INSTITUTIONAL ADVISORY & SOLUTIONS

FORECASTING LONG-TERM EQUITY RETURNS

A Comparison of Popular Methodologies

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The PGIM Institutional Advisory & Solutions group advises institutional clients on a variety of asset allocation, portfolio construction, and risk management topics.

Many investors need to make long-term asset class forecasts for planning and portfolio construction purposes. We examine the empirical performance of two different approaches to forecasting future ten-year equity returns: a regression methodology using CAPE and a more traditional "building block" approach. The regression approach produces estimates that are poor predictors of subsequent actual returns. The "building block" approach (BBA) outperforms the regression methodology (in terms of root mean squared error) with the repricing component helping to capture periods of poor equity returns. A high CAPE value is not necessarily cause for alarm and changes in asset allocation. If an investor plans to use a methodology that over time will prove more accurate, then the historical record is more supportive of the BBA approach, with or without a repricing component based on current P/E.

Introduction

CIOs use forecasts of long-term equity returns for their asset allocation decisions. Despite considerable research on the topic, there is a wide range of views for how best to generate forecasts for long-term equity returns. For example, some investors believe that equity markets are efficient (*i.e.*, equity prices reflect "all available information") and that future returns follow a random walk. If so, *expected* future returns are constant over time. While subsequent future realized returns will vary considerably, no information available today can help investors forecast future returns. For investors with this view, a long-term historical average return often serves as their constant return forecast.

However, other investors believe that expected future returns vary over time, conditional on some measure of current market valuation or market outlook. For example, when the market is "richly valued", future returns are likely to be lower than average, and *vice versa*. In other words, there is some limited ability to predict future market returns. Such a view is intuitive and commonsensical to many investors as we all remember periods of poor equity market returns following market valuation peaks (*e.g.*, 1999). However, memories can be selective and tend to disregard experiences that do not conform to our prior beliefs. Nevertheless, this view is pervasive.

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For CIOs holding the view that expected returns are time-varying, what has been the best way to generate forecasts of long-term US equity market (S&P 500 Index) total returns? To analyze this issue, we evaluate the out-of-sample historical performance of two common approaches, or methodologies, for estimating 10-year equity market returns. The first forecast methodology is based on CAPE (the cyclically adjusted price-to-earnings ratio), a market valuation metric, and generates a forecast by way of a regression using historical data. The second forecast methodology is a "building block" approach that builds a market forecast by combining more forward-looking estimates of individual components, or blocks, of future returns. Which approach has had a better track record? Has either approach produced better forecasts than simply using a long historical average return as a predictor of future returns?

The CAPE valuation metric is a variant of the well-known price-to-earnings ratio (P/E), and is calculated by dividing the real stock price by the 10-year average of inflation-adjusted earnings. Historically, high CAPE values have been associated with lower than average long-term equity market returns, and *vice versa*. While CAPE has been used to forecast equity returns over a range of horizons, it is often considered to have better predictive power over horizons of 10 to 20 years – which coincides with common horizons for long-term asset allocation. For our study, we first estimate the historical relationship between CAPE and subsequent realized returns using regression. We then project this estimated historical relationship forward to forecast equity returns.

The "building block" approach (BBA) is the most commonly used method for constructing capital market assumptions. Typically, this method uses an accounting identity to decompose equity returns into factor "blocks" of returns including inflation, real earnings growth, income return, and expected repricing. Then, forecasts of each block are summed to generate a market forecast. For our study, we use common market forecasts for each "block", if available, otherwise we use historical data. We then take the sum of our "blocks" to be the forecast of equity returns under the BBA approach.

We run a "horse race" between basic versions of the CAPE and BBA approaches to evaluate their ability to forecast subsequent 10-year equity returns.[1] During the full period of analysis (1990–2008), we find that the BBA approach, with root mean squared error (RMSE) of 3.7% (percentage points) and an error range of [−7.2%, 8.9%], outperforms the CAPE approach, which has an RMSE of 5.6% (percentage points) and an error range of [−10.5%, 7.9%]. We detail how each methodology performs since 1990 and explore possible reasons why the BBA approach has outperformed.

CAPE Approach (Regression-Based)

Campbell and Shiller (1998) found the ratio of the real stock market price divided by the 10-year average of inflation-adjusted earnings – which they called the cyclically adjusted price-to-earnings ratio (CAPE) – to have a strong empirical relationship with subsequent equity returns. This finding relates back to the fundamentals of stock market valuation and is supported by both theory and empirical evidence. Valuation (*i.e.*, CAPE) ratios have been observed to fluctuate within a range, and if we assume they will continue to do so, then if the CAPE ratio is at the higher end of its range then either future prices must fall or future earnings must rise. If earnings are relatively stable over time, then it would be reasonable to expect that when CAPE is extremely high compared to its historical range, prices will eventually fall to restore the valuation ratio back to more normal values.

It is important to highlight that Campbell and Shiller reported a long-term *empirical* relationship (*i.e.*, the result was "in-sample"). Campbell and Shiller did not analyze the ability of CAPE to *predict* returns (*i.e.*, "out-of-sample" performance). To illustrate Campbell and Shiller's findings, Figure 1 groups actual 10-year equity return ranges by the corresponding beginning-of-period CAPE value.[2] The average 10-year (annualized) equity returns clearly decline as we move to higher CAPE (*i.e.*, more "overvalued") groups. However, the range of returns corresponding to low-CAPE values is completely overlapped by that of the mid-CAPE group. In other words, some mid-CAPE years have produced better returns than the best return from a low-CAPE value. In addition, the high-CAPE group features some returns similar to those in the mid-CAPE group. Therefore, we see that high-CAPE values sometimes correspond to low 10-year equity returns, while low and mid-CAPE values are relatively uninformative in terms of future equity returns. So, despite the general average inverse relationship between CAPE and subsequent equity returns, it is an open question whether CAPE has much predictive power.

Nevertheless, since its publication, the in-sample empirical relationship between CAPE and subsequent equity returns has been exploited and widely-publicized as a guide for long-term stock market forecasting. As Siegel (2016) says, the CAPE ratio "has served as one of the best forecasting models for long-term future stock returns".[3]

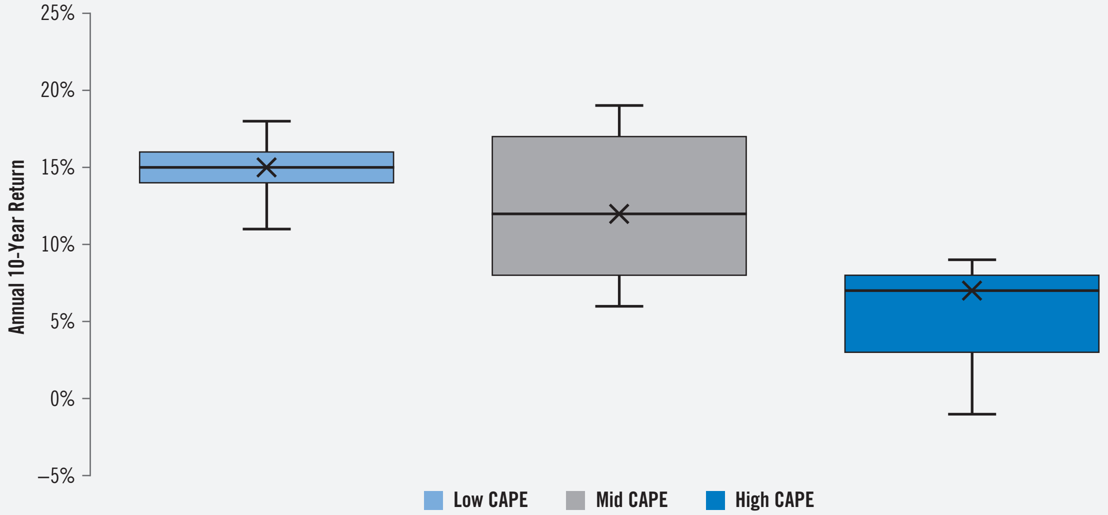
Setting aside for the moment whether there is a predictive relationship between CAPE and subsequent equity returns there is robust disagreement regarding the explanation for the observed empirical relationship. Some argue that the inverse relationship between CAPE and subsequent market returns is due to market inefficiency (*e.g.*, excessive over- or under-valuation due to speculative bubbles or investor psychology) which can be profitably exploited by rational investors. On the other hand, however, proponents

1 There are many variants, many of them proprietary, of both the CAPE and BBA forecasting approaches. We consider the approaches most widely publicized.

2 Low-CAPE corresponds to the bottom third of CAPE values in the range of beginning-of-year CAPE values from 1970–2008, mid-CAPE to the middle third of CAPE values, and high-CAPE to the top third.

3 Siegel, Jeremy J. "The Shiller CAPE Ratio: A New Look." *Financial Analysts Journal*, vol. 72, no. 3 (2016): 41–50.

Figure 1: Actual 10-Year US Equity (S&P 500) Return Ranges by Beginning-of-Period CAPE Value (1970–2008)



Note: Each block represents the return range for each CAPE group. The "x" represents the mean of the subsequent 10-year equity total returns; the bottom and top borders of the box represent the 25th and 75th percentiles of returns, respectively; and the end of the bottom and upper lines ("whiskers") extending from the box represent the minimum and maximum returns within 1.5 times the interquartile range.
Source: Datastream, Online Data-Robert Shiller, and PGIM IAS. Provided for illustrative purposes only.

of the efficient market hypothesis would argue that the observed inverse relationship reflects compensation for changes in market risk. For example, low P/E ratios tend to occur when the economy is performing poorly and investors perceive a higher risk from investing in equities. The observed higher subsequent returns simply reflect compensation for this higher risk. As Fama (1991) would say, "bubbles in stock prices are indistinguishable from rational time-varying expected returns."[4]

We evaluate CAPE's performance as a forecaster of future equity returns, without taking a position on the matter of market efficiency. We employ the following regression, which estimates the relationship between CAPE (actually, 1/CAPE) at the beginning of a year and the subsequent 10-year equity returns, without the need for subjective inputs (as we will see are required for the BBA approach):

$$r_{t,t+10} = \alpha_t + \beta_t \times \frac{1}{CAPE_t} + \varepsilon_{t,t+10} \quad (1)$$

where $r_{t,\,t+10}$ represents 10-year annualized equity market returns for the 10-year period beginning at time t.

To estimate the regression coefficients in equation (1) we consider two different estimation windows:

1. **CAPE-r:** a rolling 10-year, fixed window beginning in 1970; and
2. **CAPE-e:** an expanding window beginning in 1970.

We use the estimated parameters from equation (1) to form our objective forecasts.[5] Since we wish to evaluate CAPE's predictive power, we strive to avoid any "look-ahead bias" when generating forecasts and only avail ourselves of data available at the time a forecast is being made. For instance, if we are at the beginning of 2000 (and we wish to generate a 10-year equity forecast for the 2000–2009 period) we only use historical annual CAPE and equity returns data up to the beginning of 2000. This out-of-sample procedure for forecasting future returns is repeated for each year from 1980 onwards.

For equity total returns we use S&P 500 index total returns (from Datastream) and obtain CAPE data from 1970–2007 from Shiller's online database. Figure 2 provides a scatterplot of 1/CAPE and subsequent future equity returns. We see that, generally, when 1/CAPE is low (*i.e.*, CAPE is high and the market is relatively "overvalued"), 10-year ahead equity returns appear to be low and *vice versa*. However, while this scatter plot suggests a strong empirical ("in-sample") relationship between the two variables, it does not necessarily signal that there is a predictive ("out-of-sample") relationship. To get a sense for why there might not be a strong predictive relationship note that 1/CAPE values of approximately 6% have been associated with both relatively low returns

4 Fama, Eugene F. "Efficient Capital Markets: II." *The Journal of Finance*, vol. 46, no. 5 (1991): 1575–1617.
5 Regression statistics are provided in Figure A1 of the Appendix.

(6.7%) and high returns (18.2%). This wide range of equity market returns associated with similar CAPE values raises questions about CAPE's predictive power and the use of this approach for asset allocation.

To see this issue another way, Figure 3 plots 1/CAPE values and subsequent 10-year returns as time series. While the relationship between 10-year returns and CAPE appears to be strong prior to 1987, it was severely weakened by the high CAPE values (*i.e.*, low 1/CAPE values) paired with high equity returns during the 1988–1991 period. Few investors may recall that CAPE was relatively high in 1994 (21.4) and yet subsequent 10-year returns were above average (11.1%).

Figure 4 shows the time-varying CAPE-r and CAPE-e forecasts alongside actual S&P 500 10-year returns. Both CAPE-based forecasts formed in 1990 and 1999 performed poorly. For example, at the beginning of 1999, CAPE-r and CAPE-e produced equity forecasts of 15.0% and 5.6% (annualized), respectively, whereas the subsequent actual 10-year return was −0.3%. We see that while the CAPE regression tries to incorporate changing market valuation conditions when forming forecasts, for these years the estimated relationship between CAPE and returns impaired, rather than helped, its predictive ability.

Figure 2: 10-Year Returns and CAPE (inverted)
(1970–2008)

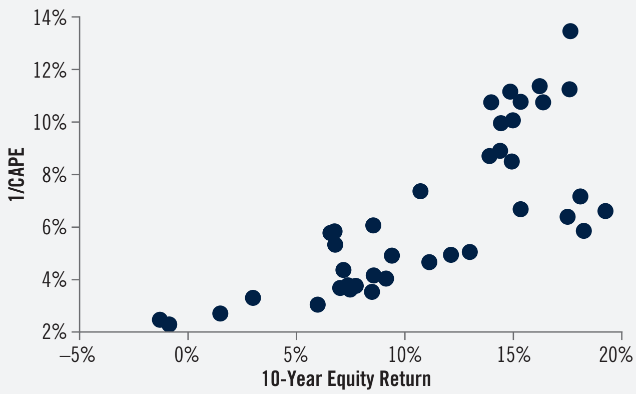
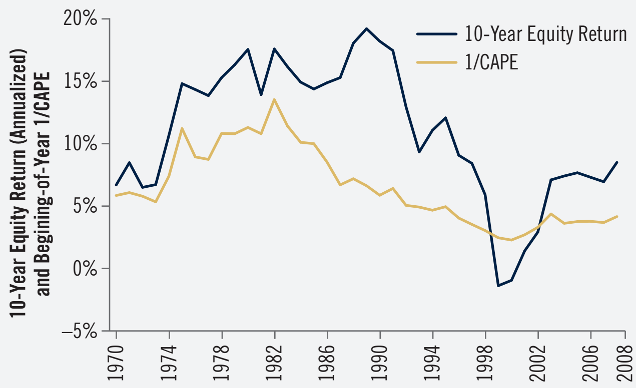
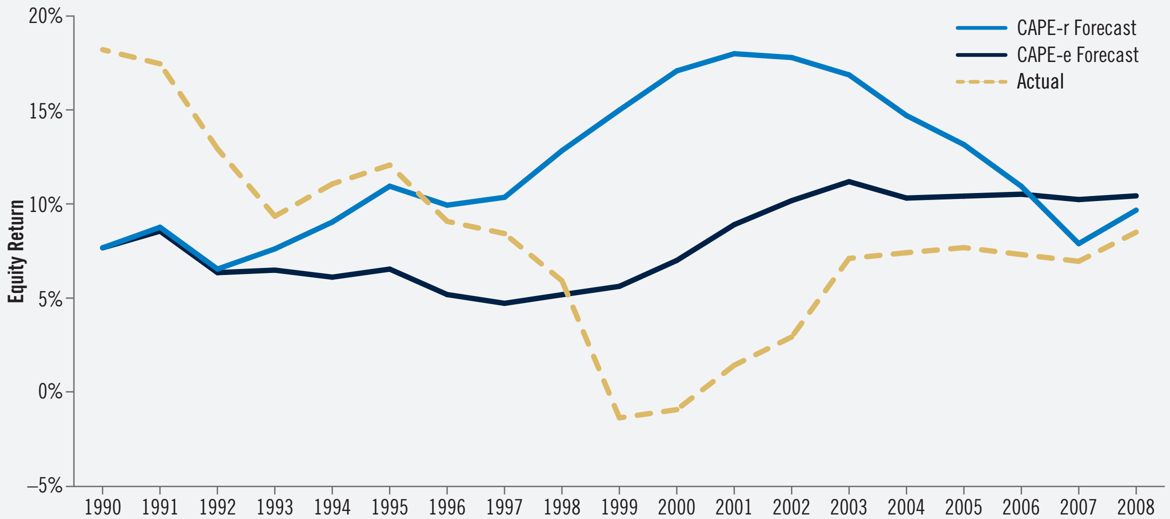


Figure 3: CAPE (inverted) and 10-Year Equity Returns
(1970–2008)



Source: Datastream, Online Data-Robert Shiller and PGIM IAS. Provided for illustrative purposes only.

Figure 4: CAPE-Based 10-Year Return Forecasts and Actual 10-Year Returns (Annualized)
(1990–2008, beginning of 10-year period)



Source: Datastream, Online Data-Robert Shiller, and PGIM IAS. Provided for illustrative purposes only.

It may be surprising that CAPE-based predictions sometimes perform very poorly, given the often-heard strong empirical relationship between current CAPE and subsequent equity returns (Figure 3). It is important to remember while goodness-of-fit measures are useful in assessing the *historical* fit of the regression, they remain silent on the topic of future predictive power of future *non-observed* returns. Shiller himself acknowledges that CAPE is not an omniscient predictor. In a 2012 interview, Shiller acknowledged "things can go for 200 years and then change, I even worry about the 10-year P/E — even that relationship could break down".[6]

Building Block Approach

The building block approach (BBA) is probably the most common institutional methodology for estimating long-term asset class returns. Following a decomposition of equity returns into its components, the BBA approach estimates each component using forecasts and historical information to construct an asset class's expected return. Ibbotson and Siegel (1988) proposed the first precursor to the modern BBA approach by stacking various risk premiums – "blocks" representing components of returns – to derive an estimate of future equity returns. More recently, Grinold and Kroner (2002) show that equity total returns (in percent) can be decomposed into the following components:[7]

$$\text{Returns} \equiv \text{inflation} + \text{real earnings growth} + \text{income return} + \text{repricing} \tag{2}$$

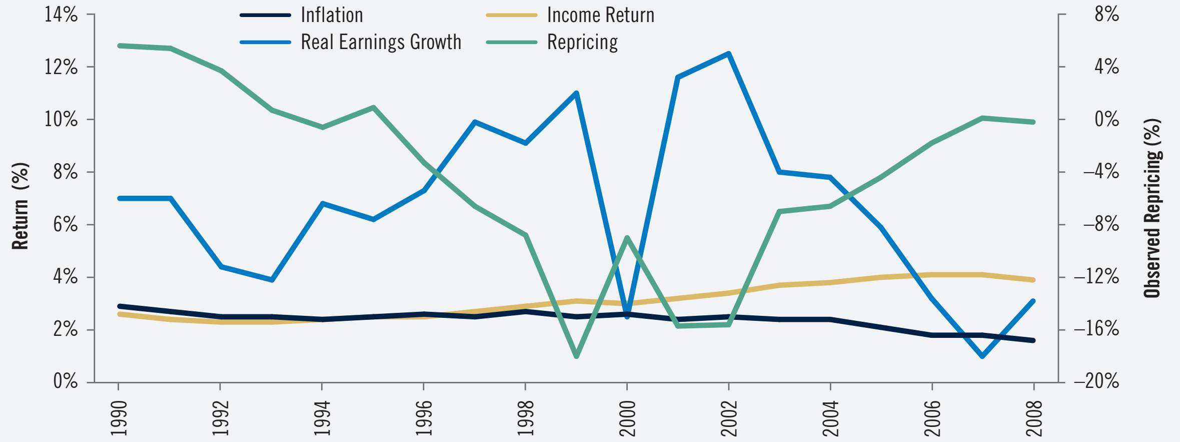
It is important to emphasize that equation (2) is an identity. However, by providing forward-looking estimates for each of these building blocks, one can generate a prediction for future equity total returns. Theoretically, if the estimates are accurate then we will have correctly predicted future equity returns. However, in providing estimates, we often introduce subjectivity into the BBA forecast and its predictive ability is only as good as the quality and suitability of our inputs. Consequently, although the building block methodology is widely used by investors, the variety of possible assumptions and inputs can lead to a wide range of equity market forecasts across investors. We will discuss the considerations that go into each block in the next section.

Data for BBA Approach

We propose estimators for each of the building block components, and then measure how well the BBA approach has performed as a predictor of 10-year equity market returns. Just as for the CAPE approach, we avoid any look-ahead bias and only use available contemporaneous data to estimate each building block and to generate equity market forecasts.[8]

Figure 5 shows several components of the actual 10-year equity market (S&P 500) total returns (using equation (2)) from 1990 to 2008. Observed 10-year inflation, real earnings growth, and income return[9] are plotted on the left axis and the "observed

Figure 5: 10-Year Equity Return Components (Actual)
(1990–2008; beginning of 10-year period)



Source: Datastream, FRED, and PGIM IAS. Provided for illustrative purposes only.

6 Kemp, Michael. *Uncommon Sense: Investment Wisdom since the Stock Market's Dawn.* Wiley, 2016.
7 For the derivation of this relationship, please see Grinold and Kroner (2002).
8 We also try to avoid data that has been either back-calculated/back-adjusted or did not exist during the historical period of analysis.
9 Inflation is the annualized 10-year horizon change in CPI headline inflation, real earnings growth is the annualized 10-year horizon change in corporate profits, and income return is the annualized 10-year horizon dividend yield less the annualized 10-year horizon net buyback yield.

repricing" component (any adjustment to returns not explained by the other three blocks), is plotted on the right axis. We see that the noisiest component of returns has been the repricing block, followed by real earnings growth. Inflation and the income return have remained relatively stable.

Inflation

For the Inflation block, we use the 10-year headline CPI Inflation Estimate[10] provided by the *Survey of Professional Forecasters*.[11]

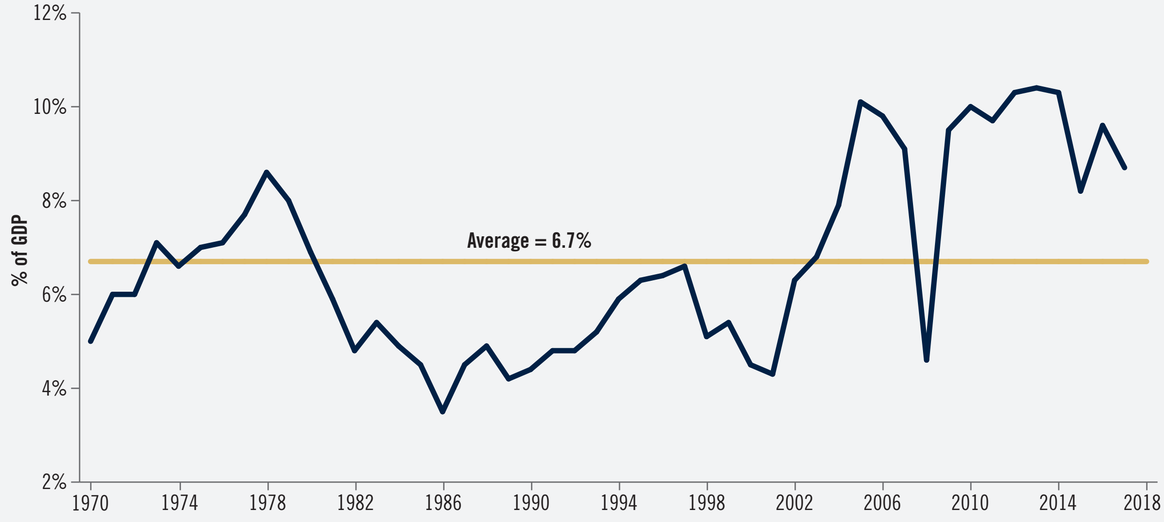
Real Earnings Growth

The Real Earnings Growth block represents the expected growth rate of equity earnings. Many users of the BBA approach exploit the empirical long-run link between broad economic growth and earnings growth which indicates that corporate profits have not deviated too far from constituting about 6.7% of GDP (Figure 6). Therefore, we equate our expected real earnings growth with the median 10-year GDP growth forecast provided by the *Survey of Professional Forecasters*.[12]

Expected Repricing

Expected Repricing measures the component of return an equity investor receives due to reversals in valuation ratios, *e.g.*, changes in P/E, CAPE, *etc*.[13] We use P/E[14] as our valuation following the well-known mathematical decomposition of equity total returns (Grinold and Kroner 2002). Figure 7 shows how P/E has changed since 1973. For this study we present two sets of results depending on the assumptions for the repricing block value: **BBA-n** assumes the market is always properly priced (à la an efficient markets view) and there is zero repricing adjustment, while **BBA-rp** assumes a non-zero repricing component. To separate the signal from the noise, we only apply the non-zero repricing component[15] when valuation (P/E) has moved sufficiently far from a long-term average value warranting adjustment.[16] Note that the BBA-rp forecast is identical to the BBA-n except for the inclusion of a non-zero repricing component when a threshold is crossed.[17]

Figure 6: US Corporate Profits as Percent of GDP, Annual
(1970–2008)



Source: FRED; National income: Corporate profits before tax (without IVA and CCAdj) over Gross Domestic Product, Datastream, and PGIM IAS. Provided for illustrative purposes only.

10 "10-Year Inflation Estimate," *Survey of Professional Forecasters*. 10-year headline CPI Inflation Estimates are calculated from the geometric average of quarter-over-quarter median one-year-ahead annual average inflation forecasts measured by the CPI. 10-year forecasts were available starting in Q4 1991 so our 1990–1999 and 1991–200 10-year inflation forecasts are calculated by taking the geometric average of quarter-over-quarter average one-year-ahead annual average inflation forecasts measured by the CPI since they were available in Q3 1981.

11 Since its inception in 1968, the *Survey of Professional Forecasters* is the oldest quarterly survey of macroeconomic forecasts in the US. The estimates from the respondents were gathered by the American Statistical Association and the National Bureau of Economic Research until 1990 when the Federal Reserve Bank of Philadelphia took over the survey.

12 10-year GDP forecasts were available starting in 1992 so for our 1990–1999 and 1991–2000 equity return estimation we use the annualized 10-year historical GDP growth for 1980–1989 and 1981–1990, respectively.

13 We acknowledge that some use CAPE for expected repricing, which we confirm yields a similar repricing value.

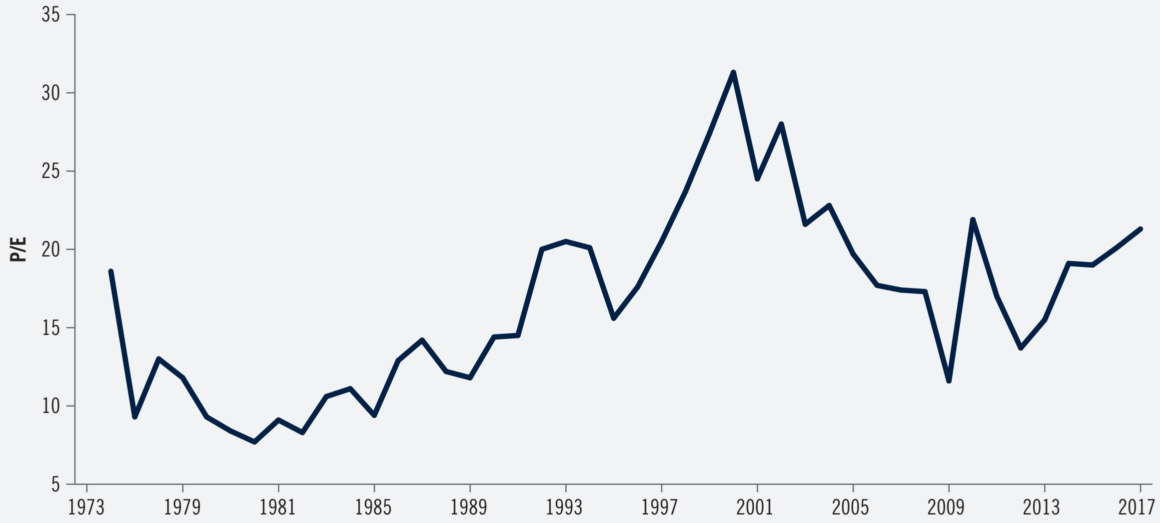
14 Datastream's S&P 500 P/E ratio data, calculated by taking price over trailing 12-month earnings, not the Shiller CAPE.

15 The repricing block is defined as the difference of the beginning-of-forecast-period P/E and the prevailing average P/E since 1970 divided by the beginning-of-the-period CAPE.

16 When the difference between the observed and historical average P/E is greater than 1.75 standard deviations of all deviations, where the standard deviation is calculated looking backward from the date the forecast is made.

17 We acknowledge that our selection of a threshold introduces some hindsight bias into our repricing component as we are knowledgeable of the full P/E time series.

Figure 7: P/E Ratio, Annual
(1973–2017)

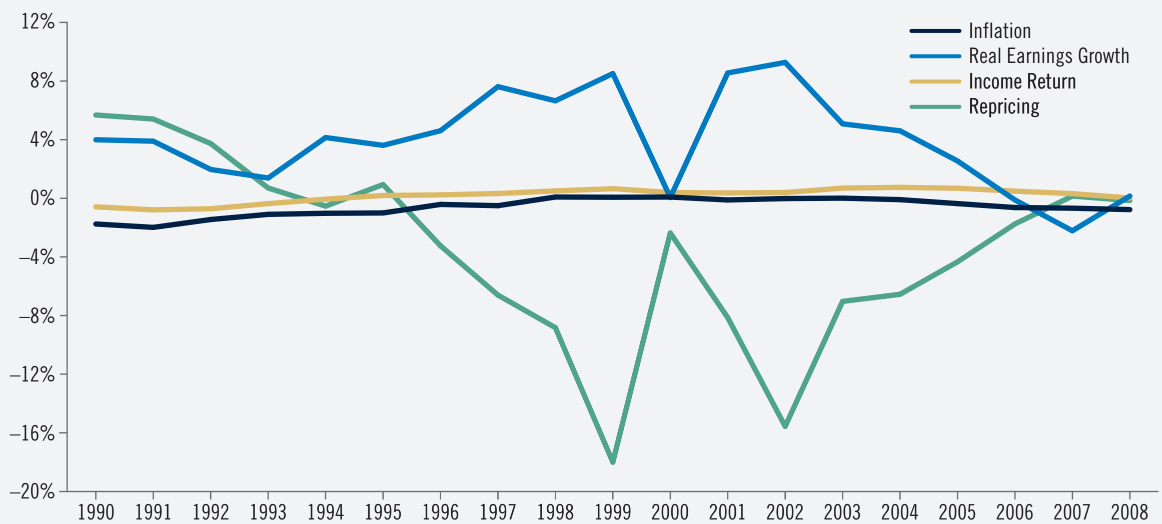


Source: Datastream calculated S&P 500 P/E ratio data and PGIM IAS.

Unlike the regression-based CAPE approach, the BBA's non-zero repricing component is more subjective. However, it is important to note that the two methodologies are not necessarily in conflict – both employ the P/E (or the variant, CAPE) to inform return forecasts – it is only the application of the valuation ratio that differs.

Figure 8 examines how close each block estimate comes to the realized block value. For each return component, we subtract the predicted value from the realized value – for example, for the inflation block we subtract the 10-year inflation forecast from actual annualized 10-year inflation. For our repricing error, we subtract our calculated repricing block from the "observed repricing", which we defined in Figure 5 as any adjustment to returns not explained by the other three observed blocks. The inflation and income return estimates are generally accurate. We overestimate real earnings growth, which is offset by the repricing component.

Figure 8: BBA-rp Forecast Error by Block
(1990–2008, beginning of 10-year period)

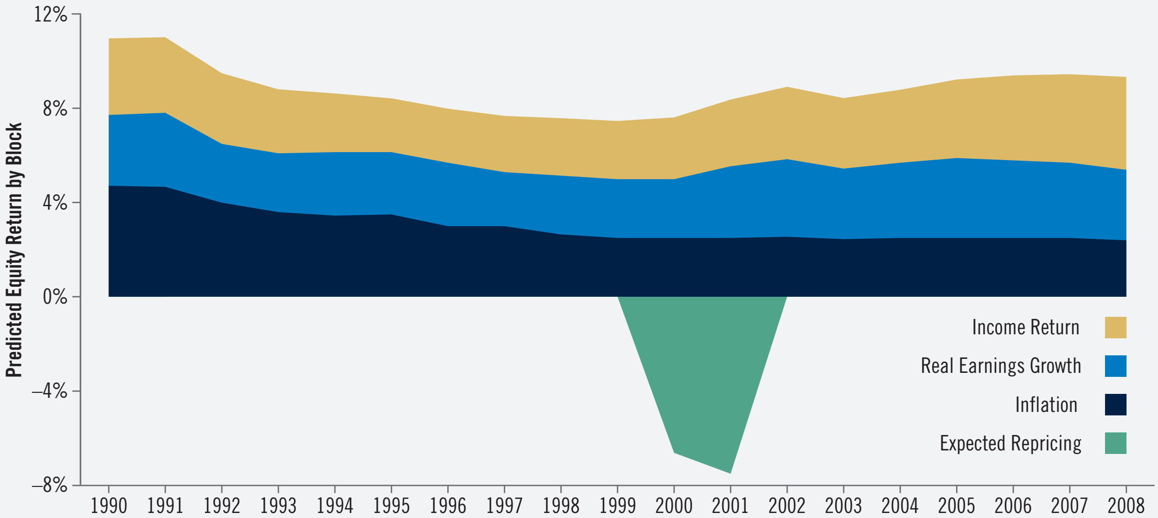


Source: Datastream, FRED, *Survey of Professional Forecasters*, and PGIM IAS. Provided for illustrative purposes only.

However, this symmetry is largely mechanical since, by construction, forecast errors sum to the difference between actual returns and the BBA-rp forecast.

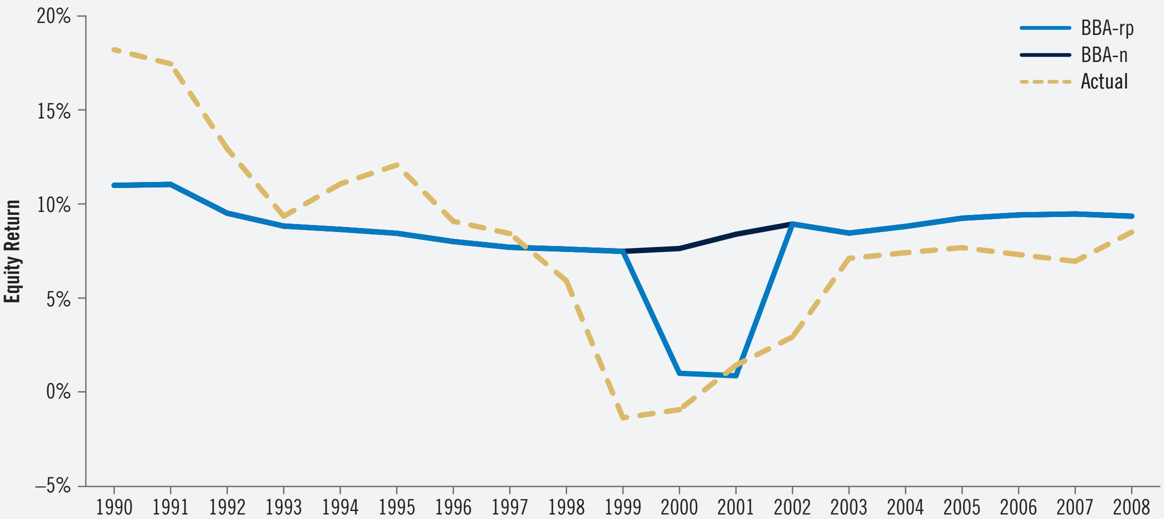
We use both BBA approaches to produce 10-year equity forecasts by taking the sum of the blocks. For example, to produce our 10-year equity forecast for 2000, we sum the annualized 10-year horizon inflation estimate for 2000 (2.5%), annualized 10-year GDP forecast for 2000 (2.5%), the average S&P 500 dividend yield less the average S&P 500 net buyback yield from 1990–1999 (2.6%), and the repricing component (−6.2% for BBA-rp, or 0% for BBA-n). For BBA-rp, Figure 9 shows the contribution each block makes to each 10-year horizon equity return forecast. We see that over time, the contributions from income return and real earnings growth have somewhat increased while that from inflation has declined, but for the most part each block forecast remains relatively stable throughout the 1990–2008 study period. The repricing block was non-zero only for the years 2000 and 2001.

Figure 9: BBA-rp Approach Forecast by Block
(1990–2008; beginning of each 10-year period)



Source: Datastream, FRED, *Survey of Professional Forecasters*, and PGIM IAS. Provided for illustrative purposes only.

Figure 10: Estimated Returns and Actual Returns using Different BBA Methodologies
(1990–2008, beginning of each 10-year period)



Source: Datastream and PGIM IAS. Provided for illustrative purposes only.

Figure 10 plots the BBA-n and BBA-rp 10-year return forecasts alongside the actual S&P 500 10-year returns. It is noteworthy that the BBA-n forecast has been roughly constant over time. This is because inflation, earning growth and income return forecasts have not varied much. Combined with a zero-repricing assumption, the BBA-n forecast is relatively constant, like a forecast given by a "simple" historical average estimator or a forecast given by someone with a view that the market follows a random walk.

In contrast, forecasts from BBA-rp are somewhat more time varying. Due to the repricing component, BBA-rp correctly anticipated poor 10-year returns for the periods beginning in 2000 and 2001 (which the BBA-n method missed). Referring to Figure 4 we see that while the CAPE-based expected returns were time varying, it forecasted *higher* 10-year returns beginning in 2000 and 2001.

Analysis of Results

Using both the BBA and CAPE methodologies, we produce four historical predictions for 10-year equity returns (Figure 11). For CAPE, we have two sets of results depending on the estimation window employed: CAPE-r for a rolling 10-year fixed window and CAPE-e for an expanding window. For the BBA approach, we also have two sets of results depending on the inclusion of the repricing block: BBA-rp for inclusion of a repricing component and BBA-n for no repricing.

For comparison we also produce other equity market return predictors that do not depend on measures of current market valuation or market outlook. One simple predictor is the most recent historical (to date) 10-year S&P total return (*e.g.*, actual returns for 2008–2017 is the estimate for 2018–2027 returns). Alternatively, we can assume the next 10-year equity return is equal to the average 10-year S&P 500 total return for all 10-year periods from 1980 up to the estimation year. We will call these two simple historical estimators "10-year historical" (**Hist-10**) and "historical expanding" (**Hist-e**), respectively. For comparison, we also report results assuming that for each year's prediction, we draw from the (to-date) sample of 10-year returns. We label this estimator "**Random**".

We see that CAPE-r and the simple historical estimators give return forecasts that are, on average, much larger than the actual average 10-year equity returns (8%), while both BBA and the CAPE-e forecasts come much closer to matching the actual average equity return. None of the forecasts capture the true volatility of returns and there is very little variability in the BBA-n forecasts altogether.

Using root mean squared error (RMSE) as the metric of prediction ability, where a lower RMSE value indicates lower prediction error and therefore, a better forecaster, we see that the BBA-rp and BBA-n performed best, with RMSE values of 3.7% and 4.5%, respectively. In contrast, CAPE-r, with an RMSE of 9.1%, not only performs worse than both BBA methods but also worse than any of the two simple historical measures. CAPE-r also performed no better than simply making a random guess! On the other hand, CAPE-e, with an RMSE of 5.6%, comes closer to the forecasting ability of both BBAs.

The relative results for CAPE and BBA highlight that good historical correlation does not necessarily translate into superior predictive performance. We see that the in-sample (1990–2008) correlation of 1/CAPE and actual 10-year equity returns (95.3%) is greater than that of BBA-rp and returns (60.7%).[18] This would seem to suggest that the CAPE would be a better forecaster of returns than the BBA approach. However, we see that this is not the case – the (out-of-sample) correlation of CAPE-e forecasted returns and actual 10-year equity returns (−5.9%) is less than that of the correlation between BBA-rp and actual equity returns (70.4%), a reminder that historical correlation is not necessarily indicative of predictive ability.

Figure 12 illustrates how the RMSE has evolved for each forecast approach.[19] We see that relatively larger forecast errors came from a small handful of periods – for instance, the CAPE-r forecast performed very poorly in the 1998–2001 periods during which the RMSE increased from 5.7% to 9.8%.[20] This can be attributed to the directional projections produced by the regression methodology that predicted increasingly larger equity return forecasts alongside decreasing actual future equity returns.

Figure 11: Estimated Returns and Actual Returns; Different Forecasting Methodologies
(1990–2008; beginning of each 10-year period)

	CAPE-r	CAPE-e	BBA-rp	BBA-n	Hist-10	Hist-e	Random	Actual
Average	11.80%	8.00%	8.10%	8.80%	14.00%	12.10%	13.50%	8.00%
StDev	3.80%	2.20%	2.60%	1.00%	3.80%	0.90%	4.50%	5.20%
RMSE	9.1%	5.6%	3.7%	4.5%	9.0%	7.0%	9.2%	

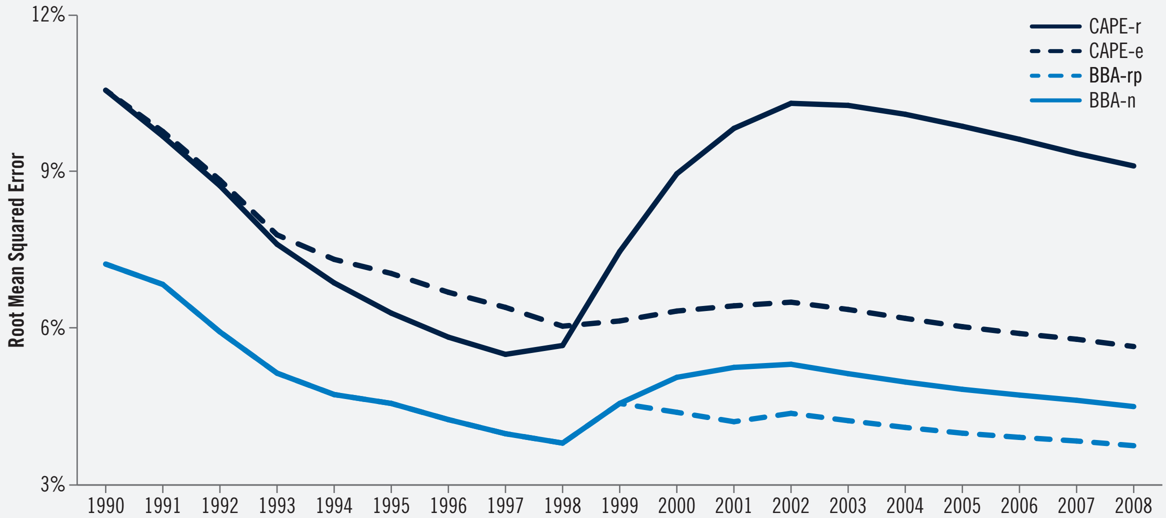
Source: Datastream, Online Data-Robert Shiller, and PGIM IAS. Provided for illustrative purposes only.

18 For our "in-sample" BBA-rp, we calculate inflation, real earnings growth, and income return over the same time period as our actual equity returns and use the annualized 10-year horizon change in P/E as our "realized" repricing block.

19 Starting from the 1990, we calculate the running RMSE and plot the result.

20 For forecasted and actual 10-year equity returns, see Figure A2 in the Appendix.

Figure 12: Root Mean Squared Error Evolution over Time; Different Forecasting Methodologies
(1990–2008; beginning of 10-year period)



Source: Datastream, Online Data-Robert Shiller, and PGIM IAS.

Figure 13 compares the range of returns for the four different methodologies together with that of actual returns. The profile of each forecasting methodology or actual return is represented by a block. The "x" represents the mean of the forecasted returns, the bottom and top borders of the box represent, respectively, the 25th and 75th percentiles of the forecasts, and finally the end of the bottom and upper lines ("whiskers") extending from the box represent the minimum and maximum values within 1.5 times the interquartile range.

Relative to the actual returns, all four forecasting methods produce estimates that are less dispersed around their mean values. The range for actual S&P 500 returns is [−1.4%,18.2%] and those for CAPE-r, CAPE-e, BBA-rp, and BBA-n are [6.5, 18.0%], [4.7%, 11.2%], [1.2%, 11.1%], and [7.5, 11.1%], respectively. We see that the CAPE methods exhibit more variation in forecasts as they rely on the dynamic relationship of equity returns and CAPE values through time. The stability of the BBA approach forecasts can be attributed to the method's reliance on long-horizon building block component forecasts which, as shown in Figure 9, have been relatively constant over time.

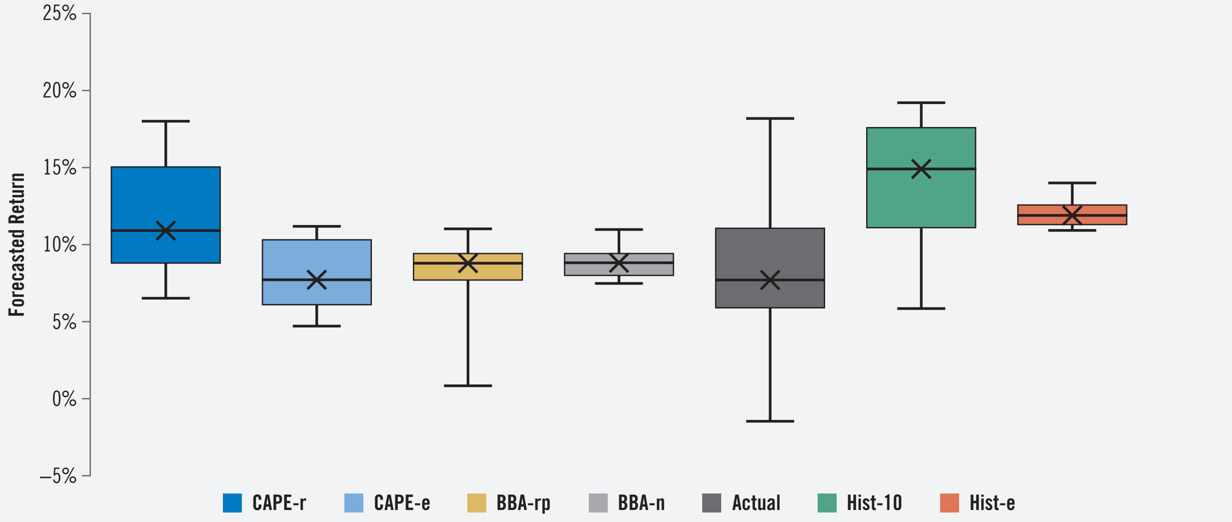
However, the stable nature of the BBA-n (BBA-rp) forecast seems to challenge the impression that the BBA approach tries to capture the time varying nature of returns. In fact, the constant nature of the BBA-n (BBA-rp) forecast, which hovers around 8.8% (8.1%), seems to have more in common with the efficient markets view in which equity prices reflect "all available information" so that future returns follow a random walk and *expected future returns are constant*. Proponents of this view recognize that while future realized returns subsequently vary considerably, no information available in the present seems to help investors forecast future returns.

The observed forecast stability can be directly attributed to the relatively constant macroeconomic block forecasts, probably due to the mature nature of the US economy. It is likely that in a different market environment (or, economy), with more highly time-varying block components, the BBA approach forecast would not be so stable. Therefore, this alignment of the BBA approach with the efficient markets hypothesis is perhaps only the product of examining relatively developed-market returns like the US S&P 500.

Given the relatively narrow range of estimates produced by all four techniques relative to the large range of actual returns, it is also no surprise that the estimation error takes extreme values on both sides of actual returns. However, we note that not all periods had equal estimation error – as the relatively larger forecast errors came from a small handful of periods. This begs the question of whether market environments drive relative prediction success. Does the CAPE approach do better when CAPE values are at extremes? Does the BBA approach only exhibit better forecasting ability than the CAPE approach in times of market crisis? To answer these questions, we plot the forecast error (actual minus predicted 10-year returns) of BBA-rp and CAPE-e against the beginning-of-period CAPE value (Figure 14) and through time (Figure 15).[21]

21 We calculate the forecast-error by taking the difference between the actual and forecasted 10-year equity return.

Figure 13: Estimated Returns and Actual Return Ranges; Different Forecasting Methodologies
(1990–2008; 10-year period)



Note: Each block represents the return range for each forecast method. The “x” represents the mean of the forecasted returns; the bottom and top borders of the box represent the 25th and 75th percentiles of the forecasts; and the end of the bottom and upper lines (“whiskers”) extending from the box represent, respectively, the minimum and maximum values within 1.5 times the interquartile range.
Source: Datastream, Online Data-Robert Shiller, and PGIM IAS. Provided for illustrative purposes only.

Figure 14: Forecast Error Sorted by Beginning CAPE Value
(1990–2008)

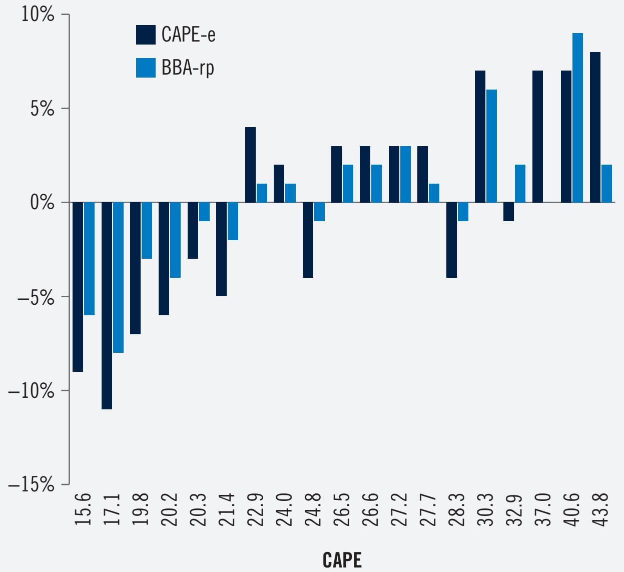
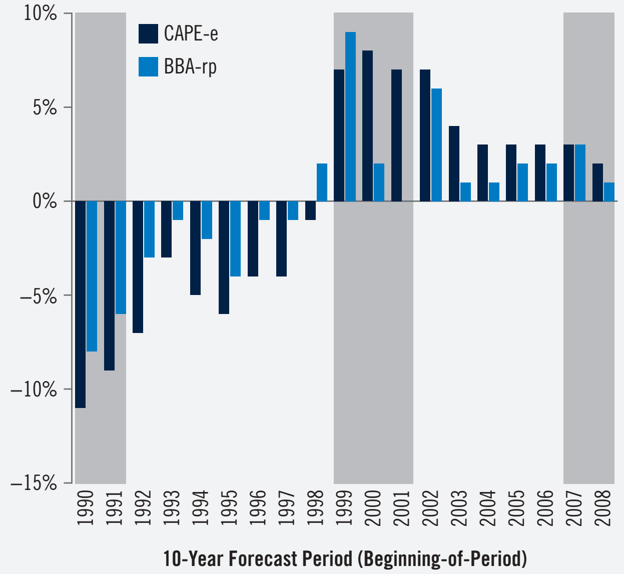


Figure 15: Forecast Error Time Series; BBA-rp & CAPE
(1990–2008)



Note: The bars in the figures represent the forecast error (predicted minus actual 10-year returns) of BBA-rp and CAPE-e against the beginning-of-period CAPE value (left) and through time (right). Gray boxes (right) represent equity bear markets, *e.g.*, oil price shock (1990–1991), dot-com bubble (1999–2001), and financial crisis (2007–2008).
Source: Datastream, Online Data-Robert Shiller, and PGIM IAS. Provided for illustrative purposes only.

Figure 14 shows that the BBA-rp almost always has lower forecast errors than CAPE-e, regardless of the prevailing CAPE value. For both methods, the lowest forecast errors are associated with mid-range CAPE values and higher forecast errors with more extreme CAPE values, in contrast to expectations for CAPE. Figure 15 shows that higher prediction errors were also associated with the 1990–1991 and 1999–2001 market crises.

Proponents of CAPE may argue that high (low) values are associated with lower (higher) returns. In our quantitative implementation of CAPE, we find that forecasts using high (low) CAPE values have led to higher forecast errors. The poor forecasts are consistent with the earlier observation where movements in valuations and equity returns can be disconnected for many years, producing forecasts that deviate substantially from realized returns.

That both the BBA and CAPE return forecasts are more stable than actual returns[22] is also consistent with the observation that forecast errors tend to be large when market return fluctuations are amplified. This observation holds in the face of the 2007–2008 financial crisis which did not suffer an extreme 10-year horizon return. For these two years, CAPE was at a moderate level and forecast-error was low.

It is important to remember that, in this context, our ability to judge relative CAPE and return levels is based on hindsight bias in which we have knowledge of all historical data and so we know what is "high" and what is "low". Standing at a given point in time there is little guidance as to whether CAPE is relatively high or low compared to the entire range of all CAPE values, past, present, and *future*. This is further evidence that a relatively "extreme" CAPE value is not necessarily sufficient reason for dramatically altering asset allocation.

Conclusion

We conduct an historical analysis of different approaches to forecasting equity returns: a "building block" approach, with and without repricing, and two regression methodologies using CAPE, one with a rolling fixed ten-year estimation window and one with an expanding window. We show that CAPE's *historical* goodness-of-fit does not translate into a superior ability to *directly* forecast future *non-observed* returns. Market valuations that deviate from fundamentals adversely affect the previous relationship between equity returns and CAPE, resulting in poor forecasts.

We find that extreme values in CAPE often persist before market returns change, making it difficult for CAPE alone to accurately forecast long-term equity returns and supports the view that a relatively "extreme" CAPE value is not necessarily reason for dramatically altering asset allocation. The "building block" approach, which utilizes macroeconomic forecasts based on history and extreme changes in P/E as a signal for valuation adjustment, proved to be a better forecaster than CAPE. However, given its remarkable stability, our BBA forecast does not seem to factor the prevailing market valuation environment into return prediction. The "building block" approach with a repricing component performed especially well in periods of poor equity returns. Our results suggest that the forward-looking approach of a BBA methodology with carefully estimated components provides better forecasts than a regression-based valuation metric method.

22 For a more detailed analysis of actual versus forecasted return volatility, see Figure A3 in the Appendix.

References

Appelbaum, Binyamin. "Economists Clash on Theory, but Will Still Share the Nobel." *The New York Times*, The New York Times, 14 Oct. 2013, www.nytimes.com/2013/10/15/business/3-american-professors-awarded-nobel-in-economic-sciences.html.

Campbell, John and Shiller, Robert. "Valuation Ratios and the Long Run Stock Market Outlook." *The Journal of Portfolio Management*, Vol. 24, No. 2. 1998. 11–16.

Campbell, John, and Robert Shiller. "Valuation Ratios and the Long-Run Stock Market Outlook: An Update." 2001, doi:10.3386/w8221.

Fama, Eugene F. "Efficient Capital Markets: II." *The Journal of Finance*, vol. 46, no. 5 (1991): 1575–1617.

Grinold, Richard, and Kroner, Kenneth. "The Equity Risk Premium." *The Investment Research Journal from Barclays Global Investors*, 2002, 7–33.

Ibbotson, Roger G., and Laurence B. Siegel. 1988. "How to Forecast Long-Run Asset Returns." *Investment Management Review* (September/October).

Kemp, Michael. *Uncommon Sense: Investment Wisdom since the Stock Market's Dawn*. Wiley, 2016.

Siegel, Jeremy J. "The Shiller CAPE Ratio: A New Look." *Financial Analysts Journal*, vol. 72, no. 3 (2016): 41–50.

Silver, Nate. *The Signal and the Noise: The Art and Science of Prediction*. London: Penguin, 2013.

APPENDIX

Figure A1 shows how well CAPE has been able to explain subsequent 10-year returns. Using R^2 as the "goodness of fit" measure, we see that the fit has not always been good. For example, up to 1990, CAPE-e moves closely with 10-year equity returns, but the relationship weakened significantly thereafter.

Our full-sample (1990–2008) R^2 estimate of 34% is comparable to Shiller and Campbell's (2001) full-sample (1871–2000) regression R^2 value of 40%.

Figure A1: 10-Year CAPE Regression Statistics
(1990–2008)

Data Period up to End-of-Year	Forecast Period	10-Year Rolling Window					Expanding Window				
		Intercept	Intercept Standard Error	Slope	Slope Standard Error	R^2	Intercept	Intercept Standard Error	Slope	Slope Standard Error	R^2
1989	1990–1999	–0.02	0.01	1.66	0.06	0.93	–0.02	0.01	1.66	0.06	0.93
1990	1991–2000	–0.02	0.01	1.65	0.06	0.93	–0.02	0.01	1.70	0.06	0.94
1991	1992–2001	–0.02	0.01	1.59	0.08	0.90	–0.02	0.01	1.63	0.06	0.92
1992	1993–2002	0.01	0.01	1.31	0.13	0.86	–0.01	0.01	1.49	0.11	0.91
1993	1994–2003	0.04	0.01	1.03	0.09	0.75	–0.01	0.01	1.49	0.10	0.91
1994	1995–2004	0.07	0.00	0.78	0.05	0.58	–0.01	0.01	1.50	0.11	0.91
1995	1996–2005	0.07	0.00	0.83	0.04	0.65	–0.01	0.01	1.50	0.11	0.91
1996	1997–2006	0.08	0.01	0.73	0.09	0.57	–0.01	0.02	1.48	0.15	0.88
1997	1998–2007	0.12	0.01	0.38	0.12	0.30	0.01	0.03	1.34	0.28	0.75
1998	1999–2008	0.15	0.02	0.12	0.16	0.03	0.03	0.04	1.21	0.39	0.58
1999	2000–2009	0.17	0.02	–0.12	0.20	0.02	0.05	0.06	1.03	0.52	0.40
2000	2001–2010	0.19	0.02	–0.27	0.18	0.13	0.07	0.06	0.85	0.59	0.27
2001	2002–2011	0.19	0.02	–0.22	0.17	0.11	0.08	0.07	0.75	0.61	0.21
2002	2003–2012	0.18	0.01	–0.21	0.17	0.05	0.08	0.06	0.71	0.54	0.21
2003	2004–2013	0.14	0.04	0.22	0.47	0.02	0.08	0.05	0.76	0.44	0.25
2004	2005–2014	0.11	0.04	0.68	0.62	0.12	0.08	0.04	0.77	0.38	0.26
2005	2006–2015	0.05	0.04	1.69	0.70	0.38	0.08	0.04	0.75	0.33	0.27
2006	2007–2016	–0.04	0.02	3.24	0.29	0.79	0.07	0.03	0.79	0.28	0.30
2007	2008–2017	–0.04	0.01	3.37	0.16	0.86	0.07	0.03	0.82	0.23	0.34

Note: Newey-West standard errors.
Source: Datastream, Online Data-Robert Shiller, and PGIM IAS.

Figure A2 shows detailed historical predictions for 10-year equity returns formed at the beginning of each 10-year forecasting period. For CAPE we have two sets of results depending on the data window employed: **CAPE-r** for a rolling 10-year window and **CAPE-e** for an expanding window. For the BBA approach we have two sets of results depending on the inclusion of the repricing block: **BBA-rp** for inclusion of a repricing component and **BBA-n** for no repricing.

We produce other, naïve measures of equity return predictors. One simple predictor is the most recent historical (to date) 10-year S&P total return (*e.g.*, actual returns for 2009–2018 is the estimate for 2018–2029 returns). Alternatively, we can assume the next 10-year equity return is equal to the average 10-year S&P 500 total return for all 10-year periods from 1980 up to the estimation year. We will call these two simple historical estimators "10-year historical" (**Hist-10**) and "historical expanding" (**Hist-e**), respectively. For comparison, we also report results assuming that for each year's prediction, we draw from the (to-date) sample of 10-year returns. We label this estimator "**Random.**" "**Actual**" refers to actual 10-year equity returns.

Figure A2: Estimated Returns and Actual Returns using Different Forecasting Methodologies

1990–2008

Forecast Period	CAPE-r	CAPE-e	BBA-rp	BBA-n	Hist-10	Hist-e	Random	Actual
1990–1999	7.7%	7.7%	10.7%	10.7%	17.6%	12.0%	6.5%	18.2%
1991–2000	8.8%	8.6%	11.1%	11.1%	13.9%	11.2%	6.7%	17.5%
1992–2001	6.5%	6.3%	9.5%	9.5%	17.6%	12.0%	14.8%	12.9%
1993–2002	7.6%	6.5%	8.8%	8.8%	16.2%	11.8%	14.8%	9.3%
1994–2003	9.0%	6.1%	8.6%	8.6%	14.9%	11.8%	13.8%	11.1%
1995–2004	10.9%	6.5%	8.4%	8.4%	14.4%	11.3%	13.9%	12.1%
1996–2005	9.9%	5.2%	8.0%	8.0%	14.9%	12.2%	6.7%	9.1%
1997–2006	10.4%	4.7%	7.7%	7.7%	15.3%	12.6%	17.6%	8.4%
1998–2007	12.8%	5.2%	7.6%	7.6%	18.1%	13.3%	14.9%	5.9%
1999–2008	15.0%	5.6%	7.5%	7.5%	19.2%	13.8%	14.9%	–1.4%
2000–2009	17.1%	7.0%	1.5%	7.6%	18.2%	14.0%	6.7%	–0.9%
2001–2010	18.0%	8.9%	1.2%	8.4%	17.5%	13.2%	14.4%	1.4%
2002–2011	17.8%	10.2%	8.9%	8.9%	12.9%	12.3%	13.8%	2.9%
2003–2012	16.9%	11.2%	8.4%	8.4%	9.3%	11.1%	17.6%	7.1%
2004–2013	14.7%	10.3%	8.8%	8.8%	11.1%	11.6%	16.3%	7.4%
2005–2014	13.2%	10.4%	9.2%	9.2%	12.1%	11.5%	18.2%	7.7%
2006–2015	10.9%	10.5%	9.4%	9.4%	9.1%	11.3%	18.2%	7.3%
2007–2016	7.9%	10.2%	9.5%	9.5%	8.4%	11.5%	6.5%	6.9%
2008–2017	9.7%	10.4%	9.3%	9.3%	5.9%	11.3%	19.2%	8.5%
Average	11.8%	8.0%	8.1%	8.8%	14.0%	12.1%	13.5%	8.0%
StDev	3.8%	2.2%	2.6%	1.0%	3.8%	0.9%	4.5%	5.2%
SSE	15.7%	6.1%	2.7%	3.8%	15.3%	9.4%	16.2%	
RMSE	**9.1%**	**5.6%**	**3.7%**	**4.5%**	**9.0%**	**7.0%**	**9.2%**	
rho	**0.89**	**0.90**	**0.57**	**0.87**	**0.81**	**0.77**	**–0.05**	**0.86**

Note: Rho, the autocorrelation coefficient, shows the relationship between error in the current period and that from the previous period.
Source: Datastream, Online Data-Robert Shiller, and PGIM IAS. Provided for illustrative purposes only.

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