15	5.97	2.02	9.14	5.84	2.01	9.92	5.5
2019	6.54	3.1	10.22	5.92	3.1	9.11	5.61	3.77	10.5	7.33	3.03	9.53	7.3
2020	6.35	3.7	8.85	4.8	2.22	10.5	7.15	3.8	9.03	6.93	3.4	9.13	6.76
2021	6.67	2.82	8.24	9.29	3.53	8.34	6.6	4.45	9.86	6.39	3.35	9.36	7.85
2022	7.01	3.22	10.48	8	3.33	11.24	4.99	5.03	10.03	5.59	3.61	11.77	6.81
2023	7.09	3.24	10.09	7.78	3.7	10.41	5.68	4.85	11.2	5.41	3.71	13.01	6.02
2024	7.74	3.14	12.11	8.05	3.71	11.44	6.87	3.51	14.9	6.21	2.97	15.09	4.92
2025	8.15	2.08	15.71	6.68	2.99	13.26	7.77	3.53	13.2	7.18	2.95	15.43	7.05

Exhibit__(NYCRP-14)

The table shows annual levels of CPI, nominal GDP, and real GDP.
These are accessed via FRED, the data access website of the Federal Reserve Bank of St. Louis.
These series are accessed at the following links:
CPI: https://fred.stlouisfed.org/series/CPIAUCNS
Real GDP: https://fred.stlouisfed.org/series/GDPCA
Nominal GDP: https://fred.stlouisfed.org/series/GDPA
CPI data are available at a monthly level; the annual level is calculated as the average of all monthly values in each year.

Year	CPI	Real GDP	Nominal GDP
1913	9.88		
1914	10.02		
1915	10.11		
1916	10.88		
1917	12.82		
1918	15.04		
1919	17.33		
1920	20.04		
1921	17.85		
1922	16.75		
1923	17.05		
1924	17.12		
1925	17.54		
1926	17.70		
1927	17.36		
1928	17.16		
1929	17.16	1,191.12	104.56
1930	16.70	1,089.79	92.16
1931	15.21	1,019.98	77.39
1932	13.64	888.41	59.52
1933	12.93	877.43	57.15
1934	13.38	972.26	66.80
1935	13.72	1,058.84	74.24
1936	13.87	1,195.25	84.83
1937	14.38	1,256.50	93.00
1938	14.09	1,214.87	87.35
1939	13.91	1,312.36	93.44
1940	14.01	1,428.08	102.90
1941	14.72	1,681.05	129.31
1942	16.33	1,998.54	165.95
1943	17.31	2,338.76	203.08
1944	17.59	2,524.75	224.45
1945	17.99	2,500.06	228.01
1946	19.52	2,209.91	227.54

Year	CPI	Real GDP	Nominal GDP
1947	22.32	2,184.61	249.62
1948	24.04	2,274.63	274.47
1949	23.81	2,261.93	272.48
1950	24.07	2,458.53	299.83
1951	25.96	2,656.32	346.91
1952	26.55	2,764.80	367.34
1953	26.77	2,894.41	389.22
1954	26.85	2,877.71	390.55
1955	26.78	3,083.03	425.48
1956	27.18	3,148.76	449.35
1957	28.09	3,215.06	474.04
1958	28.86	3,191.22	481.23
1959	29.15	3,412.42	521.65
1960	29.58	3,500.27	542.38
1961	29.89	3,590.07	562.21
1962	30.25	3,810.12	603.92
1963	30.62	3,976.14	637.45
1964	31.02	4,205.28	684.46
1965	31.51	4,478.56	742.29
1966	32.46	4,773.93	813.41
1967	33.36	4,904.86	859.96
1968	34.78	5,145.91	940.65
1969	36.68	5,306.59	1,017.62
1970	38.82	5,316.39	1,073.30
1971	40.49	5,491.44	1,164.85
1972	41.82	5,780.05	1,279.11
1973	44.40	6,106.37	1,425.38
1974	49.31	6,073.36	1,545.24
1975	53.82	6,060.88	1,684.90
1976	56.91	6,387.44	1,873.41
1977	60.61	6,682.80	2,081.83
1978	65.23	7,052.71	2,351.60
1979	72.58	7,276.00	2,627.33
1980	82.41	7,257.32	2,857.31
1981	90.92	7,441.48	3,207.04
1982	96.50	7,307.31	3,343.79
1983	99.60	7,642.27	3,634.04
1984	103.88	8,195.30	4,037.61
1985	107.57	8,537.00	4,338.98
1986	109.61	8,832.61	4,579.63
1987	113.62	9,137.75	4,855.22
1988	118.26	9,519.43	5,236.44

Year	CPI	Real GDP	Nominal GDP
1989	123.97	9,869.00	5,641.58
1990	130.66	10,055.13	5,963.14
1991	136.19	10,044.24	6,158.13
1992	140.32	10,398.05	6,520.33
1993	144.46	10,684.18	6,858.56
1994	148.22	11,114.65	7,287.24
1995	152.38	11,413.01	7,639.75
1996	156.85	11,843.60	8,073.12
1997	160.52	12,370.30	8,577.55
1998	163.01	12,924.88	9,062.82
1999	166.58	13,543.77	9,631.17
2000	172.20	14,096.03	10,250.95
2001	177.07	14,230.73	10,581.93
2002	179.88	14,472.71	10,929.11
2003	183.96	14,877.31	11,456.45
2004	188.88	15,449.76	12,217.20
2005	195.29	15,987.96	13,039.20
2006	201.59	16,433.15	13,815.58
2007	207.34	16,762.44	14,474.23
2008	215.30	16,781.48	14,769.86
2009	214.54	16,349.11	14,478.07
2010	218.06	16,789.75	15,048.97
2011	224.94	17,052.41	15,599.73
2012	229.59	17,442.76	16,253.97
2013	232.96	17,812.17	16,880.68
2014	236.74	18,261.71	17,608.14
2015	237.02	18,799.62	18,295.02
2016	240.01	19,141.67	18,804.91
2017	245.12	19,612.10	19,612.10
2018	251.11	20,193.90	20,656.52
2019	255.66	20,715.67	21,539.98
2020	258.81	20,284.50	21,375.28
2021	270.97	21,532.41	23,725.64
2022	292.65	22,075.93	26,054.61
2023	304.70	22,723.72	27,811.52
2024	313.69	23,358.44	29,298.01
2025	321.94	23,852.99	30,767.09
2026	326.02		

Exhibit__(NYCRP-15)

The following are linear regression results for predicting annual dividend per share (`DPS_nominal`) in the Fama French value-weighted average utility sector dataset, using three different explanatory economic indicators. Those indicators are consumer price index (`CPI`), real GDP (`GDPCA`), and nominal GDP (`GDPA`). The key output from these regression results is the correlation coefficient between log economic indicator and log dividend per share; these are bolded in each chart below.

Regressions were run using the publicly available software package statsmodels, available at https://www.statsmodels.org/stable/index.html.

Fama French data are in Exhibit NYCRP-13.
Annual levels of economic indicators are in exhibit NYCRP-14.

Regression Results for value weighted average, using CPI as independent variable

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     np.log(DPS_nominal)   R-squared:                       0.951
Model:                             OLS   Adj. R-squared:                  0.950
Method:                  Least Squares   F-statistic:                     1883.
Date:                 Tue, 24 Mar 2026   Prob (F-statistic):           8.67e-66
Time:                         14:36:58   Log-Likelihood:                 3.9453
No. Observations:                  100   AIC:                            -3.891
Df Residuals:                       98   BIC:                             1.320
Df Model:                            1
Covariance Type:             nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept     -3.6401      0.095    -38.480      0.000      -3.828      -3.452
np.log(CPI)    0.9653      0.022     43.394      0.000       0.921       1.009
==============================================================================
Omnibus:                        3.166   Durbin-Watson:                   0.096
Prob(Omnibus):                  0.205   Jarque-Bera (JB):                2.887
Skew:                          -0.334   Prob(JB):                        0.236
Kurtosis:                       2.503   Cond. No.                         18.0
==============================================================================
```

Regression Results for value weighted average, using Real GDP as independent variable

OLS Regression Results

Dep. Variable:	np.log(DPS_nominal)	R-squared:	0.918
Model:	OLS	Adj. R-squared:	0.917
Method:	Least Squares	F-statistic:	1061.
Date:	Tue, 24 Mar 2026	Prob (F-statistic):	2.44e-53
Time:	14:36:58	Log-Likelihood:	-19.936
No. Observations:	97	AIC:	43.87
Df Residuals:	95	BIC:	49.02
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-8.7115	0.281	-31.036	0.000	-9.269	-8.154
np.log(GDPCA)	**1.0457**	0.032	32.569	0.000	0.982	1.109

Omnibus:	6.600	Durbin-Watson:	0.077
Prob(Omnibus):	0.037	Jarque-Bera (JB):	11.299
Skew:	0.074	Prob(JB):	0.00352
Kurtosis:	4.665	Cond. No.	81.5

Regression Results for value weighted average, using Nominal GDP as independent variable

OLS Regression Results

Dep. Variable:	np.log(DPS_nominal)	R-squared:	0.946
Model:	OLS	Adj. R-squared:	0.945
Method:	Least Squares	F-statistic:	1649.
Date:	Tue, 24 Mar 2026	Prob (F-statistic):	7.77e-62
Time:	14:36:58	Log-Likelihood:	0.023888
No. Observations:	97	AIC:	3.952
Df Residuals:	95	BIC:	9.102
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
Intercept	-3.5985	0.101	-35.640	0.000	-3.799	-3.398
np.log(GDPA)	**0.5304**	0.013	40.610	0.000	0.505	0.556

Omnibus:	4.773	Durbin-Watson:	0.085
Prob(Omnibus):	0.092	Jarque-Bera (JB):	5.865
Skew:	-0.165	Prob(JB):	0.0533
Kurtosis:	4.159	Cond. No.	31.9

Exhibit__(NYCRP-16)

The following table shows the annual forecasts of CPI and GDP and the dividend growth rates implied by those forecasts and the result of regression analysis summarized in Exhibit__(NYCRP-15). Dividend growth is calculated by taking the economic indicator growth to the power equal to the correlation between dividend growth and that indicator, as reported in Exhibit__(NYCRP-15).

EIA provides a macroeconomic forecast of CPI, GDP levels, and GDP Chain Price Index (used to translate real GDP to nominal GDP). These data are published in the EIA's Annual Energy Outlook 2025, available at https://www.eia.gov/outlooks/aeo/data/browser/#/?id=18-AEO2025&cases=ref2025&sourcekey=0. These values are then translated into annual growth rates.

Table 1: EIA Forecasts

	EIA CPI Forecast	Dividend Growth Rate Using EIA CPI Forecast	EIA Real GDP Forecast	Dividend Growth Rate Using EIA Real GDP Forecast	EIA Nominal GDP Forecast	Dividend Growth Rate Using EIA Nominal GDP Forecast
2025	1.73%	1.67%	2.17%	2.27%	4.27%	2.24%
2026	1.76%	1.70%	2.32%	2.43%	4.05%	2.13%
2027	1.64%	1.59%	2.10%	2.19%	3.80%	2.00%
2028	1.85%	1.79%	1.84%	1.93%	3.76%	1.98%
2029	1.81%	1.74%	1.93%	2.02%	3.74%	1.97%
2030	1.87%	1.80%	1.82%	1.91%	3.72%	1.96%
2031	1.99%	1.92%	1.62%	1.70%	3.71%	1.95%
2032	2.03%	1.96%	1.70%	1.78%	3.85%	2.02%
2033	2.10%	2.03%	1.73%	1.81%	3.94%	2.07%
2034	2.12%	2.04%	1.70%	1.78%	3.95%	2.08%
2035	2.10%	2.03%	1.74%	1.82%	3.94%	2.07%
2036	2.04%	1.97%	1.69%	1.77%	3.79%	1.99%
2037	2.06%	1.98%	1.73%	1.81%	3.84%	2.02%
2038	2.04%	1.97%	1.75%	1.83%	3.86%	2.03%
2039	2.05%	1.98%	1.75%	1.83%	3.84%	2.02%
2040	2.11%	2.04%	1.73%	1.81%	3.87%	2.04%
2041	2.17%	2.09%	1.67%	1.75%	3.84%	2.02%
2042	2.23%	2.15%	1.71%	1.79%	3.93%	2.07%
2043	2.30%	2.21%	1.63%	1.71%	3.89%	2.05%
2044	2.26%	2.19%	1.61%	1.68%	3.87%	2.03%
2045	2.34%	2.26%	1.61%	1.68%	3.90%	2.05%
2046	2.35%	2.27%	1.56%	1.63%	3.86%	2.03%
2047	2.40%	2.31%	1.57%	1.64%	3.88%	2.04%
2048	2.38%	2.29%	1.64%	1.72%	3.96%	2.08%
2049	2.34%	2.26%	1.71%	1.79%	4.01%	2.11%

The CBO publishes a long-term economic forecast to accompany its annual budget and economic outlook publication, available at https://www.cbo.gov/publication/62105. This includes forecasts of the CPI, real GDP, and nominal GDP growth.

Table 2: CBO Forecasts

	CBO CPI Forecast	Dividend Growth Rate Using CBO CPI Forecast	CBO Real GDP Forecast	Dividend Growth Rate Using CBO Real GDP Forecast	CBO Nominal GDP Forecast	Dividend Growth Rate Using CBO Nominal GDP Forecast
2025	2.77%	2.67%	2.02%	2.11%	4.80%	2.52%
2026	2.92%	2.82%	2.36%	2.47%	5.11%	2.68%
2027	2.55%	2.46%	1.86%	1.95%	4.27%	2.24%
2028	2.36%	2.28%	1.80%	1.89%	4.01%	2.11%
2029	2.29%	2.21%	1.75%	1.83%	3.85%	2.03%
2030	2.26%	2.18%	1.78%	1.87%	3.83%	2.01%
2031	2.26%	2.18%	1.78%	1.86%	3.79%	1.99%
2032	2.26%	2.18%	1.76%	1.84%	3.77%	1.98%
2033	2.26%	2.18%	1.77%	1.85%	3.78%	1.99%
2034	2.26%	2.18%	1.77%	1.85%	3.77%	1.98%
2035	2.26%	2.18%	1.77%	1.85%	3.78%	1.99%
2036	2.26%	2.18%	1.77%	1.85%	3.78%	1.99%
2037	2.26%	2.18%	1.75%	1.83%	3.77%	1.98%
2038	2.26%	2.18%	1.74%	1.82%	3.77%	1.98%
2039	2.26%	2.18%	1.73%	1.81%	3.76%	1.98%
2040	2.26%	2.18%	1.75%	1.83%	3.78%	1.99%
2041	2.26%	2.18%	1.73%	1.81%	3.77%	1.98%
2042	2.26%	2.18%	1.71%	1.79%	3.75%	1.97%
2043	2.26%	2.18%	1.70%	1.78%	3.74%	1.97%
2044	2.26%	2.18%	1.69%	1.77%	3.73%	1.96%
2045	2.26%	2.18%	1.65%	1.72%	3.68%	1.93%
2046	2.27%	2.19%	1.61%	1.68%	3.64%	1.92%
2047	2.27%	2.19%	1.59%	1.66%	3.62%	1.91%
2048	2.27%	2.19%	1.57%	1.65%	3.60%	1.90%
2049	2.27%	2.19%	1.56%	1.63%	3.59%	1.89%
2050	2.27%	2.19%	1.53%	1.60%	3.56%	1.87%
2051	2.27%	2.19%	1.51%	1.58%	3.54%	1.87%
2052	2.27%	2.19%	1.50%	1.57%	3.53%	1.86%
2053	2.27%	2.19%	1.49%	1.56%	3.53%	1.86%
2054	2.27%	2.19%	1.49%	1.55%	3.52%	1.85%
2055	2.27%	2.19%	1.48%	1.55%	3.52%	1.85%
2056	2.27%	2.19%	1.48%	1.55%	3.52%	1.85%

Exhibit__(NYCRP-17)

This table summarizes the results of our DCF analysis. Columns 1-4 are taken from Exhibit__(JCN-4), page 1. Columns 5-10 show results of a 200-year DCF analysis, using long-term growth rates shown in Exhibit__(NYCRP-16). Column 11 takes the average of columns 5-10, while Column 12 equals Column 4 minus Column 11.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
Ticker	Stock Price	Annualized Dividend	First Stage Growth	ROE (Nowak)	ROE (CBO CPI)	ROE (CBO Real GDP)	ROE (CBO Nominal GDP)	ROE (EIA CPI)	ROE (EIA Real GDP)	ROE (EIA Nominal GDP)	Our Average ROE	ROE Diff. (Our Average minus Nowak)
AEE	$102.01	$2.84	7.48%	8.92%	6.39%	6.28%	6.32%	6.15%	6.02%	6.17%	6.22%	-2.70%
AEP	$112.98	$3.72	6.85%	9.40%	6.95%	6.84%	6.88%	6.72%	6.59%	6.74%	6.79%	-2.61%
ATO	$168.33	$3.48	7.31%	7.98%	5.31%	5.19%	5.23%	5.05%	4.91%	5.08%	5.13%	-2.85%
AVA	$37.28	$1.96	6.23%	11.57%	9.47%	9.37%	9.40%	9.26%	9.15%	9.28%	9.32%	-2.25%
CMS	$72.72	$2.17	7.74%	9.23%	6.75%	6.64%	6.68%	6.51%	6.39%	6.54%	6.58%	-2.65%
CNP	$38.62	$0.88	7.88%	8.35%	5.74%	5.62%	5.66%	5.49%	5.35%	5.51%	5.56%	-2.79%
CPK	$128.26	$2.74	8.58%	8.29%	5.67%	5.55%	5.59%	5.42%	5.28%	5.44%	5.49%	-2.80%
D	$60.48	$2.67	6.70%	10.72%	8.48%	8.37%	8.41%	8.26%	8.14%	8.28%	8.32%	-2.40%
DTE	$139.00	$4.36	6.10%	9.03%	6.54%	6.42%	6.46%	6.29%	6.17%	6.32%	6.37%	-2.66%
ES	$68.19	$3.01	5.71%	10.41%	8.13%	8.03%	8.07%	7.91%	7.79%	7.93%	7.98%	-2.43%
ETR	$91.80	$2.40	8.00%	8.82%	6.27%	6.15%	6.20%	6.02%	5.89%	6.05%	6.10%	-2.72%
EVRG	$74.22	$2.67	6.32%	9.63%	7.23%	7.11%	7.15%	6.99%	6.87%	7.01%	7.06%	-2.57%
EXC	$45.15	$1.60	6.10%	9.51%	7.09%	6.98%	7.02%	6.85%	6.73%	6.88%	6.92%	-2.59%
FE	$44.70	$1.78	6.17%	10.04%	7.70%	7.60%	7.63%	7.48%	7.36%	7.50%	7.54%	-2.50%
IDA	$128.98	$3.44	7.02%	8.67%	6.12%	6.00%	6.04%	5.87%	5.73%	5.89%	5.94%	-2.73%
LNT	$66.15	$2.03	6.54%	9.06%	6.56%	6.44%	6.49%	6.32%	6.19%	6.34%	6.39%	-2.67%
NEE	$76.40	$2.27	8.03%	9.28%	6.81%	6.70%	6.74%	6.57%	6.45%	6.60%	6.64%	-2.64%
NI	$42.32	$1.12	8.38%	8.94%	6.41%	6.30%	6.34%	6.17%	6.04%	6.19%	6.24%	-2.70%
NWN	$42.98	$1.97	6.00%	10.70%	8.46%	8.36%	8.39%	8.24%	8.13%	8.27%	8.31%	-2.39%
OGE	$45.25	$1.70	6.43%	9.85%	7.48%	7.37%	7.41%	7.25%	7.12%	7.27%	7.31%	-2.54%
OGS	$77.70	$2.68	5.55%	9.26%	6.81%	6.69%	6.73%	6.57%	6.44%	6.59%	6.64%	-2.62%
PEG	$83.19	$2.52	7.47%	9.23%	6.75%	6.63%	6.67%	6.51%	6.38%	6.53%	6.58%	-2.65%
PNW	$90.18	$3.58	4.70%	9.62%	7.23%	7.12%	7.16%	7.00%	6.88%	7.02%	7.07%	-2.55%
POR	$43.27	$2.10	5.05%	10.70%	8.48%	8.38%	8.41%	8.26%	8.15%	8.28%	8.33%	-2.37%
PPL	$36.63	$1.09	7.50%	9.17%	6.68%	6.56%	6.60%	6.44%	6.31%	6.46%	6.51%	-2.66%
SO	$94.36	$2.96	6.57%	9.14%	6.66%	6.55%	6.59%	6.42%	6.29%	6.44%	6.49%	-2.65%
SR	$79.61	$3.14	7.11%	10.27%	7.95%	7.85%	7.89%	7.73%	7.61%	7.75%	7.80%	-2.47%
SWX	$78.69	$2.48	11.01%	10.33%	7.97%	7.86%	7.90%	7.74%	7.62%	7.76%	7.81%	-2.52%
WEC	$111.35	$3.57	6.77%	9.28%	6.81%	6.70%	6.74%	6.57%	6.45%	6.60%	6.64%	-2.64%
XEL	$76.08	$2.28	7.70%	9.24%	6.76%	6.65%	6.69%	6.52%	6.39%	6.54%	6.59%	-2.65%
Average				9.49%	7.09%	6.99%	7.02%	6.87%	6.75%	6.89%	6.94%	-2.60%
Median				9.27%	6.81%	6.70%	6.74%	6.57%	6.45%	6.60%	6.64%	-2.64%

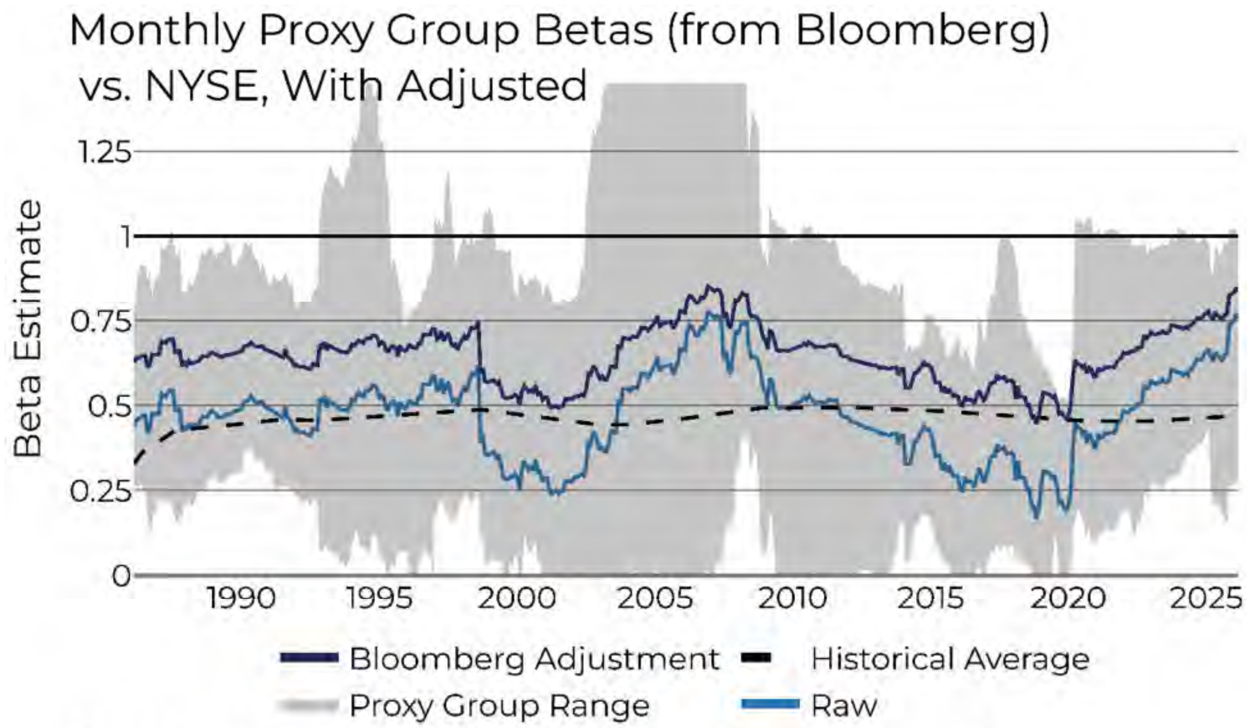
Exhibit__(NYCRP-18)

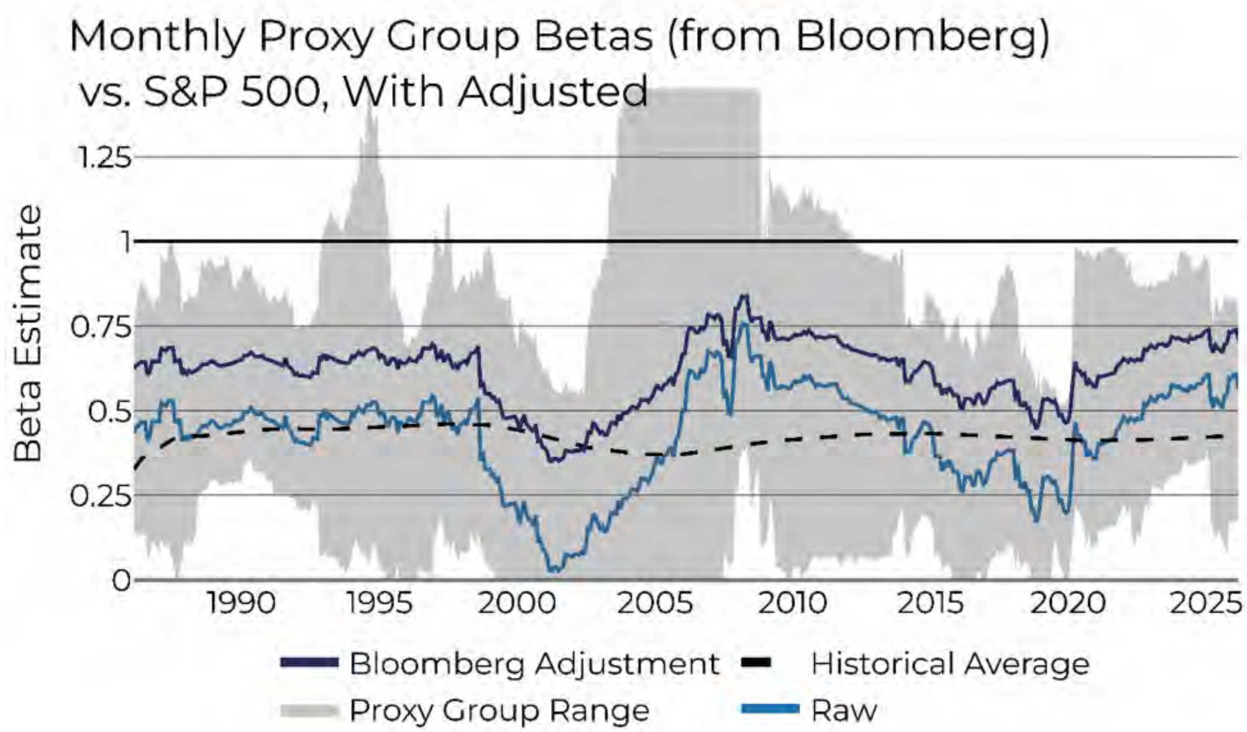
The following charts plot historical beta values, with different return frequencies (monthly or weekly) relative to different market references (NYSE or S&P 500), from two different data sources (Bloomberg Professional or Yahoo! Finance). In each chart, solid lines show the average for all proxy group companies (either raw or Bloomberg Adjusted). The grey shaded area surrounding the raw average line show the range of raw beta values. The black dotted line shows the running historical average, calculated as the average of all raw beta values where the date of calculation is no greater than the current date.

Bloomberg Betas are historical values accessed via Bloomberg Terminal.

Yahoo! Finance betas are calculated using publicly available closing stock prices of proxy group utility companies and market references from Yahoo! Finance (accessed via API reference, using the publicly available software package yfinance accessed at https://pypi.org/project/yfinance/). Daily stock prices are resampled on a weekly or monthly frequency, then the beta values are calculated as follows: $\beta = \frac{cov(target\ stock, market\ reference)}{var(market\ reference)}$

The Bloomberg Adjustment is: $\beta_{adjusted} = \beta_{raw} * \frac{2}{3} + \frac{1}{3}$


Monthly Proxy Group Betas (from Bloomberg)
vs. NYSE, With Adjusted
Beta Estimate
1.25
1
0.75
0.5
0.25
0
1990
1995
2000
2005
2010
2015
2020
2025
Bloomberg Adjustment
Historical Average
Proxy Group Range
Raw


Monthly Proxy Group Betas (from Bloomberg)
vs. S&P 500, With Adjusted
Beta Estimate
1.25
1
0.75
0.5
0.25
0
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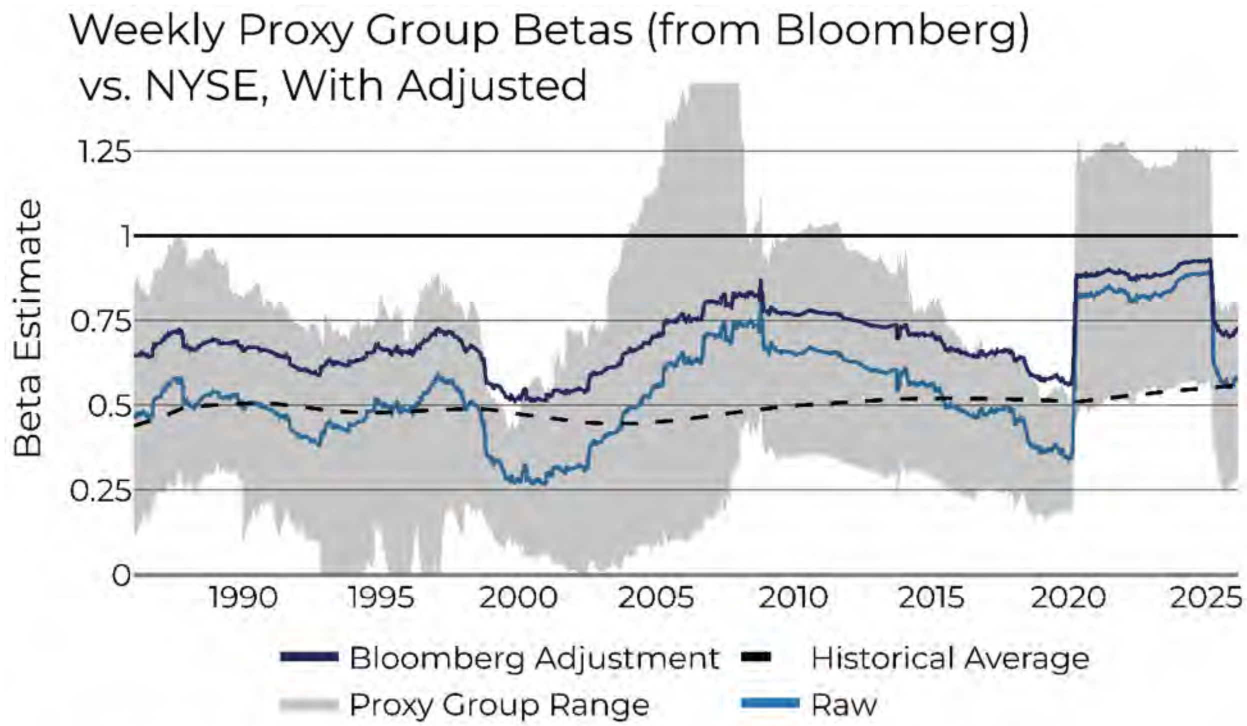
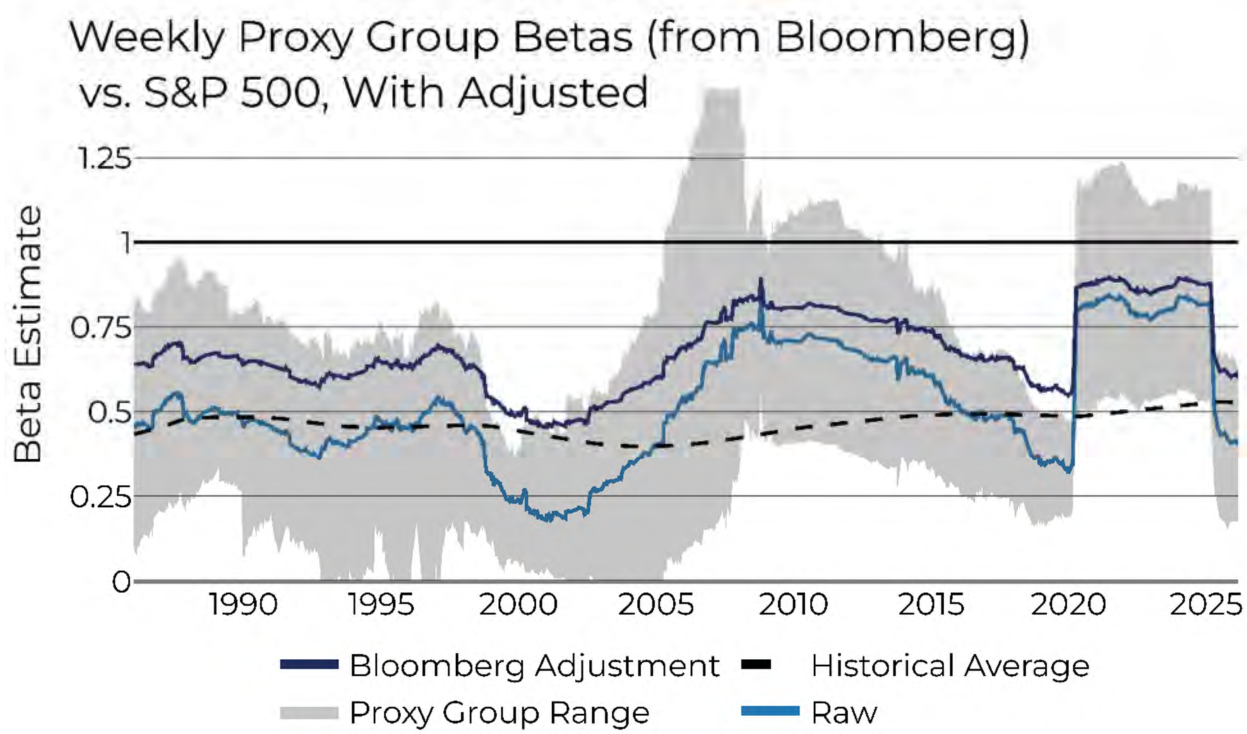
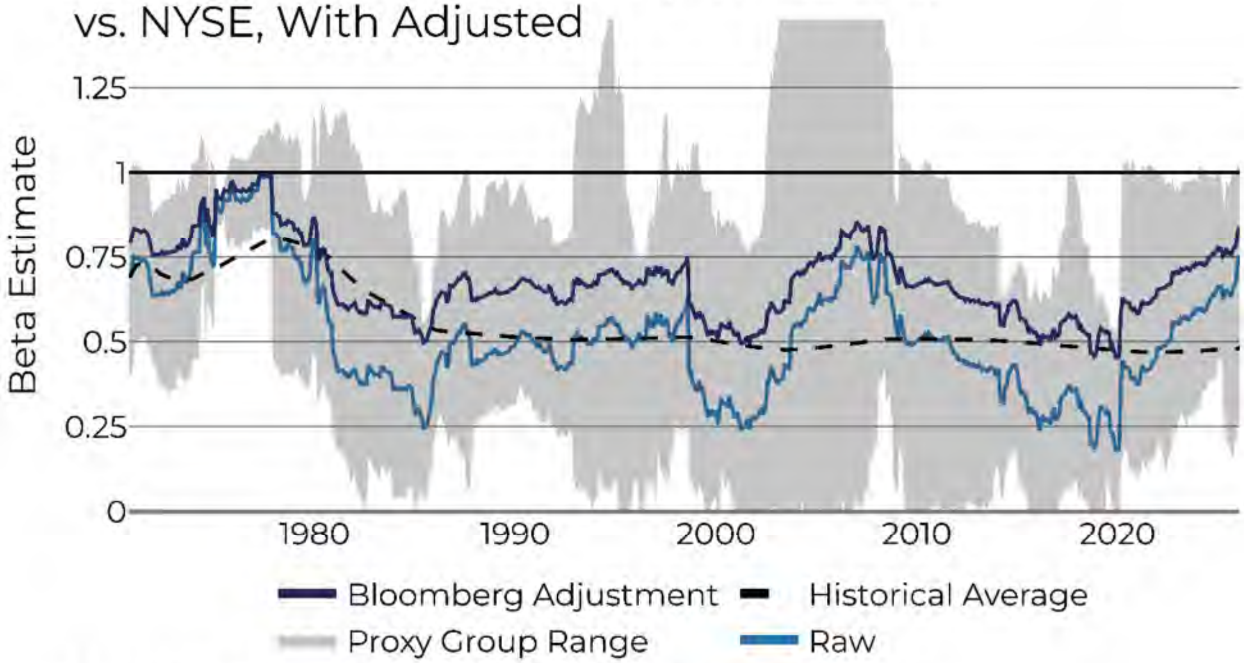
1995
2000
2005
2010
2015
2020
2025
Bloomberg Adjustment
Historical Average
Proxy Group Range
Raw

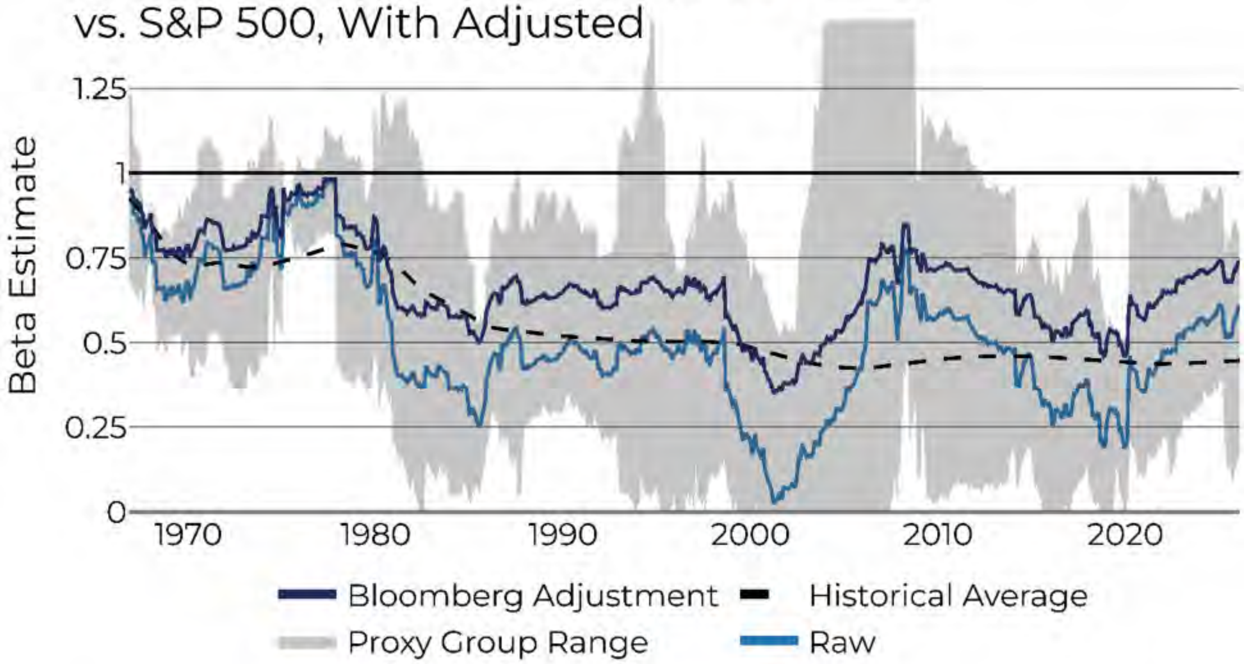

Weekly Proxy Group Betas (from Bloomberg)
vs. NYSE, With Adjusted
Beta Estimate
1.25
1
0.75
0.5
0.25
0
1990
1995
2000
2005
2010
2015
2020
2025
Bloomberg Adjustment
Historical Average
Proxy Group Range
Raw

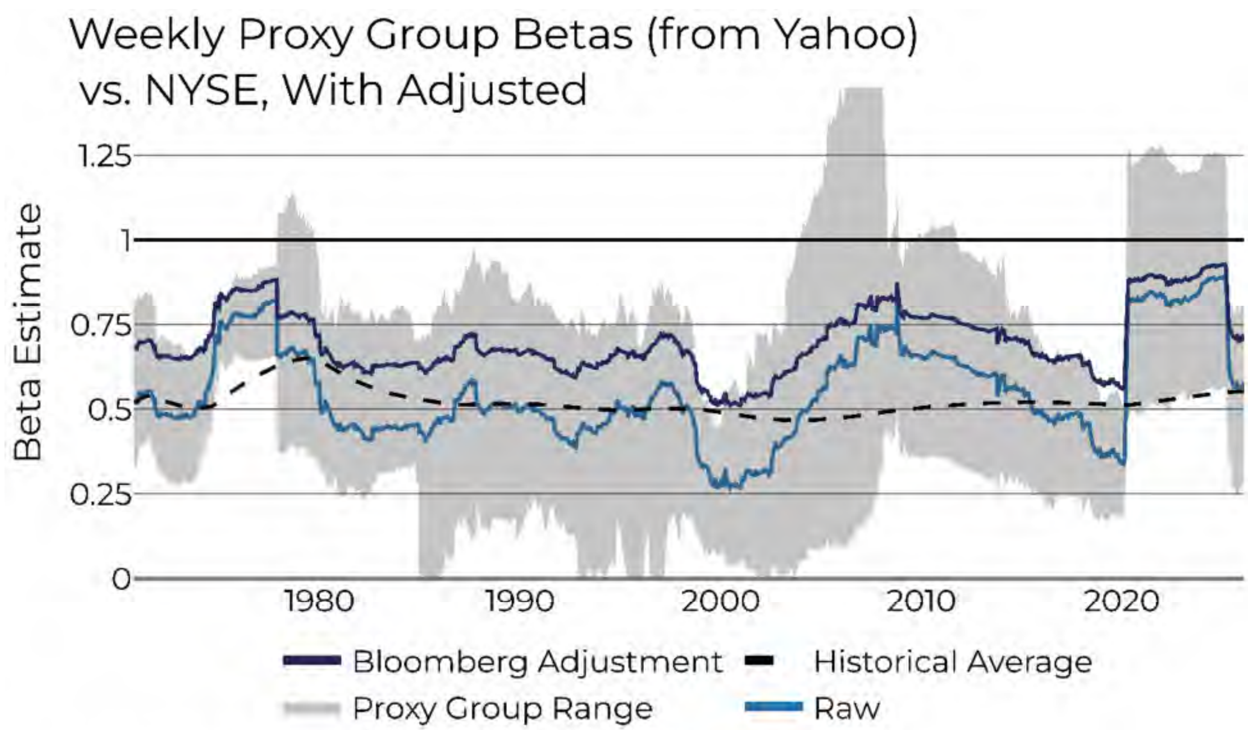

Weekly Proxy Group Betas (from Bloomberg)
vs. S&P 500, With Adjusted
Beta Estimate
1.25
1
0.75
0.5
0.25
0
1990
1995
2000
2005
2010
2015
2020
2025
Bloomberg Adjustment
Historical Average
Proxy Group Range
Raw

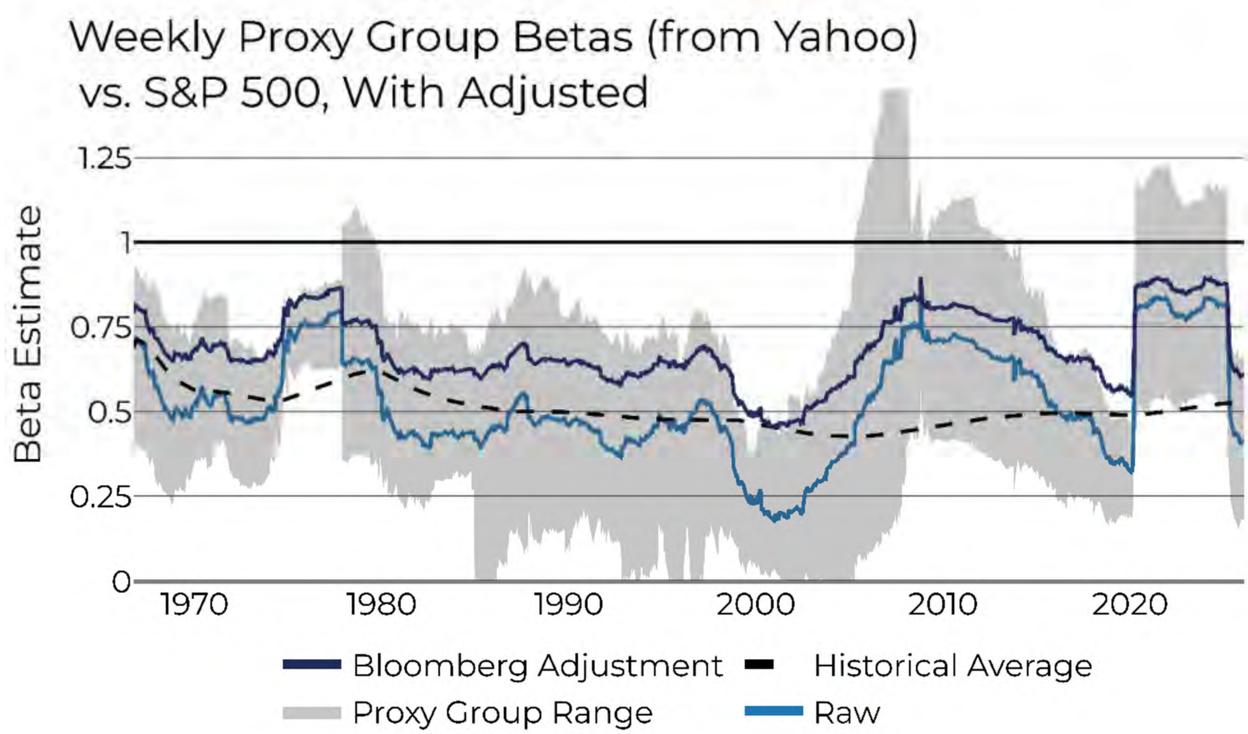
Monthly Proxy Group Betas (from Yahoo) vs. NYSE, With Adjusted



Monthly Proxy Group Betas (from Yahoo) vs. S&P 500, With Adjusted




Weekly Proxy Group Betas (from Yahoo)
vs. NYSE, With Adjusted
Beta Estimate
1.25
1
0.75
0.5
0.25
0
1980
1990
2000
2010
2020
Bloomberg Adjustment
Historical Average
Proxy Group Range
Raw


Weekly Proxy Group Betas (from Yahoo)
vs. S&P 500, With Adjusted
Beta Estimate
1.25
1
0.75
0.5
0.25
0
1970
1980
1990
2000
2010
2020
Bloomberg Adjustment
Historical Average
Proxy Group Range
Raw

Exhibit__(NYCRP-19)

The following tables show the average annualized tracking error of predicting proxy group utility stock prices, using reference indices and various beta adjustments.

Bloomberg Betas are historical values accessed via Bloomberg Terminal.

Yahoo! Finance betas are calculated using publicly available closing stock prices of proxy group utility companies and market references from Yahoo! Finance (accessed via API reference, using the publicly available software package yfinance accessed at https://pypi.org/project/yfinance/).

Daily stock prices are resampled on a weekly or monthly frequency, then the beta values are calculated as follows: β=cov(target stock,market reference)/(var(market reference))

The Bloomberg Adjustment is: β_adjusted=β_raw*2/3+1/3

The Historical Average Adjustment is: $\beta_{adjusted} = \beta_{raw} * \frac{2}{3} + (historical\ average\ beta) * \frac{1}{3}$, where the historical average beta is the average of all raw beta values in the utility proxy group calculated at a date not greater than the current beta calculation.

Tables show the average annualized tracking error for each specification (number of years' forecast/return frequency of beta calculation/data source of betas/beta adjustment method/market reference). In parentheses below each average value (except the monthly raw beta specification), the percentage difference between the average value at that specification and the average value using monthly raw betas, with the given number of years' forecast, market reference, and data source of betas.

Table 1

Average Annualized Tracking Error using S&P 500 Index and Various Beta Adjustments, Using Bloomberg Data				
Number of Years' Forecast	**Return Frequency**	**Raw (No Adjustment)**	**Historical Average Adjustment**	**Bloomberg Adjustment**
1	Monthly	17.2	17.1 (-0.7%)	17.3 (+0.4%)
1	Weekly	19 (+10.3%)	18.9 (+9.7%)	19 (+10.6%)
3	Monthly	18.3	18.1 (-0.9%)	18.3 (+0.2%)
3	Weekly	19.7 (+7.9%)	19.6 (+7.2%)	19.7 (+7.8%)

Table 2

Average Annualized Tracking Error using NYSE Index and Various Beta Adjustments, Using Bloomberg Data				
Number of Years' Forecast	**Return Frequency**	**Raw (No Adjustment)**	**Historical Average Adjustment**	**Bloomberg Adjustment**
1	Monthly	17.6	17.5 (-0.8%)	17.6 (+0.1%)
1	Weekly	18.8 (+6.6%)	18.7 (+5.8%)	18.7 (+6.4%)
3	Monthly	18.5	18.3 (-1.2%)	18.5 (-0.3%)
3	Weekly	19.4 (+4.7%)	19.3 (+3.9%)	19.3 (+4%)

Table 3

Average Annualized Tracking Error using S&P 500 Index and Various Beta Adjustments, Using Yahoo! Finance Data				
Number of Years' Forecast	**Return Frequency**	**Raw (No Adjustment)**	**Historical Average Adjustment**	**Bloomberg Adjustment**
1	Monthly	17.2	17.1 (-0.7%)	17.3 (+0.5%)
1	Weekly	19 (+10.3%)	18.9 (+9.7%)	19 (+10.7%)
3	Monthly	18.3	18.1 (-0.9%)	18.3 (+0.2%)
3	Weekly	19.7 (+7.9%)	19.6 (+7.1%)	19.7 (+7.8%)

Table 4

Average Annualized Tracking Error using NYSE Index and Various Beta Adjustments, Using Yahoo! Finance Data				
Number of Years' Forecast	**Return Frequency**	**Raw (No Adjustment)**	**Historical Average Adjustment**	**Bloomberg Adjustment**
1	Monthly	17.6	17.5 (-0.8%)	17.6 (+0.2%)
1	Weekly	18.8 (+6.6%)	18.7 (+5.9%)	18.7 (+6.4%)
3	Monthly	18.5	18.3 (-1.2%)	18.5 (-0.3%)
3	Weekly	19.4 (+4.8%)	19.3 (+3.9%)	19.3 (+4%)