Yes, Virginia, There Is [More Than] Hope:

Twenty years of sector rotation with Shiller's CAPE® Ratio

Carmine de Franco, Ph.D.
Head of Research and ESG

Luc Dumontier
Managing Director – Investments and Operations

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Introduction

Economist Professor Robert J. Shiller formally devised with John Y. Campbell in 1988 the Cyclically Adjusted Price Earnings (CAPE®) ratio (Shiller and Campbell (1988)), a powerful valuation metric that allows investors to assess the expensiveness of equity markets (initially the US and, later, major developed markets), taking into account the effect of the business cycle on corporate earnings. The CAPE® ratio, and the derived Relative CAPE® ratio, are used to design a range of rule-based, sector-rotation strategies that aim to outperform major equity benchmarks (e.g., the S&P 500 TR Index) by dynamically selecting sectors that appear most undervalued.

The standard version, jointly developed with Barclays, namely the Shiller Barclays CAPE® US Value Sector Index (hereafter the "CAPE US"), has been backtested since September 3rd, 2002, with a "live" out-of-sample period[1] beginning on October 5th, 2012. As of September 30th, 2022, the Index has significantly and consistently outperformed the S&P 500 Net Total Return Index (hereafter the "S&P 500") with a similar level of risk[2], both during the 10-year in-sample and the additional 10-year out-of-sample periods. More importantly, the implementation shortfall[3] proved limited as investment funds replicating this paper-trading strategy were able to maintain a solid risk-adjusted outperformance relative to the S&P500[4]. Finally, almost all of this outperformance is "pure alpha" that is left unexplained by standard factors[5].
This type of "anomaly", in the sense used by Fama and French, is rare. Very few investment bank indices have lived up to the promise of their backtests. In a comprehensive study analyzing a wide range of rules-based strategies designed by investment banks, Suhonen et al. (2017) show a median 73% deterioration in Sharpe ratios between the backtested and live performance periods. Moreover, of the few successful strategies, the vast majority derived much of their success from exposure to a standard set of factors rather than security selection. When analyzing the few U.S. mutual funds with positive active returns between June 30, 2005, and June 30, 2015 (from the Morningstar database), Ang et al. (2015) find that 115% of the value added can be attributed to factor investing, whether static (94%) or dynamic (21%), and -15% to security selection.

This paper argues that the strong performance of the CAPE US is a matter of efficiency rather than "luck". To reach this conclusion, we perform a comprehensive battery of robustness tests, most derived from academic research, though some have been specifically designed for this study. Furthermore, the investment funds that have replicated the strategy over the past seven years appear to have suffered little enough from implementation costs to consistently outperform the investment universe. Exactly as the saga around the "Value Line enigma" that started with the publication of the famous article of Black and Kaplan (1973) under the evocative title "Yes, Virginia, There Is Hope: Tests of the Value Line Ranking System", this case study fits into several related areas of the literature on the evaluation of investment strategies, such as: the value of active management, performance persistence and decomposition, portfolio construction, and data mining and overfitting issues.

[1] The index construction rules are strictly identical between in-sample and out-of-sample periods.
[2] Different risk indicators (i.e., volatility, beta, downside deviation, maximum drawdown, etc.) are considered in the analysis that follows.
[3] "Implementation Shortfall", a term coined by André F. Perold in 1988, is defined as the return differential between paper and actual portfolios, and includes both explicit (commissions, transaction taxes) and implicit costs (slippage, opportunity cost).
[4] See for example the "Ossiam Shiller Barclays CAPE® US Sector Value TR" fund.
[5] Different factor models are considered in the analysis that follows, including the Fama-French-Carhart 4-factor model.

This paper is organized as follows. Section 1 describes the construction rules of the CAPE US. Section 2 reviews its performance over time. Section 3 analyzes the determinants of this performance. Finally, Section 4 shows the results of robustness tests.

Portfolio construction

The valuation measure used is based on the Cyclically Adjusted Price Earnings (CAPE®) ratio, introduced in 1988 by economists Robert J. Shiller and John Y. Campbell to improve the classical Price/Earnings (PE) ratio. The CAPE® ratio is a variation of the PE ratio that uses a ten-year average of inflation-adjusted earnings instead of a single year's earnings. Since the ten-year horizon is longer than most business cycles, such a long-term average smooths out the short-term noise, and makes the CAPE® ratio better suited for detecting long-term over- and under-valuations in the stock market. Applied to individual sectors, we have:

$$\textbf{CAPE}^{\circledR} = \frac{\textbf{Real Sector Price}}{\textbf{10} - \textbf{year average of inflation} - \textbf{adjusted sector earnings}}$$

However, like most valuation measures, the CAPE® ratio does not allow for a proper comparison between sectors. Indeed, some sectors may appear structurally more expensive than others (i.e., with a systematically higher CAPE® ratio) due to different levels of industry maturity, growth prospects, and regulations. This makes the CAPE® ratio unsuited for portfolio construction. To account for idiosyncratic differences between sectors one can adjust for the long-term sector CAPE® ratio average:

$$\textbf{Relative CAPE}^{\circledR} = \frac{\textbf{Current sector CAPE}^{\circledR}\textbf{ ratio}}{\textbf{20} - \textbf{year rolling average of sector CAPE}^{\circledR}\textbf{ ratio}}$$

The equity universe considered – i.e., the S&P 500 index for U.S. stocks, the MSCI Europe for European stocks, or the MSCI World for global stocks – is divided into 10 sectors based on the Global Industry Classification Standard[6] (GICS): Energy, Materials, Industrials, Consumer Discretionary, Consumer Staples, Health Care, Financials + Real Estate, Information Technology, Communication Services[7], and Utilities. Financial and Real Estate companies are merged into one sector (in proportion of their respective capitalizations), as was officially the case until August 31st, 2016.

The portfolio construction then follows a three-step procedure. First, among the 10 sectors, the five most attractive ones based on their relative CAPE® ratios are selected. Then, from this group of the five most attractive sectors, the one with the lowest 12-month price return is removed[8]. Finally, the remaining four sectors are weighted equally (i.e., 25% each). Rebalancing is done monthly.

The data used in this study is sourced from S&P, Barclays, Kenneth French's website and Bloomberg. The data covers the period from September 2002 to September 2022. In the paper, the in-sample period starts

[6] The Global Industry Classification Standard is administered jointly by S&P Dow Jones and MSCI since 1999.
[7] Before September 2018, Information Technology, Communication Services were merged as the latter was made of a very limited number of companies. After a substantial reclassification, Communication Services become, with respect to the CAPE US, a new sector.
[8] The rationale behind the exclusion of the worst performing sector among the group of the five cheapest sectors is to limit the potential value trap phenomenon, inherent to value strategies. Using 12-month momentum as a signal would assist in identifying where the sector value continues to fall (see e.g., Moskowitz et al. (2012).

on September 3rd, 2002, and ends on October 5th, 2012. The out-of-sample period starts on October 5th, 2012 and ends on September 30th, 2022.

Preliminary Performance Review

Literature Review

In general acceptance, "alpha" is a measure of the ability of an investor to identify investment opportunities and act accordingly. The value of active management (i.e., the "alpha") is probably the most widely studied topic in the financial community, both by practitioners and academics. Some authors have explained why it is theoretically difficult to beat the market, while others have shown how complicated it is in practice. The first related studies date back to the end of the 19th century, when some statisticians noticed that changes in stock prices seem to follow a fair-game pattern. In his PhD thesis, "The Theory of Speculation", French mathematician Louis Bachelier (1900) demonstrated that stock prices are random, "like the steps taken by a drunk", and therefore, unpredictable so that "the mathematical expectation of a speculator is zero". In a well-known paper, titled "The Arithmetic of Active Management" (Sharpe (1991)), William Sharpe showed that the underperformance of active managers as a group is just a matter of… "simple arithmetic". Before costs, the market return must equal a weighted average of the returns on the passive and active segments of the market. If the first two returns are the same, the third must also be so. Because active managers bear greater costs, net return from active management must be lower than that from passive management and the market. Sharpe concludes the article with a warning: "Empirical analyses that appear to refute this principle are guilty of improper measurement."

Alfred Cowles III was the first to measure the performance of financial professionals empirically. He published his findings in a paper with a provocative title, "Can Stock Market Forecasters Forecast?" (Cowles (1933)). Over a period of four-and-a-half years, between January 1928 and June 1932, he found that investments made by 20 fire insurance companies, and recommendations given by 16 financial services companies and 24 financial publications achieved average records that were "worse than that of the average common stock" by 1.20%, 1.43%, and 4% per year, respectively. In 1944, Cowles published a broader study (Cowles (1944)) based on nearly 7,000 market forecasts over more than 15 years and concluded once again that there was no evidence to support the ability of professional forecasters "to predict successfully the future course of the stock market". In 1960, James Lorie and Lawrence Fisher, then both faculty members at the University of Chicago, partnered with Louis Engel of Merrill Lynch to establish the Center for Research in Security Prices (CRSP) and answer "the question of how much gain or loss an individual investor might have realized if he had bought all New York Stock Exchange common stocks […] from 1926 through 1960". After having assembled the data during 3.5 years, they found that "the rates of return, compounded annually, […] with reinvestment of dividends were 9%", far higher than previously thought (Fischer and Lorie (1964)). This finding led James Lorie to say in a speech in 1965 that "throwing darts at lists of stocks and dates is on the average as satisfactory a method of making investments as is reliance on competent professional judgment".

Early empirical studies only considered the return on investments, without considering their risks. By describing the relationship between risk and expected returns, the development of asset pricing models, primarily by Sharpe (1964), Lintner (1965) and Mossin (1966), then paved the way for various risk-adjusted performance measures. Treynor (1965) and Sharpe (1966) documented the now famous ratios that determine how much excess return (vs. risk free rate) was generated for each unit of systematic risk (beta) or total risk (volatility) respectively. Sharpe tested these ratios on a sample of 34 mutual funds and on the Dow Jones index between 1954 and 1963. He calculated a lower average Sharpe ratio for the funds than for the index, especially due to the funds' expenses. Jensen (1968) then introduced the foremost measure of selectivity skill of mutual fund managers, defined as the excess return earned over what would have been predicted by the Capital Asset Pricing Model. Jensen calculated the alpha of 115 mutual funds between 1945 and 1964. He found that the funds "were on average not able to predict security prices well enough to outperform a buy-the-market-and-hold policy, but also that there was very little evidence that any individual fund was able to do significantly better than what we would expect from mere random chance".

Since then, extensive empirical studies support the view that most active managers underperform most of the time. For example, according to the S&P's "SPIVA® US Scorecard", 65% of large-cap U.S. active managers have underperformed the S&P500® index on average over the calendar years from 2001 to 2021. Over long-time horizons, very few investment funds deliver consistent performance, especially in the notoriously competitive U.S. large-cap equity universe. According to the S&P's "SPIVA® US Scorecard", as of June 30th, 2022, only 3% of U.S. large-cap funds have outperformed the S&P 500 on a risk-adjusted basis over the previous 10 years.

Long-term performance

At first sight, the CAPE US seems to be part of the outstanding performing strategies. Over the 20 years ending in September 2022, the CAPE US strategy outperformed the S&P 500 by more than 3% annualized (Exhibit 1). The strategy is characterized by similar levels of annualized volatility and maximum drawdowns. Long-term CAPM beta is at 0.93, which translates into a solid and statistically significant 3.84% CAPM alpha.

	All Sample		In-Sample		Out-of-Sample	
	S&P 500	CAPE US	S&P 500	CAPE US	S&P 500	CAPE US
Performance	8.75%	12.09%	6.66%	10.66%	10.90%	13.55%
Volatility	18.94%	18.18%	20.75%	19.16%	16.90%	17.14%
Max. Drawdown	-55.71%	-43.70%	-55.71%	-43.70%	-33.83%	-34.70%
Sharpe Ratio	0.39	0.59	0.23	0.46	0.60	0.75
Beta	1.00	0.93	1.00	0.89	1.00	0.99
Tracking Error	-	4.53%	-	5.20%	-	3.73%
CAPM Alpha	-	3.84%*	-	4.5%*	-	2.76%*
Information Ratio		0.74		0.77		0.71

Exhibit 1 : Standard KPIs for the S&P 500 Index and the CAPE US strategy. * refers to statistical significance at >95 level.

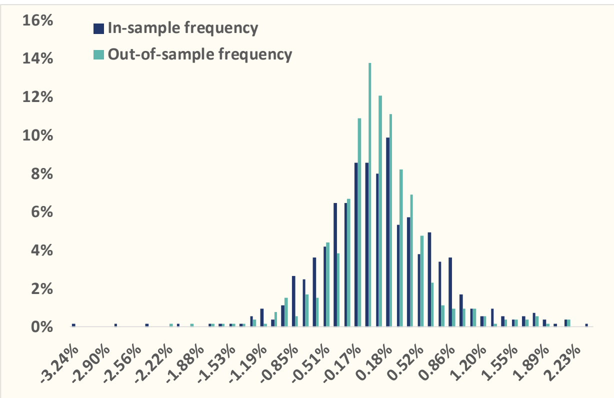
This performance is not directly comparable with that of investment funds as it does not include management and administration fees, nor transaction costs. However, for efficient implementations, the alpha is not significantly affected. For example, in the case of transaction costs, as the historical two-way turnover of the strategy is in the order of 300% per year, their impact to the total performance is around 0.10% per year. In practice, the implementation shortfall proved limited as investment funds replicating this paper-trading strategy were able to maintain solid risk-adjusted outperformance relative to the S&P500.

In-sample vs. out-of-sample results

While it is said that "promises only bind those who believe in them", investors are often willing to trust simulations of quantitative investment strategies, assuming they are built using simple criteria supported by academic research. However, a classic problem with systematic investing appears to be the abnormal discrepancies between in-sample findings and out-of-sample results, when often the latter are less appealing than the former. This is indeed a serious challenge to systematic investing and particularly for factor investing (Lopez de Prado (2022)). In a comprehensive study analyzing a wide range of rules-based long/short strategies offered by investment banks, Suhonen, Lennkh and Perez (2017) highlight a median 73% deterioration in Sharpe ratios between back-tested and live performance periods. Interestingly, the fall-off in risk-adjusted performance was even greater for complex strategies with numerous rules and filters.

With regards to the CAPE US strategy, out-of-sample results broadly confirm in-sample, simulated results (Exhibit 1). As the US market performed very differently between the two sub-periods (annualized 6.66% vs.10.90%), the comparison of Sharpe ratios is meaningless. At first glance, the out-of-sample excess return is lower at 2.65% compared to 4% in-sample. However, the tracking-error is also lower by the same magnitude – 3.73% out-of-sample vs. 5.20% in-sample – resulting in in-sample (0.77) and out-of-sample (0.71) information ratios that are very close. In other words, the excess return per unit of relative risk is broadly constant between the two sub-periods.

To measure even more formally how different in-sample and out-of-sample strategy results are, we use the popular two-sided Kolmogorov-Smirnov test (Kolmogorov (1933), Smirnov (1939)), which tests the null hypothesis that the in-sample distribution of excess returns (CAPE US vs S&P500) is statistically the same as that of the out-of-sample one. Using weekly and monthly returns we cannot reject the hypothesis that the in-sample and out-of-sample excess return distributions are the same. In other words, the results of the out-of-sample strategy are broadly in line with the properties that one could have inferred from the in-sample simulated findings. This is clearly visible in Exhibit 2 , where we plot weekly excess-returns frequencies (left panel) and their fitted distributions (right panel).



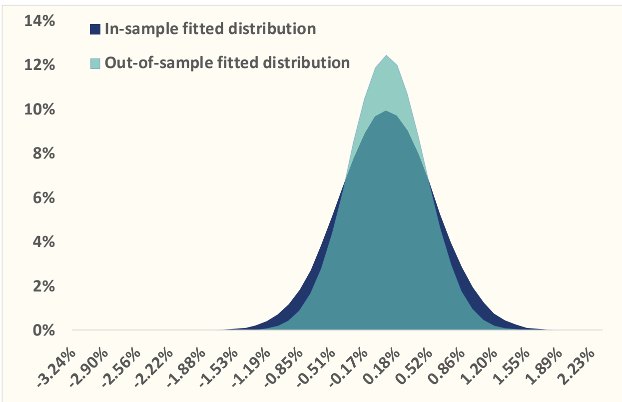
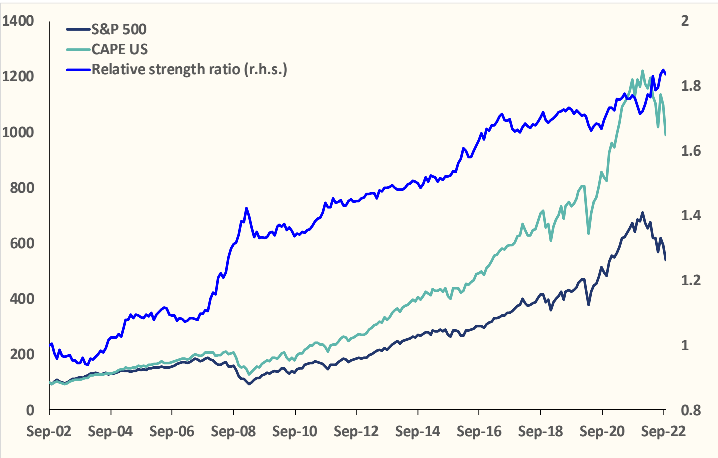


Exhibit 2 : Empirical and fitted distributions for weekly excess returns of the CAPE US over the S&P 500.

Performance consistency over time

From a long-term investor perspective, it is interesting to measure how the excess return builds up at different horizons. Exhibit 3-left panel shows the cumulative performance of the US CAPE strategy and the

S&P500, as well as the relative strength ratio between the two. It seems that the excess return of the strategy builds steadily over time. To confirm statistically this visual impression, we compute the average annualized excess return of the CAPE US over the S&P 500, with horizons ranging from one up to ten years (Exhibit 3-right panel). More precisely, we compute the hypothetical returns over the benchmark for an investor that enters the CAPE US strategy at a given time (end of quarters, March-June- September-December) and waits for one to ten years. By averaging over all possible investment opportunities, we can build the behavior of excess-return at different horizons. As Exhibit 3-right panel shows, the excess return is relatively stable across all horizons, mostly in a range around 3%. As expected, for short horizons, such as one or two years, the variability of potential excess return is high: if, on average, it has been near 3% annualized, it has been fairly volatile, with a maximum around +15% and a minimum of -5% at a 1-year horizon. As the horizon lengthens, the excess return variability decreases, and the strategy really shows its potential of delivering strong results that can be sustained over time. In other words, the ability of the strategy to deliver consistent positive excess returns seems to hold relatively well and is stable across different time-horizons.



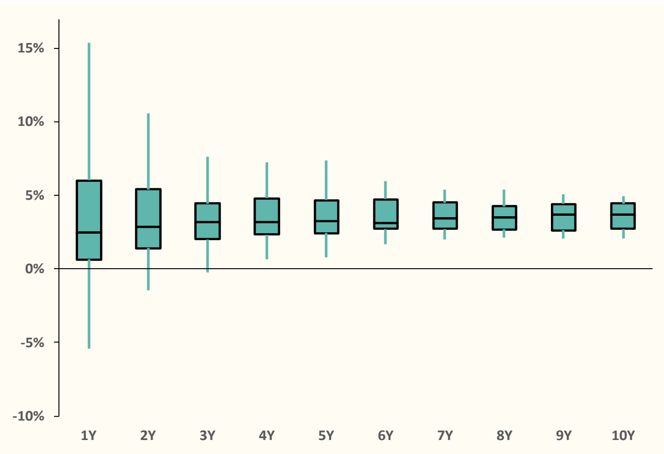


Exhibit 3 : Left panel: Historical levels for CAPE US and the S&P 500, rebased at 100 at the beginning of the period. Right panel: Average annualized excess returns at given horizons.

Performance consistency over crisis periods

Finally, investors are often worried about the behavior of the strategy in times of financial crisis. We therefore measure the performance of the CAPE US and the S&P 500 for selected periods characterized by severe corrections of the US market, such as the drawdown observed during the great financial crisis of 2008 or during the most acute phase of the COVID-19 pandemic in early 2020. Exhibit 4 collects twelve different periods during which the S&P 500 has shown large losses. During most periods, the CAPE US performed mostly in line with the S&P 500, as one would expect for a long-only strategy with a beta close to one in highly volatile market downturns. We shall note that, out of the twelve episodes we identified, the CAPE US outperformed the S&P 500 by 3% to 5% (GFC 2008, S2 in 2015 and S1 2022) on at least three occurrences, and two of those belong to the out-of-sample periods. For the remaining episodes, the differences in performance are small, close to 0%. These observations, while not exhaustive given the limited number of severe downturns we observed over the period, point to the fact that the CAPE US strategy has not displayed any particular tendency to underperform the S&P 500 in severe market conditions. That would have hinted at a tendency to exhibit high tail risk, which does not seem to be the case.

Start Date	End Date	Period	Annualized S&P 500	Annualized CAPE US	Annualized Excess Return
03/09/2002	01/10/2002	IT Crisis	-35.68%	-37.74%	-2.06%
23/07/2008	17/09/2008	Pre GFC	-48.09%	-34.39%	13.70%
19/09/2008	09/03/2009	GFC	-72.68%	-66.98%	5.69%
15/04/2010	05/07/2010	Q2 2010	-52.80%	-54.50%	-1.70%
02/05/2011	04/10/2011	EURO Crisis	-35.31%	-30.93%	4.39%
19/03/2012	04/06/2012	Q2 2012	-36.21%	-34.76%	1.44%
10/08/2015	20/01/2016	Bear Market 2015	-23.02%	-15.62%	7.40%
17/08/2015	31/08/2015	Aug 2015	-80.82%	-81.28%	-0.46%
21/09/2018	24/12/2018	Q4 2018	-56.84%	-57.52%	-0.67%
20/02/2020	23/03/2020	COVID-19	-99.06%	-99.18%	-0.12%
31/12/2021	30/06/2022	Inflation 2022	-36.47%	-30.82%	5.65%
16/08/2022	30/09/2022	Late Summer 2022	-77.01%	-77.75%	-0.74%

Exhibit 4 : Annualized performance and excess returns of the S&P 500 and the CAPE US over selected periods of market crisis.

Bull et al. (2014) provide a detailed account of the CAPE US and its results, and our study broadly confirms their findings.

Performance consistency across dispersion regimes

The average annualized excess return of the CAPE US strategy vs. the S&P500 over the twelve periods of equity market downturns stands at 5.3%, a level higher than both the all-sample excess return (3.3%) and the out-of-sample one (2.7%). The tendency for investment funds to deliver higher relative performance – whether positive or negative – in times of difficult markets is well documented. For example, using the CRSP database from December 31st, 2000, through December 31st, 2020, Chan and Lazzara (2022) show that the gap between the top and bottom performance quartiles of large-cap active U.S. managers, was wider during years of declining markets than during years of moderate positive markets (8.3% vs. 6.6%). This finding is explained by the fact that periods of market decline are often accompanied by an increase in market volatility, which feeds into an increase in dispersion (i.e., cross-sectional volatility) between stocks.

In the same study, Chan and Lazzara show that the performance gap between the top and bottom quartiles almost doubles between periods of low (5.9%) and high dispersion (11.5%). However, Harvey and Liu (2019) show that rational investors are more skeptical in periods of high cross-sectional dispersion of fund returns, as they fear that some unskilled managers can more easily disguise themselves as skilled through higher idiosyncratic risks. Using fund flow data, they show that an increase of one standard deviation of fund return dispersion is associated with a decline of 11% to 17% in flow-performance sensitivity, with a stronger effect for outperforming funds.

To test whether the strong performance of the CAPE US is only due to a few periods of high market dispersion, and therefore possibly luck, we analyze the magnitude of the excess return vs. S&P500 according to the intersectoral dispersion regime. We create three clusters of monthly cross-sectional volatility between the 10 underlying sectors of the strategy, using an equal weighting method as the strategy does. Low, medium, and high dispersion clusters contain respectively 25%, 50%, and 25% of the total number of months. Exhibit 5 shows that the ratio between the average excess return and the dispersion is roughly constant across the three clusters. The CAPE US strategy consistently captures the opportunities that arise, whether large or small.

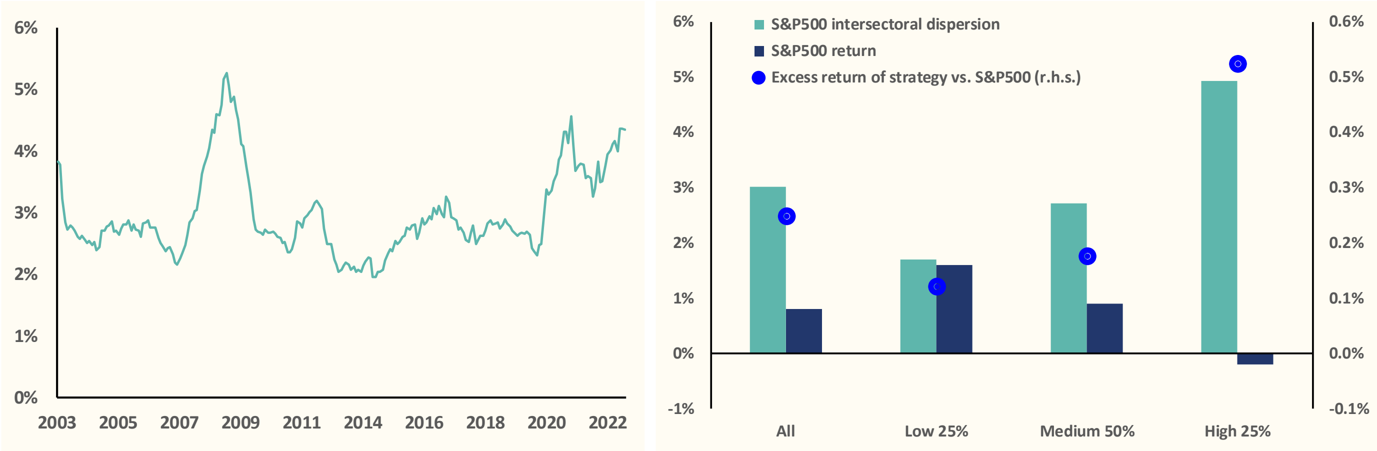


Exhibit 5 : Left-panel: 12-month average inter-sectorial dispersion. Right-panel: Inter-sectorial dispersion at 25th, 50th and 75th percentiles and respective performance of the S&P 500 and excess return of the CAPE US over the S&P 500.

To summarize,

i. Over the last 20 years, the CAPE US strategy has exhibited a 3.34% excess return over the S&P 500 with a similar level of risk.
ii. The results have been in line when comparing the 10 years in-sample (2002-2012) and the 10 years out-of-sample (2012-2022). Furthermore, we observe that, statistically speaking, the behavior of out-of-sample excess returns matched that of in-sample excess returns.
iii. The excess return is relatively stable over time, over crisis periods, and across dispersion regimes.

In the following section we test whether the excess return can be considered as a true alpha.

Performance Analysis

Literature Review

In line with the CAPM, Fama (1972) was the first to formally propose a performance attribution procedure by breaking down observed return into the part resulting from the ability to pick the best securities at a given level of risk ("selectivity") and the part that is the result of predictions of general market price movements (market "timing"). Kon and Jen (1979) applied this procedure to 49 mutual funds between 1960 and 1971. Their result supports the inability of mutual fund managers to time the market, while, in respect of selectivity, the results are unconclusive. Roll (1977) and Roll (1978) then questioned the validity of the CAPM, which is based on an unobservable market portfolio, as it should theoretically include all risky assets (i.e., not only stocks). After Roll's critique, Ross (1976) proposed an alternative model of capital market equilibrium, the Arbitrage Pricing Theory (APT), which states that compensation for bearing risk may be comprised of several risk premia, rather than just one risk premium as in the CAPM. Using data for individual equities between

1962 and 1972, Roll and Ross (1980) claimed to find at least three and probably four factors in the generating process of returns. In the following years, abundant empirical evidence also questioned the validity of the CAPM. For example, Banz (1981) found that small firms experienced higher beta-adjusted returns than large firms. Rosenberg et al. (1985) reported abnormal stronger returns for stocks with higher book-to-market-equity.

Jegadeesh and Titman (1993) documented an overperformance of stocks that had performed better than the others in the past, a phenomenon that could not be attributed to higher systematic risk. However, Roll and Ross did not offer an economic interpretation of these factors and admitted that their test was a weak one. Fama and French (1996) popularized multifactor models of asset returns and showed that many of the CAPM average-return anomalies could be captured by a three-factor model (excess return on market index, size and book-to-market ratio) for the universe composed of NYSE stocks between 1963 and 1993. However, they acknowledged that the anomaly related to the continuation of short-term returns had not disappeared in their model. Carhart (1997) thus introduced a fourth momentum factor to obtain the Fama-French-Carhart (FFC) 4-factor model. Other factors have since been documented (e.g., quality, low-volatility, liquidity, macroeconomic factors), but the FFC model remains the gold standard for revealing market anomalies. Since then, intentionally or not, quantitative and fundamental fund managers alike have skewed their portfolios towards factors to outperform their cap-weighted benchmarks.

Ang et al. (2009) reported that approximately 70% of the active portfolio returns of the Norwegian Government Pension Fund could be explained by exposure to systematic factors. Another famous example is Berkshire Hathaway's Warren Buffett, whose performance can largely be explained by exposures to the value, low-risk and quality factors, together with a leverage of about 1.6 to 1 (Frazzini, 2013). Bender et al. (2014) showed the same phenomenon in a more recent study, finding that a handful of risk premia indexes accounted for as much as 80% of alpha in US equity markets from 2002 to 2012. This finding recurs in long-short portfolios. Harvey et al. (2017) find that the performance of equity hedge funds from 1996 to 2014, whether systematic or discretionary, was mainly attributable to their exposure to a standard set of factors.

These factor-based (or risk-based) performance attribution methods can be performed easily (e.g., through regression), as they just require time series return data of the portfolio and the selected factors. Holdings-based performance attribution methods were developed in parallel. In 1985 and 1986, Brinson and Fachler (1985) and Brinson, Hood, and Beebower (1986) introduced the Brinson model, which can be described as "arithmetic attribution" in the sense that it divides the difference between the returns of the portfolio and its benchmark into (i) security selection (i.e., return achieved through selecting different securities than the benchmark), and (ii) asset allocation (i.e., return achieved through weighting sectors, countries, etc. differently than the benchmark). This type of performance attribution models can provide additional useful information but requires holdings data.

Factors-based performance attribution

To test whether the CAPE US strategy performance is the result of successful exposures to traditional equity premia so that its alpha would be zero, we test its monthly excess returns over the risk-free rate with several factor models for, as in the study of Bender et al. Exhibit 6 collects the results of such regressions. We highlight the fact that the CAPM alpha in Exhibit 6 is slightly different from the one in Exhibit 1, as we use here the Fama-French market factor instead of the S&P 500. As we move from the CAPM to the Fama-French-Carhart model (FFC), the alpha decreases only slightly, from 3.15% to 2.93%, while remaining statistically significant. In conclusion, most of the alpha associated with the CAPE US strategy cannot be explained away by considering traditional style factors.

Models	Alpha	MKT	SMB	HML	MOM	R^2
CAPM	3.15%*	0.90				0.92
MKT+SIZE	3.06%*	0.93	-0.15			0.93
FF3	3.08%*	0.93	-0.15	0.01		0.93
FFC	2.93%*	0.94	-0.15	0.03	0.04	0.93

Exhibit 6 : Regressions of monthly excess returns of the CAPE US over the risk-free rate for different factor models.
* refers to statistical significance at >95 level

As pointed out in De Franco et al. (2017), spurious alpha may appear when either the factor model is misspecified (which we can reasonably exclude given the R^2 in Exhibit 6) or when the real underlying exposure of a strategy to a set of factors is dynamic. In the simplest framework, regime-dependent market and factor exposures could lead to spurious alpha if this is estimated under the assumption of static exposures. Since the CAPE US strategy moves in and out of sectors over time, its market beta (as well as other factor exposures) may dynamically change, as high or low beta sectors are invested or divested. Therefore, the positive alpha that is shown in Exhibit 6 could be the result of successful dynamic exposures to the market or other factors. Exhibit 7, for example, shows the ex-ante beta of the CAPE US (computed as the weighted average of CAPM betas of the four sectors in the strategy at each end of month). It could be a possibility that the CAPM alpha is therefore the result of successful market-timing, increasing or decreasing the market exposure of the CAPE US. Because long-term estimation of CAPM beta hides changes in beta exposure, this could falsely lead to abnormal and positive alpha.

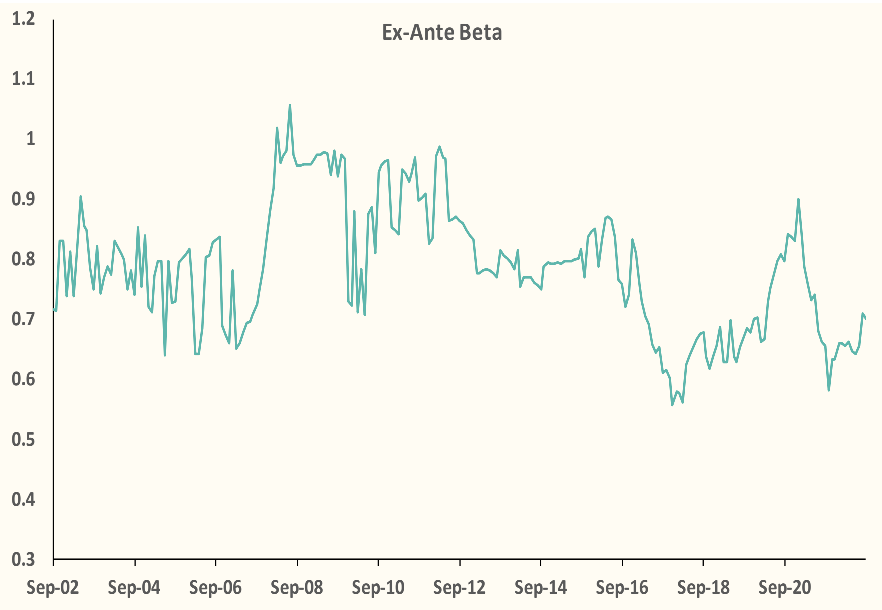


Exhibit 7 : Ex-ante beta of the CAPE US strategy. Ex-ante beta is calculated as the weighted average of each sector’s beta computed over the previous 12 months.

To test whether this could be the case, we run a simple regime-switching two-state regression between excess returns over the risk-free rate of the CAPE US versus the S&P 500. The two states, based on the behavior of the S&P 500, typically represent bull and bear market regimes. We then run regressions over these two regimes to see whether a) the market beta is regime-dependent and b) the alpha is a state-dependent and decreases or vanishes. Exhibit 8 shows the results of the Markov-regime regressions and the baseline CAPM regressions (as reported in Exhibit 1).

Model		Alpha	Beta	R^2
CAPM		3.84%*	0.93	0.93
Regime Switching	Bull	3.25%*	0.95	0.94
	Bear	3.64%*	0.93	

Exhibit 8: CAPM Alphas compared to 2-state regime switching model. * refers to statistical significance at >95 level.

The results are straightforward: not only, on average, does the beta not change much when we move from one regime to the other, but alphas in each regime remain robust and statistically significant (not far from the CAPM alpha, as a matter of fact). In line with the results in De Franco (2019), we then see that the risk-adjusted performance of the CAPE US is not regime-dependent and does not come with market timing (which would be the case if the betas were regime-dependent and materially different).

Holdings-based performance attribution

While there is little evidence that the CAPE US alpha is the result of successfully leveraging/deleveraging of market beta in different regimes (which, per se, would not be a bad thing), we can also measure how much the strategy's total performance comes from strategic exposures on sectors and how much it takes from dynamically investing in and out of sectors. For this, we introduce three portfolios related to the CAPE US: *Allocation*, *Rebalancing and Timing*. *Allocation* is defined as the portfolio that implements at time t=0 the average weight over the 20-year period between 2002 and 2022 for each sector and keeps it until the end of the period:

$$\boldsymbol{W_0^{Allocation,S}} = \frac{\boldsymbol{1}}{\boldsymbol{n}}\sum_{\boldsymbol{t=1}}^{\boldsymbol{n}} \boldsymbol{W_t^S}$$

where S is a given sector and $\boldsymbol{W_t^S}$ is the weight of the sector in the CAPE US at time t. Allocation is therefore the average portfolio over time for the CAPE US. *Rebalancing* is the portfolio that implements the *Allocation* weights each month. This portfolio captures the effect of regularly rebalancing *Allocation* towards the average weights. Finally, *Timing* is defined as the difference between the CAPE US and *Rebalancing*. From a total return point of view, we have then:

$$\boldsymbol{CAPE\ US - S\&P500 = Allocation - S\&P500} + \underbrace{\boldsymbol{(Rebalancing - Allocation)}}_{\boldsymbol{Rebalancing\ Effect}} + \underbrace{\boldsymbol{(CAPE\ US - Rebalancing)}}_{\boldsymbol{Timing\ Effect}}$$

Exhibit 9 shows the total return decomposition of CAPE US in terms of allocation, rebalancing and timing.

CAPE US	Total Return	Relative to total
Allocation	129.40%	28.71%
Rebalancing Effect	-33.45%	-7.42%
Timing Effect	354.82%	78.71%
Total	450.78%	100.00%

Exhibit 9 : Allocation/Rebalancing/Timing Decomposition

The excess return of *Allocation* is 129.40%. Thus, the average portfolio of CAPE US is already a good basis from which to outperform the S&P 500. The *Rebalancing* effect is small but negative (at -33.45%), signaling that bringing the *Allocation* portfolio back to target does not add value. Finally, the Timing effect is responsible for 354.82%, a significant portion of the CAPE US total return. This Timing effect signals that by deviating, dynamically, from the long-term average allocation, the CAPE US delivers strong performances. So, one third of the CAPE US total return comes from the choice of sectors while two thirds stem from its ability to deviate from it, over time, and invest tactically into sectors that appear opportunistically undervalued according to the Relative CAPE® measure. We can use both *Allocation* and *Timing* in a simple linear regression to see how much alpha they can explain away from CAPE US.

We shall expect betas to be very close to 1 (as both Allocation and *Timing* capture the fundamental exposures of CAPE US). Exhibit 10 shows how both portfolios leave an unexplained and statistically significant positive alpha (2.17% when we use *Allocation* as explanatory variable in the linear regression, and 2.63% when we use instead *Timing*). In other words, there is a substantial portion of the CAPE US's performance that comes from its ability to rotate across sectors dynamically and opportunistically, that is not captured by its long-term average exposures.

Model	Alpha	Beta Allocation	Beta Timing	R^2
vs. Allocation	2.17%*	0.99	-	0.94
vs. Timing	2.63%*	-	0.96	0.94

Exhibit 10 : Linear regressions of CAPE US over Allocation and Rebalancing portfolios.

The previous section and this one contain abundant evidence that the significant alpha that is associated with the CAPE US strategy is neither the compensation for some kind of tail risk, nor that it can be explained away if one uses multi-factor or dynamic regime-switching models. Furthermore, the alpha is a combination of a strategic allocation to undervalued sectors (thus related to the ability of the Relative CAPE® signal to identify them) and a tactical exposure to sectors that look appealing over a shorter time frame. In the next section, we will explore the choice of portfolio design and how much it impacted the results.

Robustness Tests

Building a new active strategy index with an attractive backtested performance is in theory not very difficult. However, without a strong economic rationale, the performance may well disappear out-of-sample, because, for example, of data mining and overfitting. Recent papers help to assess whether a strategy is likely to deliver its promises or not, considering the length of the track-record as in Bailey and de Prado (2012), the number of tests performed as in Harvey and Liu (2021). As illustrated in the two previous sections, the CAPE US strategy has delivered true "sector rotation" alpha. The probability that this alpha is ultimately a false positive comes out at 0.03%[9]. A further way to test the robustness of the strategy is to check whether the alpha depends strongly on the choices made in portfolio design and rebalancing.

Sensitivity to the number of selected sectors, momentum window, and rebalancing frequency

To test how much the strategy is sensitive to the different portfolio specifications, we run different specifications of the CAPE US by changing one parameter while keeping the others as in the baseline case. We run different simulations of the CAPE US with a different rebalancing frequency (Exhibit 11 – bottom left panel); by looking at different windows when computing the momentum of each sector (Exhibit 11 – Top right panel); by looking at different specifications in the number of selected and rejected sectors (Exhibit 11 – top left panel); and finally by looking at specifications that are implemented from one to four days after the CAPE US (Exhibit 11 – bottom right panel). For each set of simulations, we compute CAPM alphas, the excess

[9] We compute the false positive ratio as the probability that a T-Student random variable falls outside the interval given by the T-stat associated to the alpha: False Positive = 2*P(|T|>t-statistic)

return and the information ratio (vs. S&P 500) and compare the results with the baseline case (i.e., the CAPE US). As Exhibit 11 shows, relative to the S&P 500, results are particularly robust to different specifications. The most sensitive parameter is the number of selected sectors (by the Relative CAPE®): considering too many sectors (6 or plus) deteriorates the relative outperformance, which is a natural consequence of the dilution of the signal. It is fair to say that results are mostly dependent on the discriminating power of the Relative CAPE®, as one should expect.

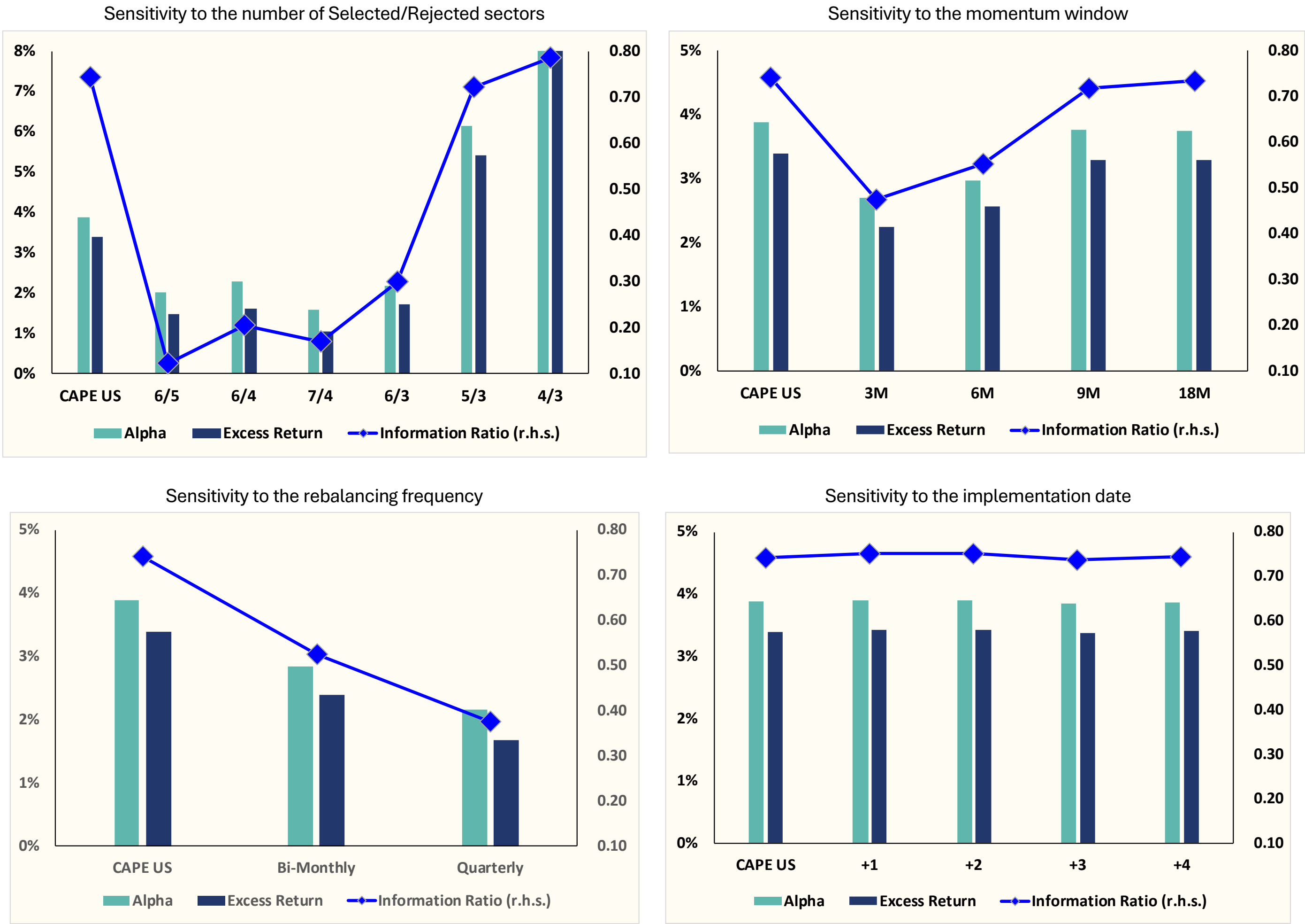


Exhibit 11: CAPM alphas, annualized excess return and information ratio (vs S&P 500), for alternative versions of the CAPE US strategy built by modifying one parameters of the baseline strategy.

Sensitivity to the weighting method

A different way to assess how much the CAPE US strategy is dependent on the choice of portfolio design consists in running parametric simulations of portfolios that leverage the Relative CAPE® signal in a different way. According to the methodology that underpins the CAPE US strategy, only four sectors are selected each time, and their weights are set at 25% each. This approach does not consider the market beta specific to each sector. Therefore, the ex-ante beta will change as sectors move in and out of the portfolio (see Exhibit 7). To see if these changes in ex-ante beta could drive unexpected performance, we test a different implementation that accounts for the ex-ante beta of each sector and see how this would have impacted the alpha of the strategy. We consider two versions: a "quadratic" and "lasso". For the quadratic version, we set the sectors' weights as:

$$\boldsymbol{W} = \mathbf{25\%} + \boldsymbol{\Delta W}$$

where $\boldsymbol{\Delta W}$ is optimized to solve the following problem

$$\min_{\Delta W}\left(\gamma|\Delta W|^2 + (1-\gamma) * ((25\% + \Delta W)' * \beta - 1)^2\right)$$
$$|\Delta W| \leq 12.5\% \; and \; \sum \Delta W = 0$$

$\boldsymbol{\beta}$ is the vector of historical sectors' betas and $\boldsymbol{\gamma} \in [\mathbf{0}, \mathbf{1}]$ is the trade-off parameter.

The problem above identifies the optimal tilt to apply to the current sector weight in the CAPE US (25%) that minimizes the ex-ante active share versus CAPE US, while at the same time pushing the ex-ante beta towards one. For $\boldsymbol{\gamma} = \mathbf{1}$ the solution is clearly $\boldsymbol{\Delta W} = \mathbf{0}$, which gives us the CAPE US strategy. We optimize and compute the optimal strategies for different levels of $\boldsymbol{\gamma}$, and collects historical CAPM alphas and betas in Exhibit 12.

γ	Beta	CAPM Alpha
0.1	0.99	3.46%*
0.2	0.98	3.57%*
0.3	0.96	3.66%*
0.4	0.95	3.72%*
0.5	0.94	3.77%*
0.6	0.94	3.80%*
0.7	0.93	3.82%*
0.8	0.93	3.84%*
0.9	0.93	3.85%*
CAPE US	0.93	3.84%*

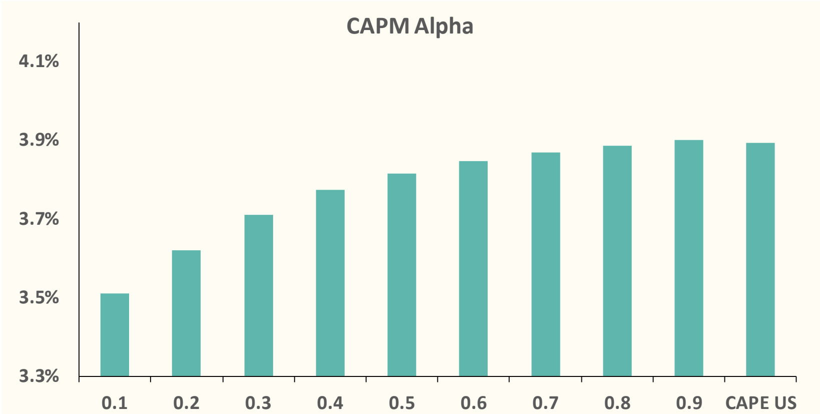


Exhibit 12 : Simulated CAPM alphas as a function of the beta-adjustment under quadratic penalization.
* refers to statistical significance at >95 level.

We see that for lower values of $\boldsymbol{\gamma}$, the beta is close to 1, as the optimization will force the sectors' tilts in a way to penalize deviations from beta=1. Alphas show a monotonically increasing pattern, peaking at $\boldsymbol{\gamma} = \mathbf{1}$ which corresponds to the CAPE US strategy, but the gap between the two extremes is very narrow: only ~0.4% between CAPE US and the version with $\boldsymbol{\gamma} = \mathbf{0.1}$. In any case, alphas are all statistically significant.

For the lasso penalization, the problem becomes:

$$\min_{\Delta W}\left(\gamma|\Delta W|^2 + (1-\gamma) * |(25\% + \Delta W)' * \beta - 1|\right)$$
$$|\Delta W| \leq 12.5\% \; and \; \sum \Delta W = 0$$

As in the previous case, we also look at optimal tilts to the current sector weights in order to minimize the active share compared to the CAPE US, while penalizing deviation from ex-ante beta equal to one, this time in a lasso-like fashion. Results, as shown in Exhibit 13, are very similar to the ones in Exhibit 12. The pattern is no longer monotonic in $\boldsymbol{\gamma}$, but the range between the best and the worst CAPM alphas is narrower, at ~0.30%, well within the boundaries of statistical estimation errors.

γ	Beta	CAPM Alpha
0.1	1.00	3.89%*
0.2	1.00	3.74%*
0.3	1.00	3.67%*
0.4	1.00	3.68%*
0.5	0.99	3.74%*
0.6	0.97	3.84%*
0.7	0.96	3.88%*
0.8	0.94	3.91%*
0.9	0.93	3.94%*
CAPE US	0.93	3.84%*

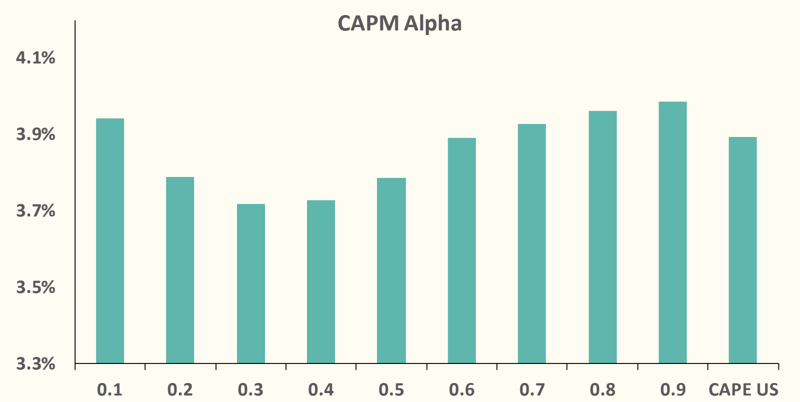


Exhibit 13: Simulated CAPM alphas as a function of the beta-adjustment under lasso-like penalization.
* refers to statistical significance at >95 level.

Our tests therefore show that the ability of the CAPE US strategy to deliver alpha is not specifically related to the weighting scheme chosen, but rather to its ability to pick the right sector at the right time. Taking into account sectors' ex-ante beta only marginally affects the overall alpha. An alternative weighting schemes around the equal weighing of the four sectors would yield similar risk-adjusted performances and alphas.

Sensitivity to the benchmark comparison

The CAPE US outperformed the S&P 500 over the period by an annualized 3.34%. While the performance of the CAPE US is given by the choice of its sectors (as they are all weighted at 25% each), the S&P 500 total return depends on both the weights and the performances of sectors over time. More precisely, the total return of the S&P 500 is given by[10]:

$$\boldsymbol{TR_{S\&P500}} = \left(\prod_{t}(\mathbf{1} + \sum_{s=1,..10} \boldsymbol{w_{t,s}} * \boldsymbol{R_{t+1,s}}\,)\right)$$

where $\boldsymbol{w_{t,s}}$ is the weight of sector s at time t, and $\boldsymbol{R_{t+1,s}}$ is the total return of sector s between consecutive months t and t+1. What would have been the outperformance if the S&P 500 were using different sectors' weights over time? To answer this question, we simulate the performance of a hypothetical S&P 500 with "different" sector weights. Let us define the $\boldsymbol{\sigma}$-permutated S&P 500 as follows: For a given permutation[11] $\boldsymbol{\sigma}$ of the set [1, 2, ..., 10], we have

$$\boldsymbol{\sigma T_{S\&P500}} = \prod_{t}(\mathbf{1} + \sum_{s=1,..10} \boldsymbol{w_{t,\sigma(s)}} * \boldsymbol{R_{t+1,s}}\,)$$

$\boldsymbol{\sigma T_{S\&P500}}$ represents the hypothetical performance of a strategy that would have invested in sector S with the weight of sector $\boldsymbol{\sigma}$(S) in the S&P 500. To understand how this would work in practice, let us look at Exhibit 14 below. For the given permutation $\boldsymbol{\sigma}$ (which associates 1 to 4, 2 to 3 and so on), the $\boldsymbol{\sigma T_{S\&P500}}$ allocation is shown on the bottom line: the Energy sector (sector 1) represents 5% of the S&P 500 while it is 11% in

[10] In reality, the total return is slightly more complex as dividends are reinvested in the index and not in each sector. But, for the purpose of the test, this is not an issue.
[11] A permutation $\boldsymbol{\sigma}$ of the set [1, 2, ..., 10] is a bijection of [1, 2, ..., 10] onto itself, that to each element in [1, 2, .., 10] associates a unique element of [1, 2, ..., 10].

this new strategy, as 11% is the weight of Consumer Discretionary (sector 4 which is associated with sector 1).

	Energy	Materials	Industrials	Cons. Discretionary	Cons. Staples	Health Care	Financial + Real Estate	IT	Comm. Services	Utilities
S	1	2	3	4	5	6	7	8	9	10
Weight	5%	3%	8%	11%	7%	15%	14%	26%	8%	3%
σ(S)	4	3	7	9	1	8	2	5	10	6
New Weight	11%	8%	14%	8%	5%	26%	3%	7%	3%	15%

Exhibit 14: Example of a permuted strategy

For each permutation (randomly drawn), we can compute the excess return of the CAPE US vs this hypothetical benchmark and plot the historical distribution to see where the real 3.34% falls. If the performance of the CAPE US strategy is mainly driven by a successful (and potentially lucky) market timing, we shall see that a substantial proportion of random excess returns vs the hypothetical benchmarks would be near zero, therefore labelling the real one as rather an outlier. Exhibit 15 below shows the histogram for N=10,000 simulations.

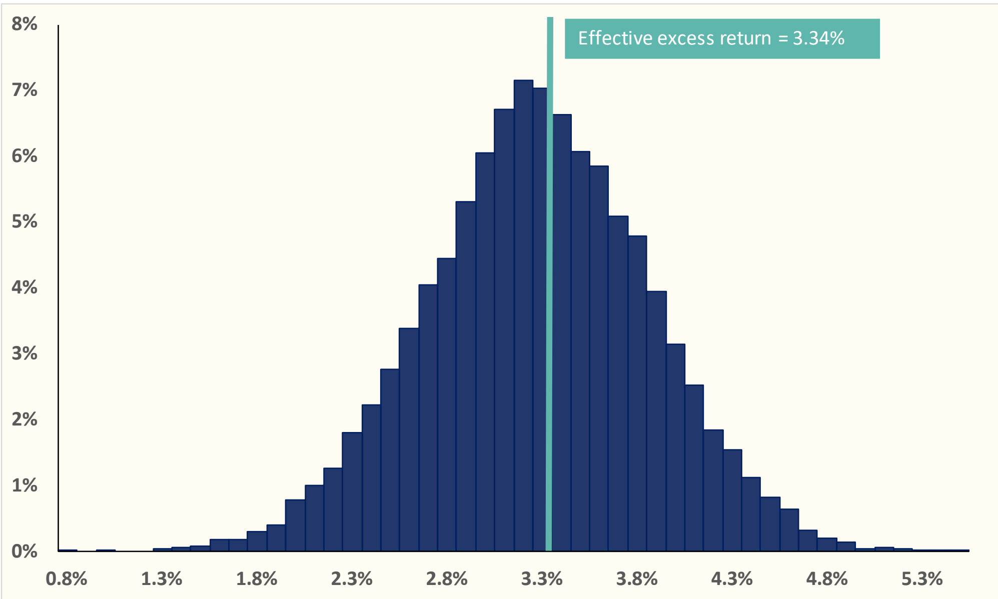


Exhibit 15 : Histogram of simulated excess return of CAPE US vs. hypothetical benchmark with fixed permutation.

According to Exhibit 15, by averaging across randomly selected permutations, we find a value for the excess return at ~3.2% (annualized), not far from the real one at 3.34%. In the worst cases (i.e., when the permutation gives us a very performing hypothetical benchmark), we still see a ~1.8% excess return, against a ~5% in the most favorable cases. In any case, the 3.34% value does not appear as an outlier. We can make the test more complex by allowing time-dependent permutations. Contrary to the test above, where the hypothetical benchmark total return was calculated once the permutation is drawn, a time-dependent permutation is drawn at each date, and it only affects the next-period return:

$$\tau T_{S\&P500} = \left(\prod_{t} (1 + \sum_{s=1,..10} w_{t,\tau(t,s)} * R_{t+1,s}) \right)$$

Exhibit 16 produces the histogram of simulated excess returns under hypothetical benchmarks with time-dependent permutations. It has a very similar structure as in Exhibit 15, peaking at ~3.2%. In the most unfavorable cases, we find an annualized performance of ~0.8%, and in the most favorable ones at 5.3%. Once again, the 3.34% real excess return does not appear to be an outlier.

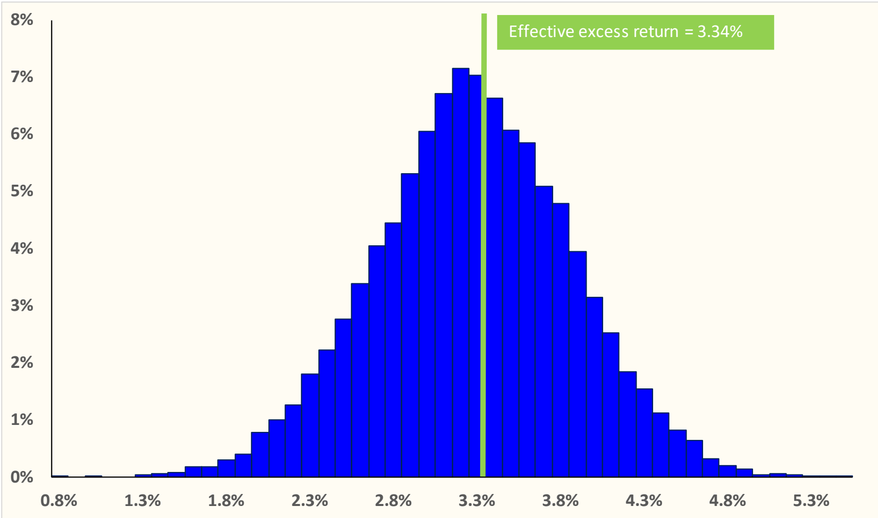


Exhibit 16 Histogram of simulated excess return of CAPE US vs. theoretical benchmark with dynamic reshuffle.

In conclusion, we see that the excess return is not the consequence of a lucky strike of successful sector overweightings in the CAPE US strategy. If this were the case, Exhibits 15-16 would appear drastically shifted to the left and mostly centered around zero, which is not what we observe.

Conclusion

Ten years ago, the CAPE US was just another quantitative investment strategy, with an in-sample backtest that held promises for potential investors. After a subsequent 10-year period during which the parameters were kept unchanged, the out-of-sample has lived up to the initial promises of the backtest. As validated by the extensive battery of tests we have conducted, the CAPE US is an "anomaly", in the sense used by Fama and French. The CAPE US strategy has delivered true "sector rotation" alpha, consistent over time, over crisis periods, and across dispersion regimes. Moreover, most of the alpha came from the signal itself (i.e., the relative CAPE ratio) rather than from the choices made in portfolio design and rebalancing. Further evidence is that the same strategy applied to European markets[12] has also generated very robust results.

The CAPE US is not only a paper trading strategy. It has been successfully implemented by investment funds with little implementation shortfall. Transaction costs are indeed limited given the monthly rebalancing frequency and the liquidity of the underlying investment universe (S&P500). Furthermore, we have shown that execution can be smoothed out over a few days without any material impact on performance.

[12] Shiller Barclays CAPE® Europe Sector Value Net TR Index (BXIICESE Index)

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