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CAPM and beyond

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qblue balanced

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Agenda

- Recap CAPM – a naive model or corner stone in empirical finance
- Extension with the Fama-French factors – why did FF create the 1993 paper with extension in 2015
- Is the FF factors an extension used by practitioners?
- How does the beta-again-beta fit into the FF factors
- What is it we at Qblue Balanced is trying to achieve
  - What is a risk factor
  - What is a risk premium
  - What is alpha
- How does all this link to the article betting against beta

CAPM model

From Wiki: "The CAPM was introduced by Jack Treynor (1961, 1962) William Sharpe (1964), John Lintner (1965) and Jan Mossin (1966) independently, building on the earlier work of Harry Markowitz on diversification and modern portfolio theory. Black (1972) developed another version of CAPM, called Black CAPM or zero-beta CAPM (often used just like the CAPM). This version is more robust against empirical testing and was influential in the widespread adoption of the CAPM."

- The Black CAPM does not rely upon the assumption that all investors can borrow at the risk-free rate of interest. Rather, the Black CAPM relies upon the assumption that investors can short sell risky assets. Historical this has not been the case but the possibility to short sell for even retail investors has improved the last decade. Still short selling of individual stock is primely for professional investors with good broker relationship.
- This alternative assumption leads to result that the expected return on a risky asset is equal to the return on a zero beta asset (r_z) plus a premium for bearing systematic risk $\beta \times (r_m - r_z)$, where r_m is the expected market return. The zero beta premium refers to the difference between the return on a zero beta asset and the risk-free rate ($r_z - r_f$). From BaB: "One may wonder why zero-beta assets require returns in excess of the risk-free rate. The answer has two parts: First, constrained agents prefer to invest their limited capital in riskier assets with higher expected return. Second, unconstrained agents do invest considerable amounts in zero-beta assets so, from their perspective, the risk of these assets is not idiosyncratic, as additional exposure to such assets would increase the risk of their portfolio. Hence, in equilibrium, zero-beta risky assets must offer higher returns than the risk-free rate."
- The classical CAPM and be derived as a consumption-based with different utility functions, return distribution and periods, see Cochrane book, "Asset Pricing", chapter 9.

CAPM and Finance

Historically Finance has been split into two a “Q-world” and “P-world”

- Q-world is based on existing of no arbitrages in the market (Q is actual a probability distribution)
  - This theory has given us Black-Scholes formula which price European options in frictionless market conditions (no transaction costs, can short assets)
  - The formula is based on a self-financing strategy which with the given option premium yields the option payoff hence you are indifferent holding the option or doing the self-financing strategy
- Scholes and Merton were awarded the 1997 Nobel Prize in Economics for their work in finding a new method to determine the value of derivatives (Black died in 1995 and the price is not given posthumously).

- The P-world is based on the empirical return distributions of assets
  - This theory tries to explain empirical relationship of asset returns here CAPM is one key model
  - Sharpe, Markowitz and Miller received the Nobel Price in 1990 for the their work including the CAPM model
  - Fama, Shiller and Lars Peter Hansen received the Nobel Price in 2013 for the their work in the area of empirical finance much can be seen as extensions of the CAPM framework

CAPM - a naïve finance model?

Differences between physics, statistics and finance

- Physics are rolled by laws, such as heat equation, and be rather complex modelling. In 1926 Erwin Schrödinger posited an equation that predicts both the allowed energies of a system as well as the probability of finding a particle in a given region of space. These probability distribution can be link to stochastic differential equations and hence suddenly a physical problem turns into probability distribution, just link the P and Q finance.
- Statistics is based by knowledge and understanding what generate the data. In statistics the normal distribution is similar to CAPM in P-finance and Black-Scholes in Q-finance. Much more complex distributions is used but using these incorrectly will come with a high price
- In Finance models tends to be more simple but starting to thinking about the underlying assumptions and implication relaxing these can be complex. If a physicist says that empirical finance is just estimating linear regressions in CAPM is like a finance person stating that physic is just learning to solve PDEs

Fama-French 3-factor model

In 1993 Fama-French paper they extended the CAPM in model with two new factors. The Fama-French factor construction is based on the CRSP database, nearly 4,000 constituents across mega, large, small and micro capitalizations, representing nearly 100% of the U.S. investable equity market.

- Value factor: (HML) Buy stocks with low price-to-book (P/B) (value stocks) and sell stocks with high P/B (growth stock)
  - Book value is not a simple concept and included intangible assets and goodwill and varies across industries
  - Rationale for why value should work:
    - **Distress Risk** The most prominent explanation is the Fama-French version, which links the Value Risk Premium to some distress factor – and that value strategies are fundamentally riskier
    - **Behavioural - Extrapolation** The behavioural based explanations focuses on the tendency of investors to extrapolate past earnings growth too far into the future. Eventually resulting in an overpricing respectively underpricing of the stock value
- Size factor: (SMB) Buy small cap stocks and sell large cap stocks
  - Rational for SMB
    - Risk: Liquidity risk. You hold liquidity risk when holding small cap stocks.

Does the Fama-French 3 factor fit into the CAPM framework?

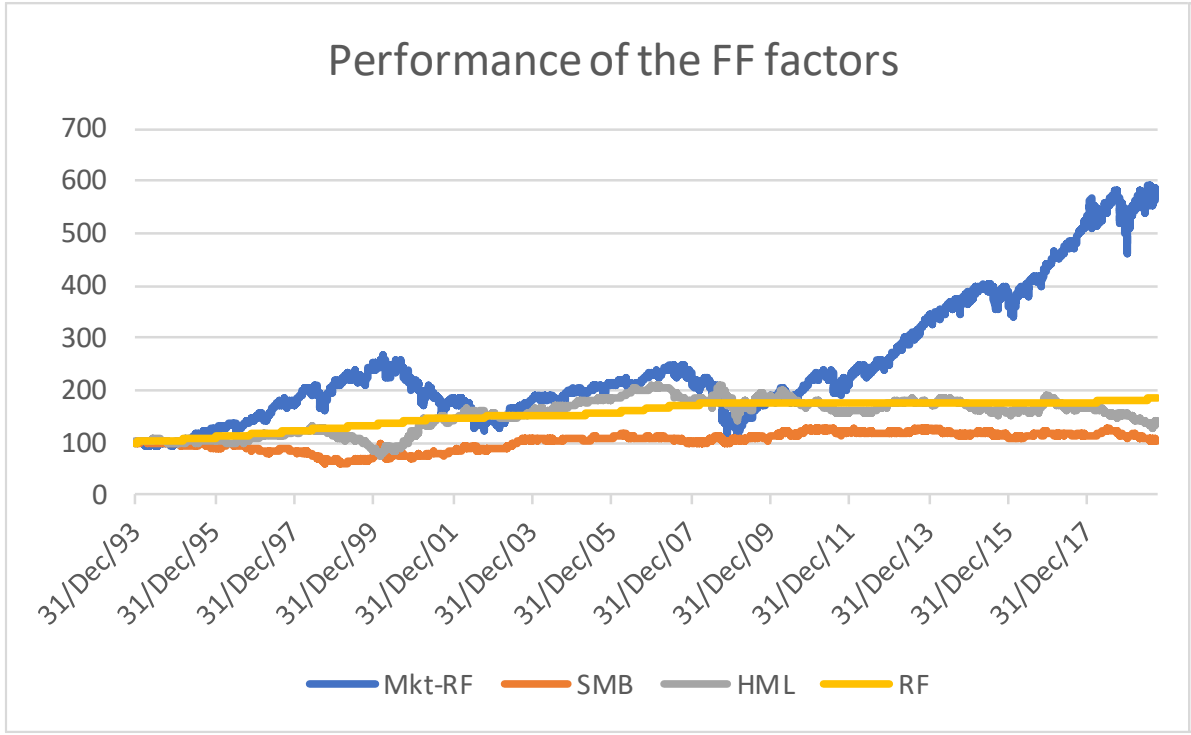
Fama-French argue in their 1993 that their 3-factor model is a ICAPM model with their factors as proxy for state variables.

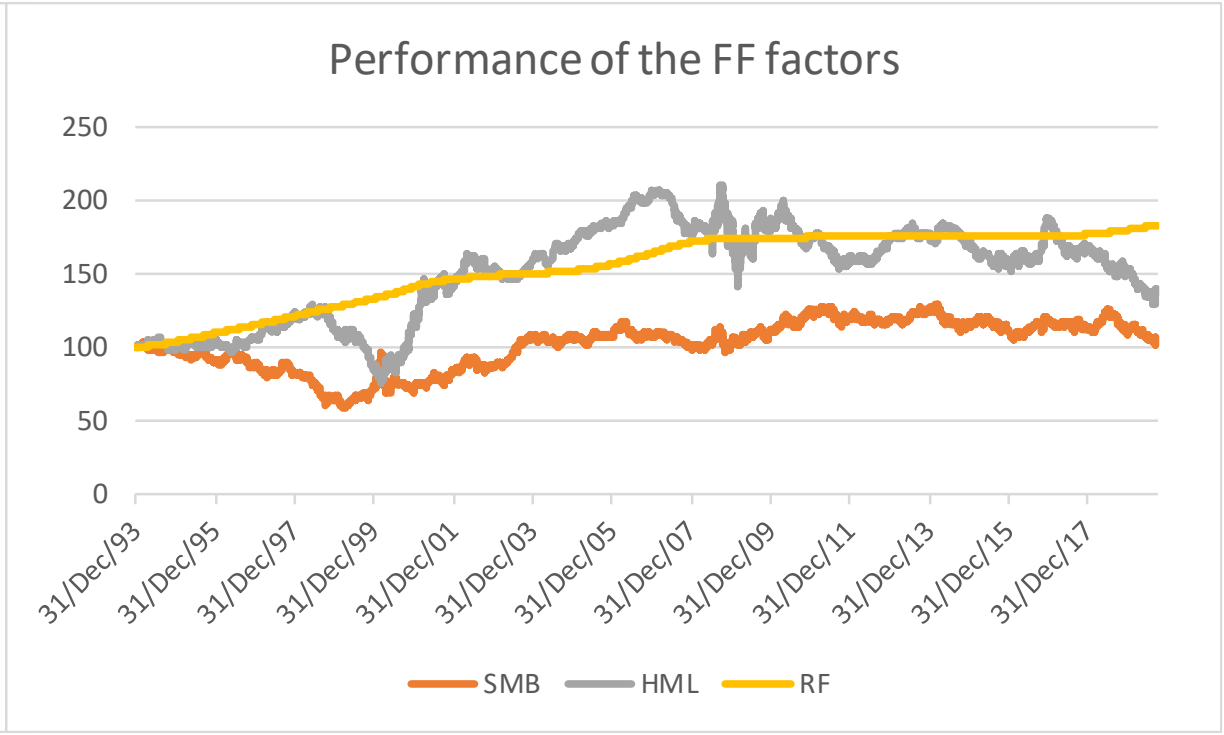
- State variables is random variables which describe the agents wealth and possible consumption. If the Fama-French factors is such state variables it requires that these factors is what determine the agent investment opportunity set
  - It's true that factors can explain part of the risk / variation in the covariance matrix but this is not the same as there is a income stream behind
  - As an example one could argue that currency risk, example an European investor buy US stocks unhedged, is a factor but not a state variable.

I prefer to definition a factor as a stochastic variable which explain some of the total risk of assets. There is no guaranty that this factor has an expected return significant larger than zero. I'll get back to this puzzle later.

Performance of the Fama-French 3 factors

Is the Fama-French a risk factor with expected return zero?





Source: https://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

What is value?

- P/B can be a noisy measure
  - Example: Intangible assets are difficult to assess, in Nov 2019 Denmark experienced large revisions in GDP forecasts because of difficulties evaluating foreign intangible assets
  - Example: If a bank holds a lot of it properties / real estate (part of the book value) and prices goes up on real estate the book value will increase but this is not a good indication for how good the bank is run

Value Risk Premium

'Portfolios populated with cheap stocks outperform portfolios populated with expensive stocks over the long term'

Risky Value *(risk factor)*
- Not a risk premium, but explains a lot of the return variance
- Positive at market turning points when high risk outperforms low risk/quality and is therefore a good diversifier to Momentum which tends to struggle in these periods

Book to Price

Long term mean reversion

Value Creation *(risk premium)*
- *Value* created via earnings growth
- A compensation for holding future earnings growth which is at risk not being materialized

Earnings to Price (E/P)

Value Distribution *(risk premium)*
- *Value* distributed to shareholders via dividends and share buybacks
- The Dividend Puzzle?
- A compensation for future dividends/share buybacks being cut

Dividend Yield

Buyback Yield

Net Debt Reduction

Why does classical value not work

- Before 1990'ties the stock market consists of the "old" industries such as automobile sector
- For these industries P/B where a good proxy for cheapness
- Today, many providers of risk systems use sophisticated classification systems with different levels.
- Maybe the most widely used is GICS, Global Industry Classification Standard provided by MSCI, https://www.msci.com/gics
- To the right you see an example of an industry classification. It's just a snap but hopefully give a flavor of granularity of industry classification today

By Industry

Factor	Prop. of Risk
Energy Equipment & Services	4.46
Semiconductors & Semiconductor Equipment	2.90
Software	2.32
Health Care Equipment & Supplies	1.18
Internet Software & Services	1.02
Airlines	0.87
Textiles, Apparel & Luxury Goods	0.67
Professional Services	0.48
Oil, Gas & Consumable Fuels	0.42
Health Care Providers & Services	0.35
Tobacco	0.33
Real Estate Investment Trusts (REITs)	0.33
Communications Equipment	0.32
Computers & Peripherals	0.20

Fama-French 3-factor model

Today there is a debate in academia and industry if there exists a size premium

- Access and transparency of the stock market has dramatically increased the last 30 years and today every body can trade stocks easily can get access to even micro cap
- There could be argument that the micro cap space is overlooked both by
  - News and media
  - Institutional investors because it does make sense for them to by micro cap stocks
  - ETF space, ETFs is a scalability business and just like institutional investors require a certain markets cap

The industry use the Fama-French factors as a reference point. If you construct a value premium it will positive correlated to the Fama-French factor but maybe/hopefully with a better return stream (going forward)

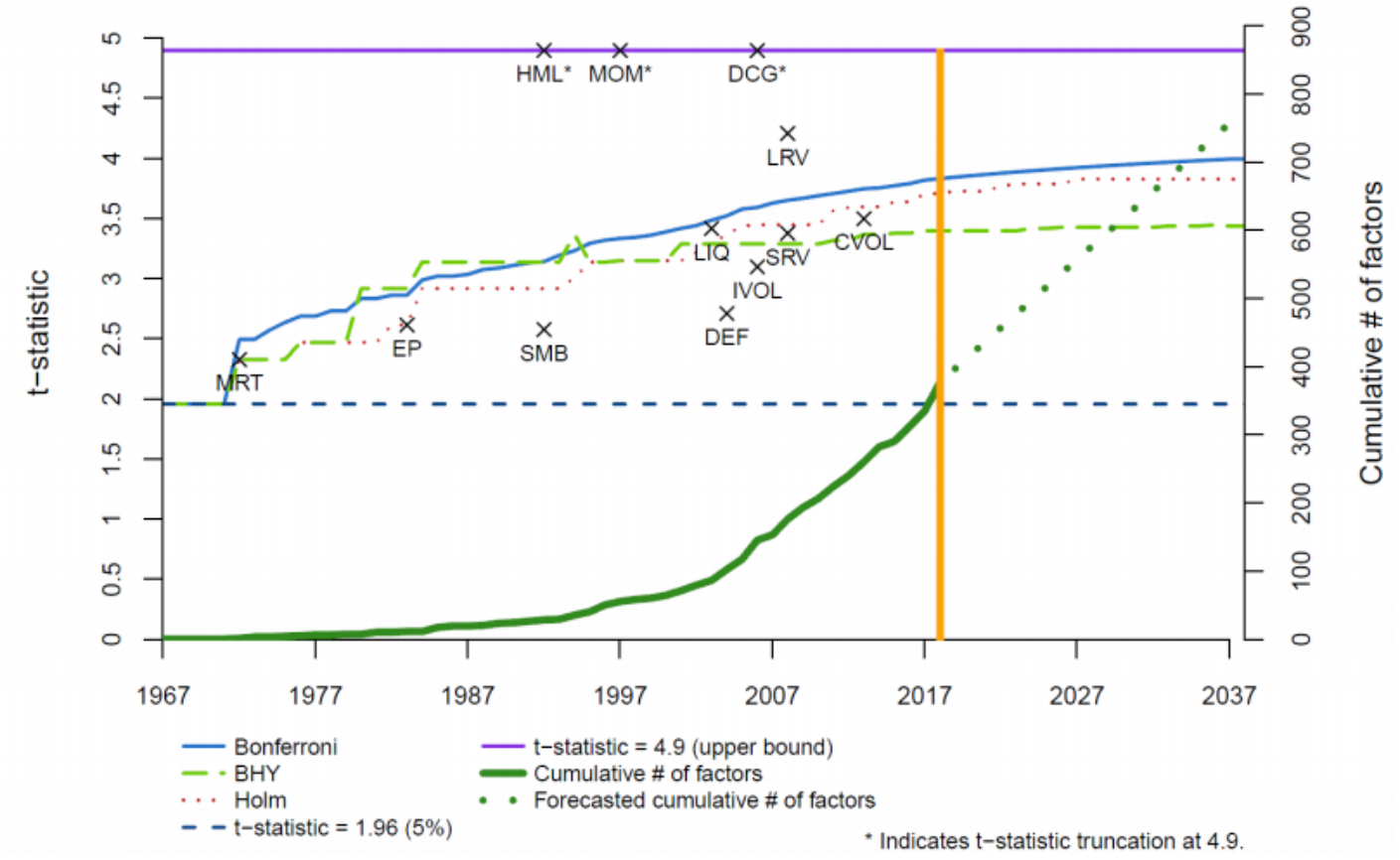
More factors – the factor zoo

- Carhart introduced the momentum factor in 1997 and Fama-French extended their 3-factor model with two more factors in 2015
- Since then the number of factors have exploded and some call is a factor-zoo. Harvey and Lie 2018 paper, Lucky Factors is a good read, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3341728 plus Arnott 2019 et al. paper https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3331680. They provide an overview of when the different factors were published in a Google sheet, the problem with t-stats and typical mistake made by investors. From abstract of Arnott el paper "Factor investing has failed to live up to its many promises. Its success is compromised by three problems that are often underappreciated by investors. First, many investors develop exaggerated expectations about factor performance as a result of data mining, crowding, unrealistic trading cost expectations, and other concerns. Second, for investors using naive risk management tools, factor returns can experience downside shocks far larger than would be expected. Finally, investors are often led to believe their factor portfolio is diversified. Diversification can vanish, however, in certain economic conditions, when factor returns become much more correlated. Factor investing is a powerful tool, but understanding the risks involved is essential before adopting this investment framework."

More factors – the factor zoo

- To the right Harvey and Liu (2019) show the increased numbers of factors and how this should lead to increased t-stats to avoid accepting false positive (type II error).
- Also Novy-Marx 2015 WP https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2629935 discuss the problem about selecting best-of n strategies and how this should influence the t-stats when testing if alpha is significant for the strategy

Figure 3. Historical testing thresholds controlling for cumulative factor discovery, 1963–2018



Source: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3341728 1

Qblue Balanced

Qblue Balanced is a Copenhagen based asset manager founded in 2018 by Bjarne Graven Larsen, former CIO at ATP and Ontario Teachers' Pension Plan.

Co-founded by a team of experienced pension fund investment professionals with a long and successful history together.

We are systematic and process oriented in nature and approach.

Bjarne Graven Larsen
CEO

Fredrik Martinsson
CIO

Thomas Stryger Olsen
Senior PM

Lars Voss Toft
Senior PM

Lars Hougaard Nielsen
PhD, Senior PM

Martin Richter
PhD, Senior PM

Kevin Mitchell
PM

Alexandra McGuigan
Singapore Office

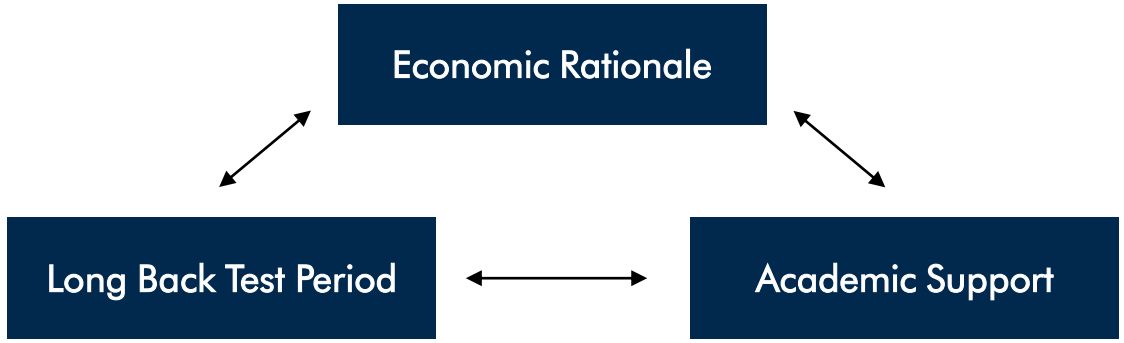
Andreas Wulff
Risk Manager

Julie Helene Lauritzen
Finance & Compliance Officer

Michelle Porsby Barth
Student assistant for the PMs

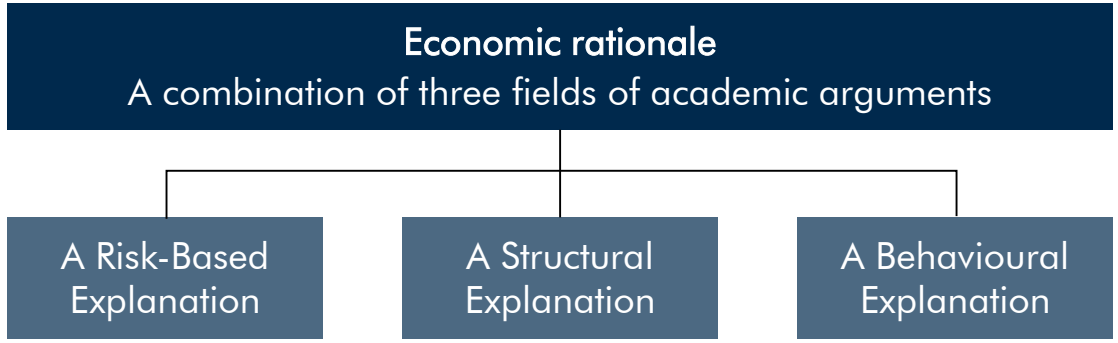
A Rigorous Identification Process

We have done this before and in big size:

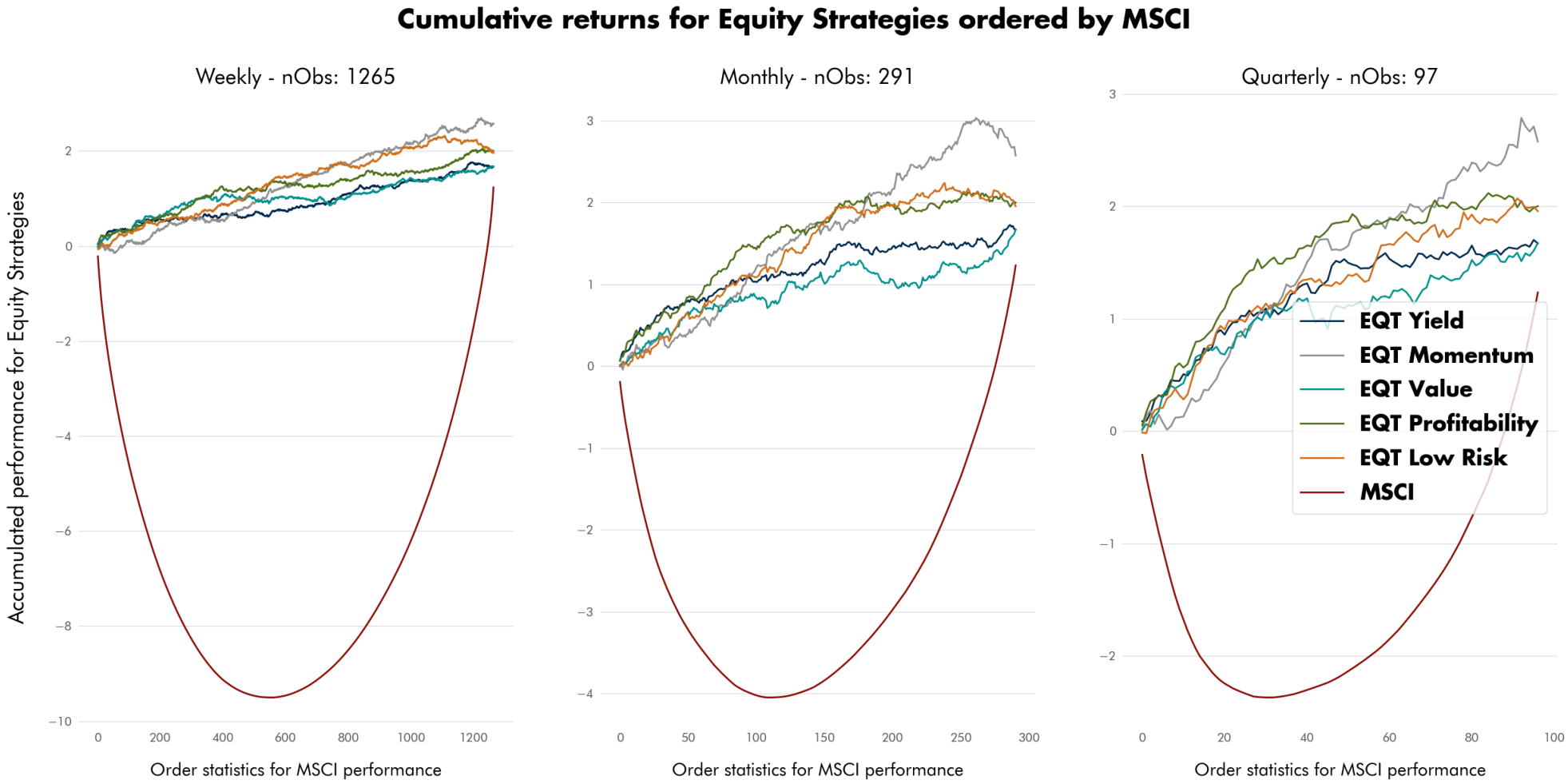


- We use a multi-decade 1995 – 2018 period
- We use experience-based trading and lending cost assumption
- We have internal checks and balances to mitigate back-fitting behaviours

- We naturally screen and follow academic research in the ARP space
- Academic support is an important criterium, but not a prerequisite, in our internal single ARP approval process



Equity Factor Analysis



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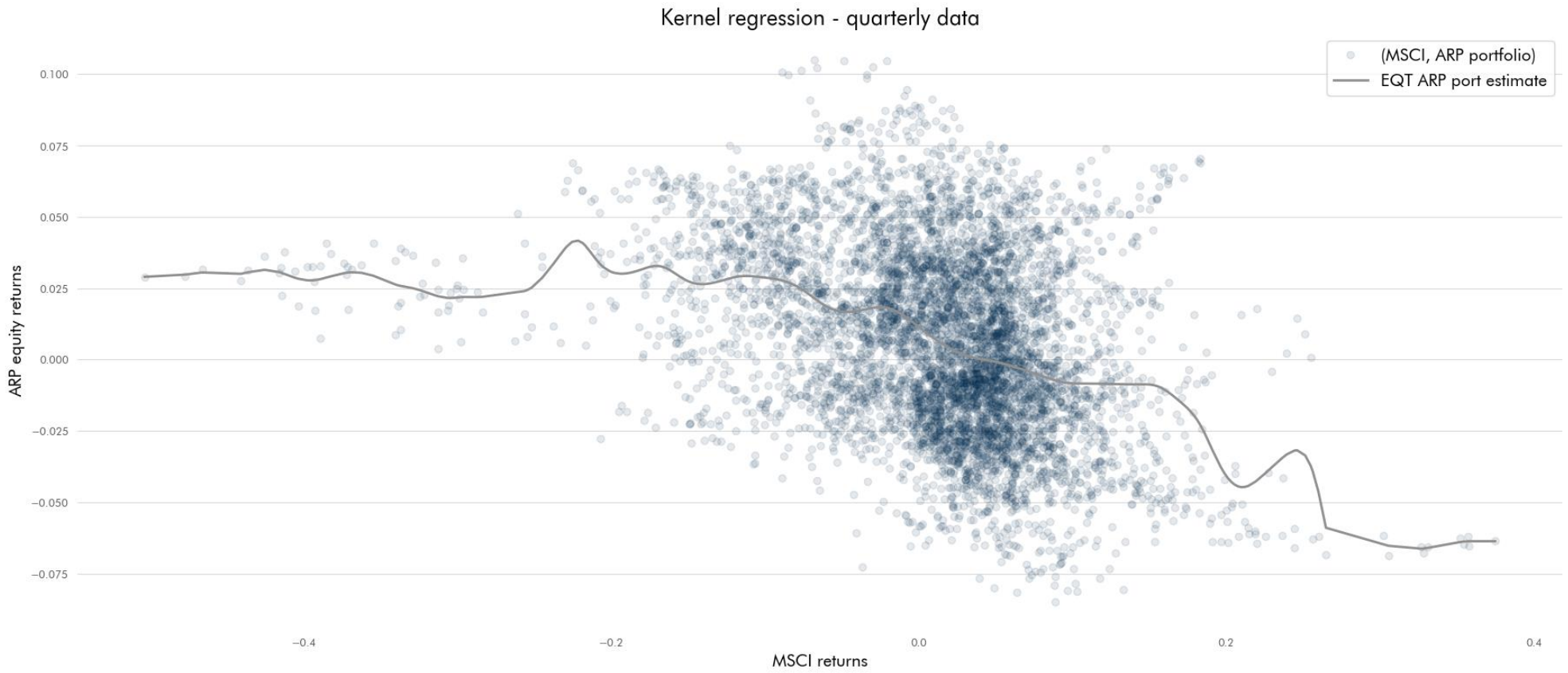
Don’t expect even linear factor portfolios to have simple linear relationship to mkt



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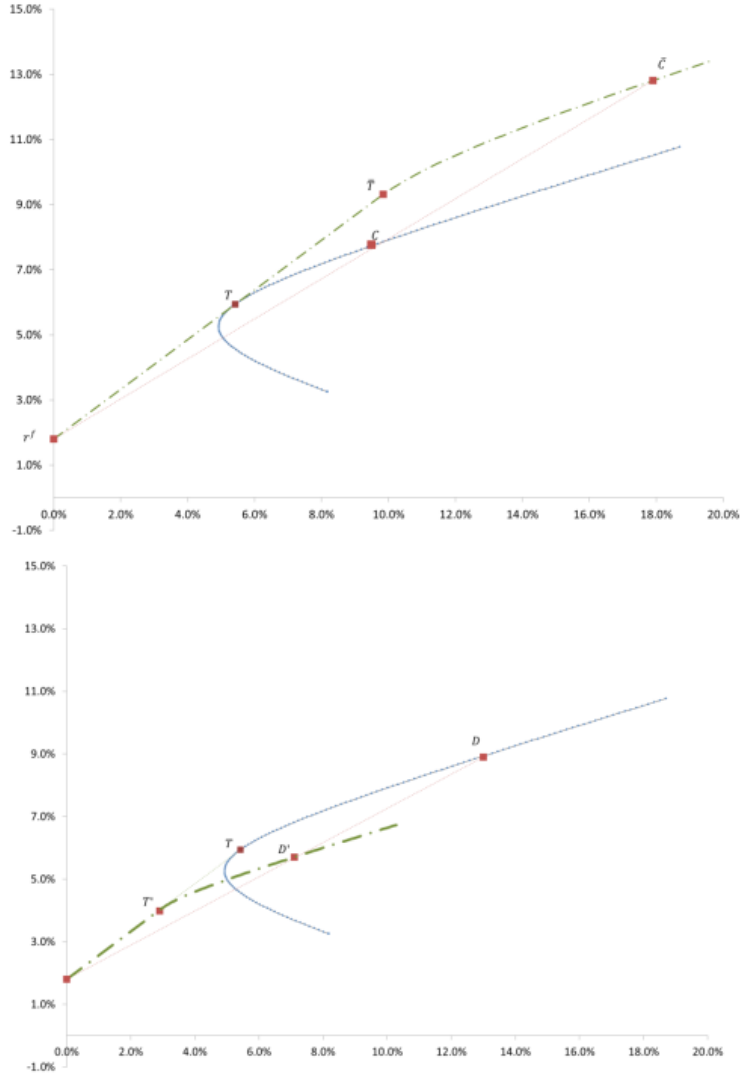
Betting-against-Beta (BaB factor)

- Structural
  - Leverage constraints
    - Investors use high risk stocks as a substitute for leverage. Thus resulting in a flatter Security Market Line than dictated by the CAPM. Less focus on risk adjusted returns. Allocation of capital – not risk
  - Benchmark constraints
    - Including low/high beta names can imply high tracking error and is thus avoided by benchmark constrained investors
    - Buying high beta stocks can be a way for (desperate) active managers to outperform their benchmark
- Behavioural Effects
  - Lottery ticket preference
    - Willingness to 'over-pay' for stocks that appears to have an asymmetrically large upside. The lottery ticket is best express in the ivol level but stocks with high ivol will normally also have high beta

Betting-against-Beta (BaB factor)

- The efficient frontier looks different for an agent/investor who have access to leverage and one who needs to hold cash
- Today the most professional investors works with risk budgets and have access to leverage. If you don't have access to leverage you will ending up working absolute return target and instead of leverage portfolio T they will go for portfolio D. To get to portfolio D you need to hold more securities with high betas

Figure A1. Portfolio Selection with Constraints. The top panel shows the mean-standard deviation frontier for an agent with $m<1$ who can use leverage, while the bottom panel show that of an agent with $m>1$ who needs to hold cash.

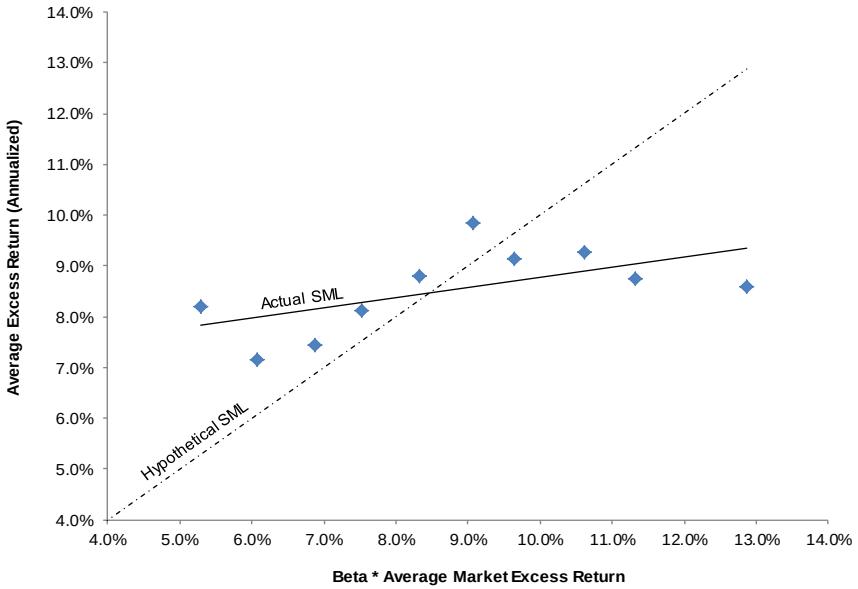


Betting Against Beta - Andrea Frazzini and Lasse H. Pedersen – Appendix A - Page A2

Betting-against-Beta (BaB factor)

- This generate a flatter SML than predicted by CAPM which was already observed by Black in 1972
- At first this look like a simple idea and easy to exploit but let us dick into the greedy details
- I will extensively use the Frazzini and Pedersen article which you have read, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2049939 but also Novy-Marx and Velikov paper "Betting against BaB"(BaB2) https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3300965

➢ Theoretical and Empirical Security Market Lines of Ten Beta-sorted Portfolios (1926 to 2010)



Betting-against-Beta (BaB factor)

Background – shorting stocks

- Stock borrowing of cash equity stocks is not a simple process
  - Some stock can in periods been banded from short selling as seen during the financial crises in 2008-2009
  - You need a broker relationship to have access to shorting and the price and availability varies across brokers
  - The number of stocks you can short sell depends typically of the market cap but also of ownership structure of the stock and micro cap stocks is notoriously hard to short sell. As a roll of thump in the in the US it is today possible to short sell the largest 2500 stocks cheap (around 25 – 30 bps) but if you want to go down the cap to maybe the largest 5000 stocks in the US the annual price could go up to 300 bps (and even higher in periods)
  - In most countries it is not allowed to short sell naked so the broker need someone who is willing to lend the stock, you cannot do it synthetic
  - The high beta stocks are normally the one which are hard to get and come with higher price. These stock typically attention crabbing and demand/supply can change dramatically (Snapchat and famous example from 2018 the VW short squeezes, https://www.reuters.com/article/us-volkswagen/short-sellers-make-vw-the-worlds-priciest-firm-idUSTRE49R3I920081028)

Betting-against-Beta (BaB factor) – problem 1

Costs of funding the short positions

- The BaB is a special premium since it is not natural USD-neutral, an expression used when short and long leg of a strategy have the same notional. To be beta-neutral you need to buy more low beta stocks than sell high beta stocks
- Additional to short selling costs you need to place the money you get from short selling into your broker account at LIBOR – x bps. This cash cannot be used to buy the stock on the long leg
- Buying stocks forthe long leg you can either use your own cash or pay the broker LIBOR + y bps. Since a lot of your cash is need for collateral and liquidity buffer you need to borrow this cash
- In the end you are ending up pay a lot for the liquidity and access to short selling and most paper either ignore this costs or only include a proxy for the lending rate of the stock.

Note: In the BaB paper they write "For example, on average, the US stock BAB factor is long $1.4 of low-beta stocks (financed by shortselling $1.4 of risk-free securities) and shortsells $0.7 if high-beta stocks (with $0.7 earning the risk-free rate).

Betting-against-Beta (BaB factor) – problem 2

Problem shorting all stocks in the BaB factor

- In the BaB paper they rank-weight stocks in their portfolio construction. As pointed out by BaB2 this weighting is very close to equally weighting. Normally equally weighting yield better results than cap weighting but allocating away from cap weighting lower capacity in the strategy. It is more likely to observe high beta stocks in the smaller market cap segment simply because their weight in the index is insignificant. Therefor, the BaB factor will end up having overweight (short part) in the lowest 1% market capitalization, see BaB2 for details. These beta stocks will be expensive and hard to sell.
- The performance difference is significant between equal and cap weighted as shown in the figure to the right (from BaB2)

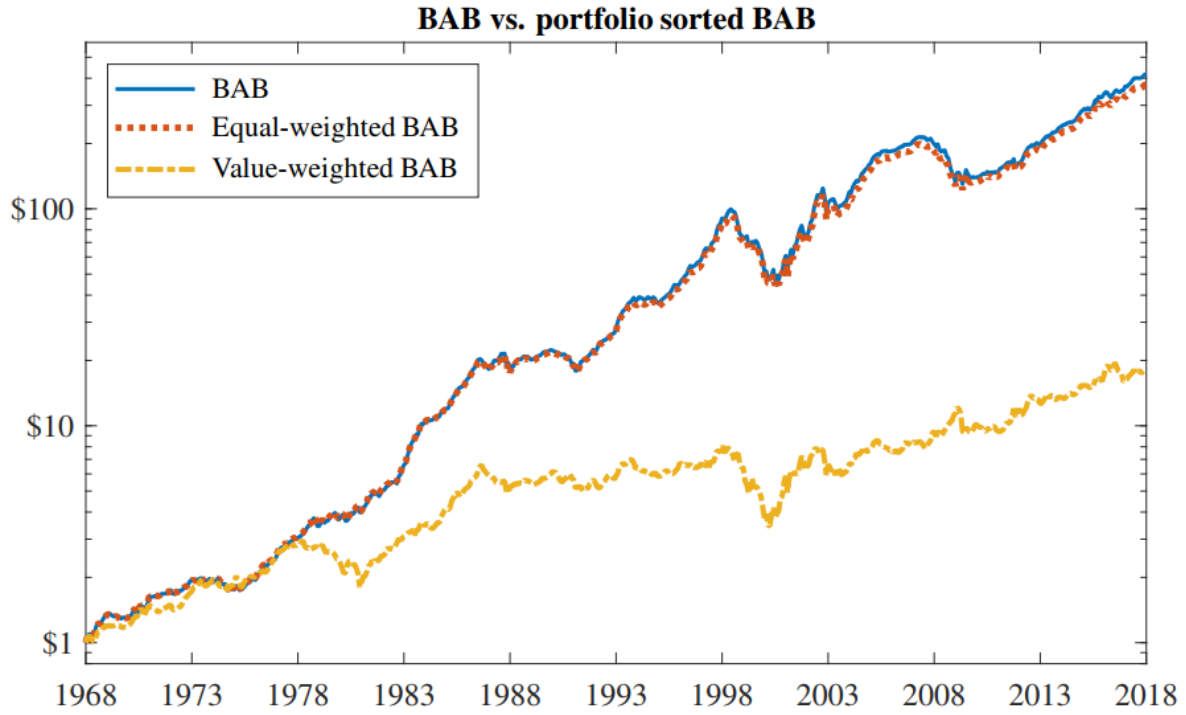
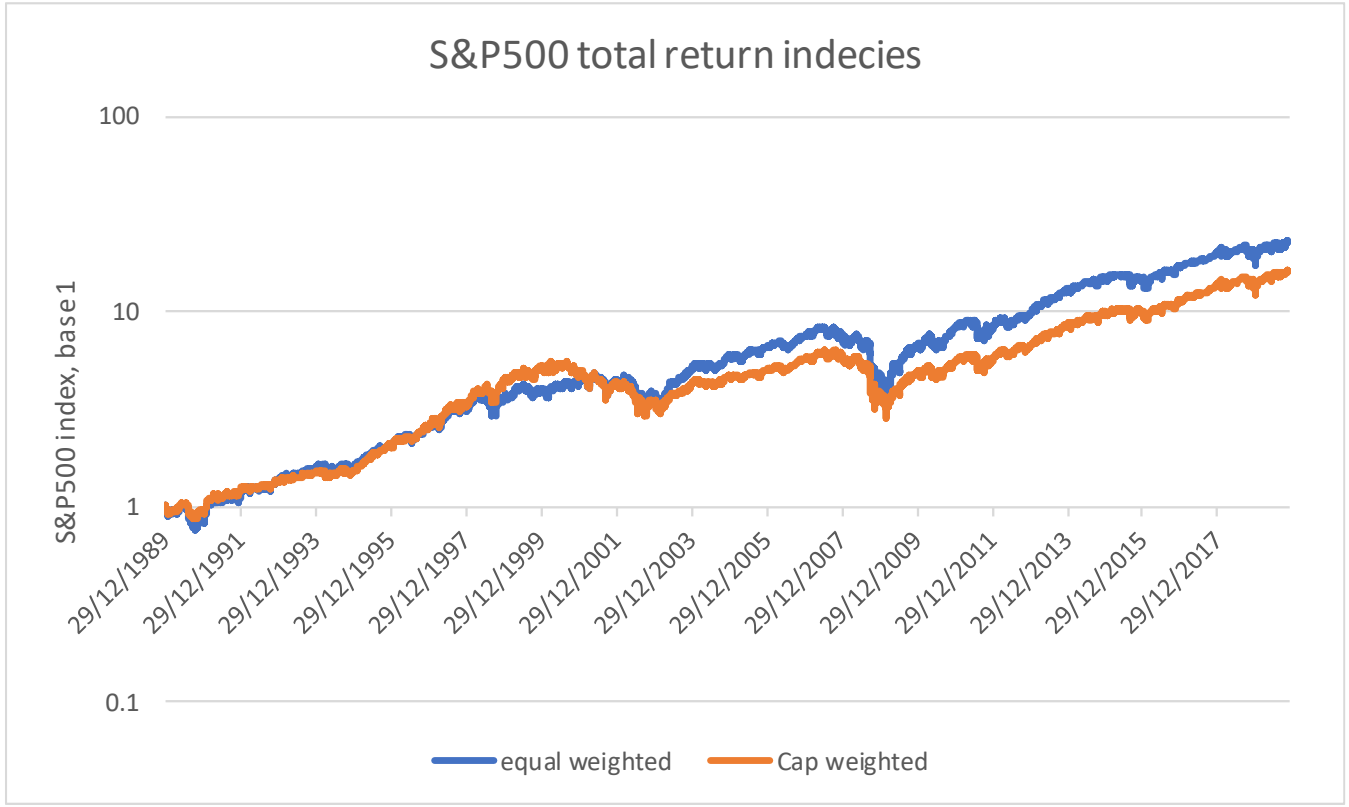


Fig. 2. The figure shows the performance of our replication of BAB (solid line), and two variations on BAB, built using the same methods used to construct BAB, but based on quantile-sorted underlying low and high beta portfolios. Equal-weighted BAB (dotted line) is based on equal-weighted portfolios that hold the top and bottom thirds of stocks selected on the basis of the same beta estimates used when constructing the rank-weighted portfolios underlying BAB, while value-weighted BAB (dot-dashed line) is based on the value-weighted versions of these same portfolios. The sample covers January 1968 through December 2017.

Betting-against-Beta (BaB factor) – problem cont. 2

It is typical that the equal weighted portfolio outperform cap weighted simply because of better diversification between asset

- Equally weighted indices have higher transaction costs
- They have lower capacity
- To the right you see the equally weighted and cap weighted total return S&P500 index (no tax on dividend and transaction costs). Today you can buy both indices as ETFs
- Equal weighted index have higher weight to high vol stocks but is more diversification and the realized volatility of the two indices are roughly the same (18.4% for eql and 17.7% for cap weighted with 97% correlated. You can argue that the outperformance of the equal weighted is not significant (not tested here))



Source: Data is from Refinitiv

Betting-against-Beta (BaB factor) – problem 3

Beta hedging of the premium

- BaB2 criticize the BaB for not keeping the portfolio USD-neutral and using the cap weighted marked as hedge
  - We actual hedge the same way as BaB and I don't agree with the BaBs critic. Maybe the benchmark case is cap weighted and as BaB2 shows, it can be a different.
  - Hedging using the marked complicate things. In this case you will need to buy "the marked" so in that hedge you will buy some of the stocks you have already sold. Second if you use an index as hedge the factor properties will not be the same as the underlying portfolio and you will can both momentum, size and industry exposures embedded in the hedge

Beta hedging is complicated and there is other challenged addressed in the BaB paper

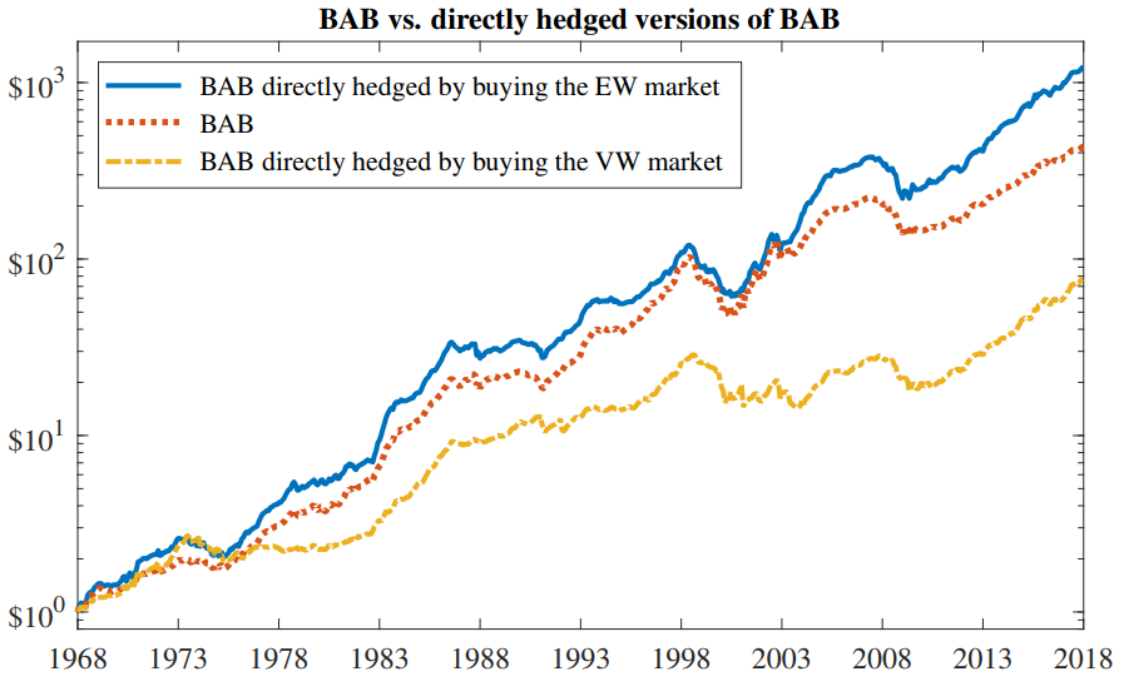


Fig. 3. The figure shows the performance of our replication of BAB (dotted line), and two strategies based on the same low beta-minus-high beta strategy underlying BAB, but hedged directly with debt-financed positions in the market portfolio. One of these is hedged by buying the equal-weighted market (solid line), while the other is hedged by buying the value-weighted market (dot-dashed line). Because the version directly hedged by buying the equal-weighted market naturally has a significantly lower volatility (9.6%), the directly hedged versions are leveraged to run at the same sample volatility as BAB (11.9%). The sample covers January 1968 through December 2017.

Betting-against-Beta (BaB factor) – problem 4

Beta neutrality of the premium

- Firstly, you need to define the marked. There is a different between being beta neutral to S&P500 cap weighted, S&P500 equal weighted, MSCI US, MSCI World. Since the stock indices are very correlated the differences are not huge but it is always good be very precise what is the objective to neutralize and measure against.
- When estimating beta there will roughly be two cases
  - Stocks which has high/low beta because of structural patterns (some industries have higher vol, newly IPOs, embraced by retail investors, …)
  - Stocks which by coincident/randomness observe high/low volatility. So in some cases a high/low beta estimates in the extreme quantiles are expected to revert back to more neutral taritory.
  - In the BaB paper they use a naïve shrinkage approach which I think is problematic. Here $\hat{\beta}_i = w_i \hat{\beta}_i^{TS} + (1 - w_i)\hat{\beta}^{XS}$ where $\hat{\beta}^{XS}$ is the cross sectional mean set to one and w = 0.6 for all stocks.

Betting-against-Beta (BaB factor) – problem 4

The table below is from BaB and shows two problems

1. Average beta is not one. I expected it is because they use a cap weighted index. When they shrink there beta estimate they use one a neutral state which is this case is biased
2. They use the same shrinkage on the short and long leg. You can see that realized beta is more biased for high beta stocks. Academic this is not a problem when generating alpha estimates, but for us it is.

	P1 (Low beta)	P2	P3	P4	P5	P6	P7	P8	P9	P10 (high beta)	BAB
Excess return	**0.91** (6.37)	**0.98** (5.73)	**1.00** (5.16)	**1.03** (4.88)	**1.05** (4.49)	**1.10** (4.37)	**1.05** (3.84)	**1.08** (3.74)	**1.06** (3.27)	**0.97** (2.55)	**0.70** (7.12)
CAPM alpha	**0.52** (6.30)	**0.48** (5.99)	**0.42** (4.91)	**0.39** (4.43)	**0.34** (3.51)	**0.34** (3.20)	**0.22** (194)	0.21 (172)	0.10 (0.67)	-0.10 -(0.48)	**0.73** (7.44)
3-factor alpha	**0.40** (6.25)	**0.35** (5.95)	**0.26** (4.76)	**0.21** (4.13)	**0.13** (2.49)	**0.11** (194)	-0.03 -(0.59)	-0.06 -(102)	**-0.22** -(2.81)	**-0.49** -(3.68)	**0.73** (7.39)
4-factor alpha	**0.40** (6.05)	**0.37** (6.13)	**0.30** (5.36)	**0.25** (4.92)	**0.18** (3.27)	**0.20** (3.63)	**0.09** (163)	**0.11** (194)	0.01 (0.12)	-0.13 -(101)	**0.55** (5.59)
5-factor alpha*	**0.37** (4.54)	**0.37** (4.66)	**0.33** (4.50)	**0.30** (4.40)	**0.17** (2.44)	**0.20** (2.71)	**0.11** (140)	0.14 (165)	0.02 (0.21)	0.00 -(0.01)	**0.55** (4.09)
Beta (ex ante)	0.64	0.79	0.88	0.97	1.05	1.12	1.21	1.31	1.44	1.70	0.00
Beta (realized)	0.67	0.87	1.00	1.10	1.22	1.32	1.42	1.51	1.66	1.85	-0.06
Volatilty	15.7	18.7	21.1	23.1	25.6	27.6	29.8	31.6	35.5	41.7	10.7
Sharpe ratio	0.70	0.63	0.57	0.54	0.49	0.48	0.42	0.41	0.36	0.28	0.78

* Pastor and Stambaugh (2003) liquidity factor only available between 1968 and 2011.

Betting-against-Beta (BaB factor) – problem 5

Estimating beta as long term correlations (5Y) and volatilities (1Y)

- The mean reverting feature of beta's makes is an obvious candidate to use GARCH type estimation instead of a equal weighted window.
- By mixing windows in the beta estimate you introduce a bias in the beta's such that in periods with increasing systematic risk you shrink the beta's. The explanation is given in BaB2 with the formula (which is easily calculated)

$$\beta^i_{\text{FP}} = \left(\frac{\sigma^i_1 / \sigma^i_5}{\sigma^{\text{mkt}}_1 / \sigma^{\text{mkt}}_5} \right) \beta^i_5.$$

- When systematic risk increases, the market risk increases more than the idiosyncratic risk and hence the bracket expression will decrease. This might be a wanted property but they (BaB paper) concludes that the dispersion in beta values decreases with the TED spread and this is almost by construction the way beta is constructed here (from BaB2).

Betting-against-Beta (BaB factor) – problem 6

Do BaB comes with other factor exposures?

- Does the BaB strategy have unwanted factor exposure such as ivol, fixed income exposures (example could be duration or curve positions)? Is the BaB created here cleaned for unwanted industry exposures and if yes, how?

The goal with the BaB strategy discussion here is to show that there are many choices to make when creating the strategy. All these choice impact performance but also exposure to other factors. In the end it always important to be true to the rationale and keep the extraction design as simple as possible but not so simple that you get a lot of unwanted risk in the strategy.

As Einstein once said:

"Everything should be made as **simple** as possible, but no **simpler**."