BETTING AGAINST BETA

An empirical study on Eurozone Equities

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ABSTRACT

The Capital Asset Pricing Model was and continues to be one of the most important tools that predicts assets returns. Despite that, it has been documented time and again, that the model overestimates the returns of high beta assets while underestimates returns of low beta assets. Combining that with an empirically recorded high intercept or abnormal return for zero beta assets, the Security Market Line has been docu mented to be flatter than the model estimates it. In our Thesis, we used approximately 1,500,000 data observations in equities within Eurozone to empirically test signs of this irregularity. We constructed twelve betting against beta portfolios following the methodology of Frazzini & Pedersen (2014), that go long low beta assets and short high beta assets, as well as beta-sorted portfolios for ten Eurozone countries, Denmark and a general Euro Index (EuroStoxx 50). We examined the persistence of beta anomaly (Proposition 1) for the aforementioned instruments, evaluated the performance of BAB portfolios (Proposition 2) and inspected the effects that funding shocks may have upon them (Proposition 3). Our findings suggest that BAB portfolios exhibit a positive average monthly excess return. We find *some* firm signs of beta disequilibrium within the Eurozone however we did not find a significant relationship between possible funding shocks and BAB portfolio returns mostly due to the statistical insignificance of our coefficients. Our results suggest that beta anomaly is a phenomenon not constricted within a single market and that beta arbitrage strategies can be implemented upon equities by leverage unconstrained investors within the Eurozone with signinficant positive retruns.

Keywords: Betting against beta, leverage constraints, beta anomaly, funding shocks, Eurozone Equities.

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1. INTRODUCTION

The calculation, or rather the approximation, of an asset's return has been a major concern of Financial Economics. In essence, measuring the risk of a financial asset and quantifying its potential return is one of the main priorities of portfolio managers. The Capital Asset Pricing Model, developed by Sharpe (1964) and Lintner (1965), was a principal cornerstone in Financial Economics (Sharpe, 1964; Lintner, 1965). The concept of the Capital Asset Pricing Model (henceforth referred to as CAPM) is seductively easy as it explains asset returns as a linear function of the overall market return. The main advantage of the CAPM is that it is, in its core, a powerful tool in producing some acceptable predictions about how to quantify risk and establish the correlation between expected return and risk. Thus, the CAPM is still widely being taught as an introduction to the concepts of portfolio management and asset pricing (Fama and French 2004). However, from an academic point of view, researchers have tried to empirically test the CAPM time and again, arriving at inconsistent results. The problems of empirically testing the CAPM derive either from its tight theoretical assumptions or from difficulties emerging when trying to implement valid tests (Bourdouvali, Syrmas, and Bourgias 2018).

One of the most unrealistic assumptions of the CAPM is that of unrestricted access to leverage for all investors. Indeed, even from a theoretical viewpoint and without any empirical results, it can be deduced that not all investors have access to leverage, not to mention unrestricted access. Personal investors may be constrained by behavioural drives, whereas large institutional investment funds may be constrained by bankruptcy laws limiting lender access to a borrower's future income, margin requirements and tax rules limiting deductions for interest expense (Black 1972).

Empirical work shows that the relation between beta and average return is flatter than the one predicted by the Sharpe-Lintner version of the CAPM. Consequently, the model estimates the equity cost for high beta securities as too high compared to historical returns, while estimating the equity cost for low beta stocks as too low; thus, the equilibrium is disrupted as low beta assets become more attractive and high risk assets become less attractive since investors are not compensated enough for holding the excess risk (Fama and French 2004; Friend and

Blume 1970; Jensen, Scholes, and Black 1972). As a result, it is possible for unconstrained agents within an economy to exploit the price disequilibrium by using leverage to buy low beta assets while selling high beta securities.

Black, Jensen & Scholes (1972) were among the first to empirically test the relaxation of the unconstrained leverage assumption (Jensen et al. 1972). They constructed beta arbitrage portfolios and found that high beta securities delivered significant negative intercepts (Jensen's alpha), whereas low beta assets delivered significant positive intercepts, results that were contrary to the predictions of the traditional model (Jensen et al. 1972). Black (1993) updated the Black, Jensen & Scholes study, finding similarly significant results. It is worth noting that, in this paper, Black expressed his scepticism about whether the flatness of the line relating past returns and beta will remain consistent in the future and whether low beta securities will continue to perform higher than the CAPM predicted.

More recently, Frazzini & Pedersen (2014) conducted extensive research, broadening the market limits and asset classes[1], and constructed BAB (or betting against beta) portfolios with statistically significant returns. The above-mentioned portfolios are long in leveraged low beta securities and short positions on high beta, risky assets. Their results indicate that indeed, low beta securities continually tend to perform better than predicted by the CAPM. Their research is also consistent with Black's (1972) restricted borrowing model (Frazzini and Pedersen 2014).

Since the beta arbitrage phenomenon has drawn an immense amount of attention, the objective of this thesis is to partially test Frazzini & Pedersen's model on both a sub region of the Eurozone and Denmark, for a smaller number of stocks, and examine whether satisfactory results to back up a beta arbitrage statement on a sub region of Europe can be obtained.

[1] Frazzini & Pedersen's model considered US and international markets as well as various asset classes such as Stocks, Treasury Bonds, Credit Indices, Currencies & Commodities.

1.1 PROBLEM STATEMENT

In our Thesis, we will try to analyze and answer the following research question:

Is the beta arbitrage theory valid when applied to 20 years of daily historical data on Eurozone Equity Indices?

In order to answer the aforementioned problem, we have divided it into three segments:

- Is the alpha intercept decreasing as the beta of assets is increasing – negative relation between alpha and beta, indicating a beta anomaly?
- Is the excess return of BAB portfolios constructed within our focused markets statistically significant and positive?
- Does a funding shock lead to a contemporaneous loss for the aforementioned portfolios and an increase in their future required return?

1.2 ASSUMPTIONS, LIMITATIONS & POSSIBLE BIASES

Contrary to Frazzini & Pedersen's article, we chose to focus mainly upon the Eurozone area since, in their article, they did include international equities, but did not consider a specific market segment other than the US market. Furthermore, the authors do not provide analytical results for Propositions 1 and 3 for specific countries.[2] Thus, with our research we aim to provide more details on individual countries. In our Thesis, we have included 10 Eurozone countries, one Euro continental index, and Denmark. Even though Denmark has a different currency, the underlying reason for choosing it is its fixed exchange rate policy. The fact that the Danish krone is pegged to the euro essentially indicates that the exchange rate between the euro and the krone will not have fluctuations outside the predetermined boundaries set by Denmark's Central Bank.

The continental Euro Index that we chose to include in our analysis (EuroStoxx 50) will help us present a more generalized illustration of the beta anomaly phenomenon since we were not able to cover data for all countries encompassed within Eurozone. An alternative more diversified index would be the MSCI EMU (European Economic and Monetary Union).

[2] Table 5 in Frazzini & Pedersen's article provides results only for Propositions 2, covering the excess return on the constructed BAB portfolios and its four-factor alpha.

However the plethora of stocks constituent to MSCI EMU would have made the calibration of BAB portfolios not manageable in Excel[3].

In our analysis, we have covered a 20-year time span, starting from 1999 when most of the countries converted their previous currency to the conjoint Euro. We feel that 20 years of daily historical prices should suffice in order to provide a cohesive and comprehensive picture of the model's core concepts and propositions.

In our Thesis, we have also chosen to focus solely upon stock indices for the aforementioned market segments and not to study further asset classes by reason of the complexity of additional data retrieval. Moreover, we have examined the first three propositions of the published article due to a lack of access to relevant data (such as brokerage houses and databases on buyouts and mergers) as well as time constraints. All the stocks analyzed are taken from the benchmark indices of the corresponding country. Naturally, our data sample is quite limited when compared to that of the authors'. Nevertheless, we are optimistic that we can conduct a thorough analysis on beta arbitrage.

Throughout our analysis, we tried to stay as close to the authors' methodology as possible; however, due to the nature of the databases we used, our results may be prone to common research biases. Specifically, the stocks we downloaded provide an illustration of the contemporaneous benchmark indices that they belong to. Unfortunately, we do not have the indices' composition in the past; therefore, we cannot know which firms once belonged to the benchmark indices, but do not belong today. For this reason, our research might be subject to survivorship biases.

Even though our thesis takes effect in the European market, some of the international equities we studied had already been studied by Frazzini & Pedersen. To some extend our data samples may not be completely independent since some of the constituent equities we included may have been analyzed by the authors, thus the assumption of statistical independence is not satisfied and our analysis might also be prone to data-mining biases.

[3] Excel was used for the main analysis of our data; Stata was also used for the final regressions

However, we believe that the similarity of the datasets is quite small; therefore we do not expect these biases to have major effects on our results.

1.3 ORGANIZATION OF THE PAPER

The first part of our Thesis which was presented is a brief introduction to the core theoretical concepts that our thesis was based upon. We also defined our problem statement by isolating three segments. Lastly, we demonstrated some of the assumptions and limitations we made in order to make the data processing more manageable.

In the second part of our Thesis, we will discuss the theory behind the CAPM, exhibit some of the key alternative theories that have arisen in the last century and display some of the crucial elements behind Frazzini & Pedersen's BAB factor.

In the third part, we will carefully describe all our data samples, including frequency, timespan, sources and any alterations made in order to make them comparable. Additionally, we will demonstrate the methodology we used, along with any differences from the original article. We will also analyze the calculation of beta estimates, the construction of betting against beta portfolios and detail the method in which we evaluated the portfolio performance in order to derive our results.

In the fourth part, we exhibit all our findings as well as discuss our results analytically and separately for each instrument. At the end of the section, we offer a comprehensive summary table and answer our abovementioned problem statement.

This leads us to the fifth chapter where we discuss our findings further, suggest additional research paths and wrap up with our conclusion.

2. LITERATURE REVIEW

In this section, we describe the theoretical foundations behind the CAPM as well as provide some background information about extensions of the model, such as Black's Restricted

Borrowing CAPM. Finally, we introduce the basic concepts behind Frazzini & Pedersen's Betting against Beta factor, while also offering some insights into the propositions we will be testing through our Thesis.

2.1 LOGIC & ASSUMPTIONS OF THE CAPM[4]

The CAPM is based upon a portfolio choice model presented by Henry Markovitz (1952). According to this model, an investor selects a portfolio at time t-1 which at time t gives a specific return (Markowitz 1952). The assumptions under which the model was conceived state that investors are risk averse, meaning that investors are willing to sacrifice a portion of their asset returns in order to reduce their risk as a total (thus, when investors hold on to additional risk, it follows that they demand a higher return as a compensation); in addition, when selecting portfolios, they care about the mean and variance of their one period investment return. As a result, investors choose among mean variance-efficient portfolios, meaning that they seek to firstly minimize the variance or fluctuation of the portfolio return in regards to their expected return and, secondly, maximize their expected return in relation to the expected return of the chosen portfolio.

Sharpe (1965) & Lintner (1966) add two more premises under which the CAPM works. "First, we assume a common pure rate of interest, with all investors able to borrow or lend funds on equal terms", that is to say that there is borrowing and lending at a risk-free rate, which holds true for all investors and is uncorrelated with the amount borrowed or lent. "Second, we assume homogeneity of investor expectations: investors are assumed to agree on the prospects of various investments – the expected values, standard deviations and correlation coefficients (previous) described" (Sharpe 1964 pp. 433–434). We can see that the second assumption is that investors agree on the joint distribution of the investments. To summarize, the CAPM works under the following premises:

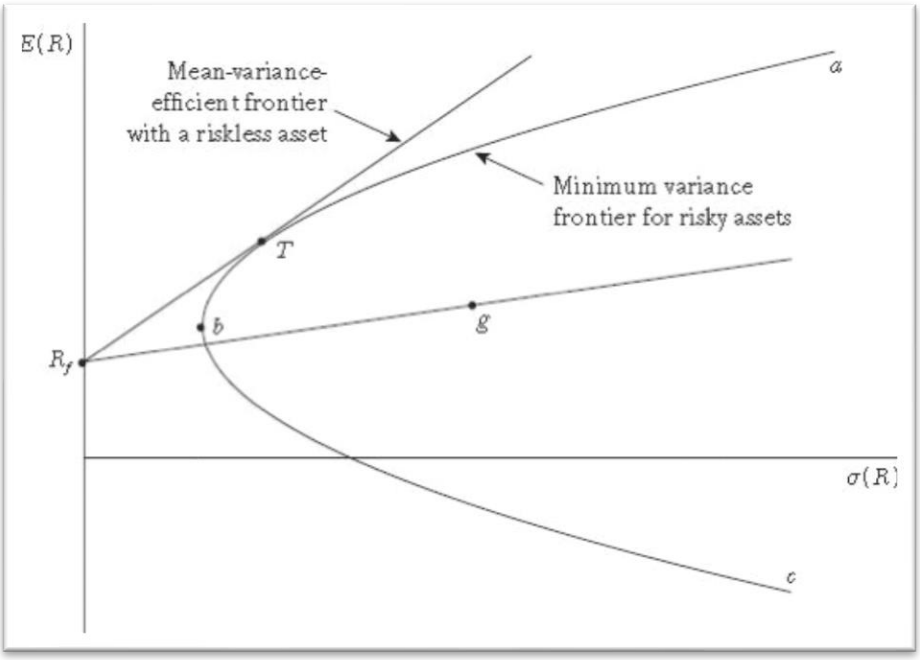
- It is a one-period model;
- There is borrowing and lending at the same *r*-rate;

[4] This Section has been a part of our Business Project as well.Written by (Syrmas,Bourdouvali & Bourgias 2018).

- The returns follow a normal distribution;
- There is a homogenous expectation / complete agreement about investments;
- There are no transaction costs such as taxes and other frictions.

We will now present a figure described by Fama &French (2004), which presents the portfolio opportunities and the algebraic formula of the CAPM, explaining its parts in detail. The horizontal axis describes the portfolio risk measured as the standard deviation of the portfolio return, whereas the vertical axis shows the expected return of given portfolios. The abc curve is called the minimum variance frontier and it represents combinations of portfolios that minimize variance at given levels of expected return.

Figure 1: The CML



Source: Fama and French 2004, The Capital Asset Pricing Model: Theory and Evidence

From the above diagram, one can easily understand the relation of risk and returns. A risk tolerant investor (point a) will form a portfolio that has a remarkably high expected return with, of course, a high amount of risk. We should underline here that, if there is no risk-free borrowing and lending, then the portfolios that are considered mean variance efficient are above point b and that is because, for the same value on the x-axis, we get two values on the y-axis. In other words, for the same risk, a hypothetical investor can get a higher expected return if he chooses a portfolio above point b.

Since the abc curve depicts portfolios that do not include risk-free borrowing and lending, we will now see what happens if we introduce this new concept. Risk free borrowing & lending turns the effective frontier into a straight line that begins at a value equivalent to R_f (a portfolio that is solely composed of risk free securities, thus having zero variance and a risk free rate of return). "Portfolios that combine risk-free lending or borrowing with some risky portfolio g plot along a straight line from R_f through g" [Fama & French, 2004, p.3]. The straight line R_f to T is the mean variance-efficient portfolios which are combinations of the risk-free asset and a risky tangency T-portfolio. Under the assumption that there is complete agreement about the distribution of returns, all investors hold the same T-portfolio, it must be the value weighted market portfolio of risky assets.

The CAPM implies that the market portfolio M is on the minimum variance frontier if the asset is to clear. Therefore, the following formula, which holds for any minimum variance portfolio, also holds for the market portfolio.

Given N assets: $E(R_i) = E(R_{zM}) + [E(R_M) - E(R_{zM})]\beta_{iM} \ \ , i = 1, \dots, N$

Analysing the CAPM formula, we can see that $E(R_i)$ is the expected return of the given *i* asset; $E(R_{zM})$ is the expected return on assets that are uncorrelated with the market return – assets that have their market beta equivalent to 0 and, essentially, contribute nothing to the variance of the market return; and, finally, β_{iM} is the market beta of the i^{th} asset.

The market beta of an asset is the covariance of its return with the return of the market, divided by the variance of the market return. The equation is as follows:

$$\beta_{iM} = \frac{cov(R_i, R_M)}{\sigma^2(R_M)}$$

The numerator of the above formula shows the covariance risk of asset i in M, measured by the denominator which is the variance of the market return.

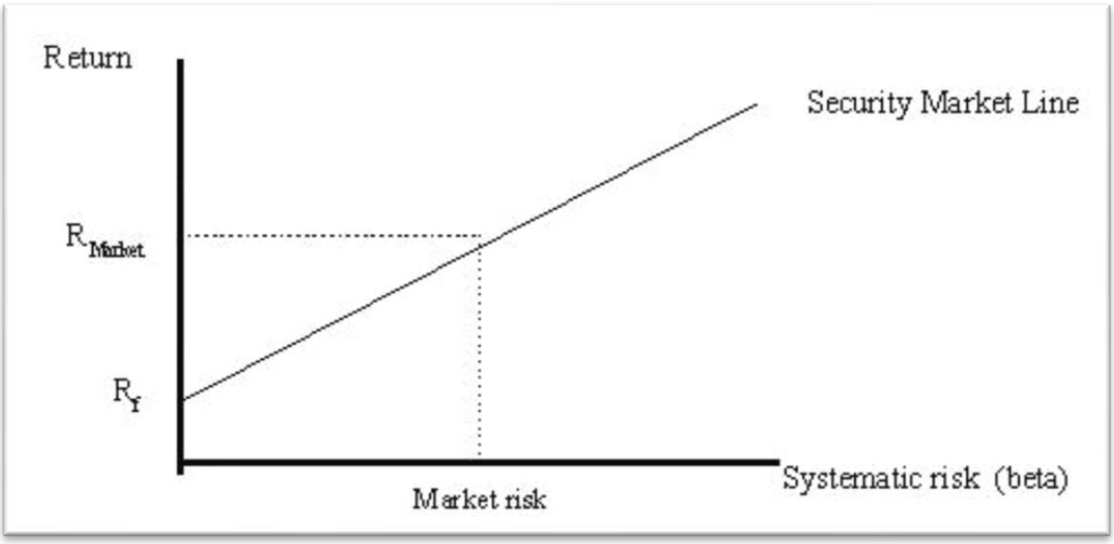
The last step to formulate the Sharpe & Lintner CAPM model is to include the concept of risk-free borrowing and lending. When there is risk-less borrowing and lending, the return on assets that are uncorrelated with the market equals the risk-free rate (Fama & French, 2004). Considering the above, the formula becomes as follows:

For given N assets, $E(R_i) = R_f + [E(R_M) - R_f)]\beta_{Mi},\ i = 1, \ldots, N$

As can be easily understood, $E(R_i)$ is the expected return of the given asset and $E(R_M)$ is the expected return of the considered market portfolio under which the asset is issued.

The chart below illustrates the relation between beta and expected return, widely known as Security Market Line (SML).

Figure 1: The SML



Considering the formula developed by Sharpe & Lintner and its graphic depiction (SML line), we can derive some implications of the CAPM: all assets or portfolios of assets lie on the SML and the expected return of an asset is linearly and positively related to the asset's beta. Now, if we also take into account the notion of the mean-variance efficient frontier analyzed previously, we can see that the CAPM also implies that the market portfolio is mean-variance efficient. The latter means that the market portfolio has the highest Sharpe[5] ratio among the Sharpe ratios of all possible portfolios, and thus, is equivalent to the tangency portfolio.

The restrictive assumption under which the Sharpe & Lintner formula was developed (i.e. that any investor may borrow or lend any amount he wants at the riskless rate of interest) has been the topic of heated debate. Thus, a similar model was developed and tested by Fisher Black in 1972[6] that did not contain the aforementioned restriction of riskless borrowing and lending. Indeed, a model in which borrowing is restricted was consistent with their empirical research. It should be underlined that Black assumed that investors were free to take unlimited long or short position on the risky assets, thus creating a new assumption. The only difference between the Sharpe-Lintner model and the Black model is what they each say about the expected return of the zero beta assets $E(R_{zM})$.

- The Sharpe-Lintner model states that $E(R_{zM}) = R_f$
- In the Black model, the $E(R_{zM})$ must satisfy the inequality

$$R_f < E(R_{zM}) < E(R_M)$$

so that the premium for beta is positive.

Both the models developed have unrealistic assumptions regarding the selection of an efficient market portfolio; therefore, the CAPM has been heavily criticized regarding its results unto real life problems since, once the concept of an efficient market portfolio selection is in question, the relation between expected return and market beta is lost. Another important drawback is that security betas do not remain stable across various periods. Investors and researchers usually estimate the betas of a specific security using historical data; however, the betas of standalone securities change across time and, consequently, historical betas are not ideal indicators of the future risk of securities (Syrmas ,Bourdouvali & Bourgias 2018).

[5] The Sharpe ratio is the quantification of return per unit of risk, calculated as: asset excess return / standard deviation of asset excess return.

[6] We will further analyse Black's models later in section 2.3.

2.2 ARBITRAGE PRICING THEORY & MULTI-FACTOR MODELS

A breakthrough in empirical asset pricing was achieved by Ross (1976), who developed the first multifactor model (Ross 1976). The Arbitrage Pricing Theory suggested that asset prices were not determined by a single market factor, but rather by multiple macroeconomic and asset-specific factors. The assumptions about investor behavior underlying the APT are less restrictive, indicating only that investors exploit arbitrage opportunities. Undeterred by its more refined nature, the APT remains silent about the exact choice of factors that may have an impact upon asset pricing. Thus the model, leads to an approximation of expected returns (Munk, 2019).

Fama & French (1993) extended the APT multifactor and developed the more precise three-factor model, constructed with *size* and *value* alongside the traditional market factor. The aforementioned factors were proven to have significant explanatory power in asset pricing (Fama and French 1993). The first one refers to the size (market capitalization) of the firms. Commonly referred to as Small Minus Big (SMB), the factor is essentially a self-financing portfolio constructed by buying small-cap and shorting large-cap stocks. Similarly to the SMB factor, the value factor or High Minus Low (HML) is a self-financing portfolio which is constructed by buying high book-to-market (value) stocks and shorting low book-to-market (growth) stocks.

Through econometric analysis of historical stock prices, Fama and French uncovered a couple of interesting patterns. Small-firm stocks have provided higher returns than large corporations. In addition, value stocks have been observed to outperform growth stocks. Therefore, the size and value of the firm carry some inherent risk which is not properly accounted for in the original CAPM model. The outperformance is generally attributed to the excess risk that small-cap and value stocks carry as a result of their higher business-related risk and cost of capital. Other explanations include the consideration of mispricing phenomena; market agents incorrectly measure the value of firms, thus creating arbitrage opportunities and excess returns. Even though there are contradicting views on whether SMB and HML are actually based on some solid theoretical or economic principles or are simply manifestations of data mining (Black 1992), they have been widely used not only for evaluating manager performance but also for evaluating the performance of other factors that continually emerge.

Further extending the empirical research, Carhart (1997) suggested the addition of the price momentum factor (Carhart 1997; Jegadeesh and Titman 1993). Price momentum is the tendency of the stock price to retain the trend it already has in recent months. Stock prices that have been rising tend to continue rising while, conversely, stock prices declining tend to keep declining. Similarly to Fama-French's model, the Up minus Down (UMD) is a zero-investment portfolio constructed by going long positive momentum (recent winners) and short negative momentum (recent losers) of the past 12 months.

Even though we have mentioned only the most prominent factors that have been suggested to have an explanatory power upon asset pricing over the course of 30 years, researchers have identified over 300 variables as possible candidate factors. Ultimately, some of them have and will appear significant by chance (Harvey & Liu, 2014; Harvey, Liu & Zhu, 2016). Analogous comments have been presented by Merton (1987) and Black (1992) as even renowned economists in the academia are unsure whether multifactor models actually provide additional informative power or are products of data mining and statistical misinterpretations (Merton,1987; Black, 1992). Additionally, there are a number of statistical issues in the empirical-factor-modelling literature. Problems in the measurement of the beta have been documented by Berk, Green & Naik (1999).

Lastly, another aspect of finance has recently emerged and offers alternative explanations as to the anomalies observed in real life asset pricing. Typically, risk models propose an analogous relationship between an asset's risk and its required return. However, behavioral finance argues that inefficient phenomena arise due to behavioral biases. Empirical studies have suggested or, rather acknowledged, the fact that, contrary to the traditional risk modelling assumption, investors do *not* act rationally (Bali, Cakici, and Whitelaw 2011; Barber and Odean 2013). Behavioral drives like *myopic loss aversion* -an occurrence when investors take a view of their investments that is strongly focused on the short term, leading them to react too negatively to recent losses, which may be at the expense of long-term benefits (Thaler, Tversky, Kahneman, & Schwartz, 1997)- , *the disposition effect* -a tendency to hold on to losses for an irrational amount of time, while realizing gains extremely fast and *overreaction/ underreaction to unexpected news* (De Bondt & Thaler, 1985),(Frazzini 2006)- create additional frictions and deviations from theoretical asset pricing.

2.3 RESTRICTED BORROWING

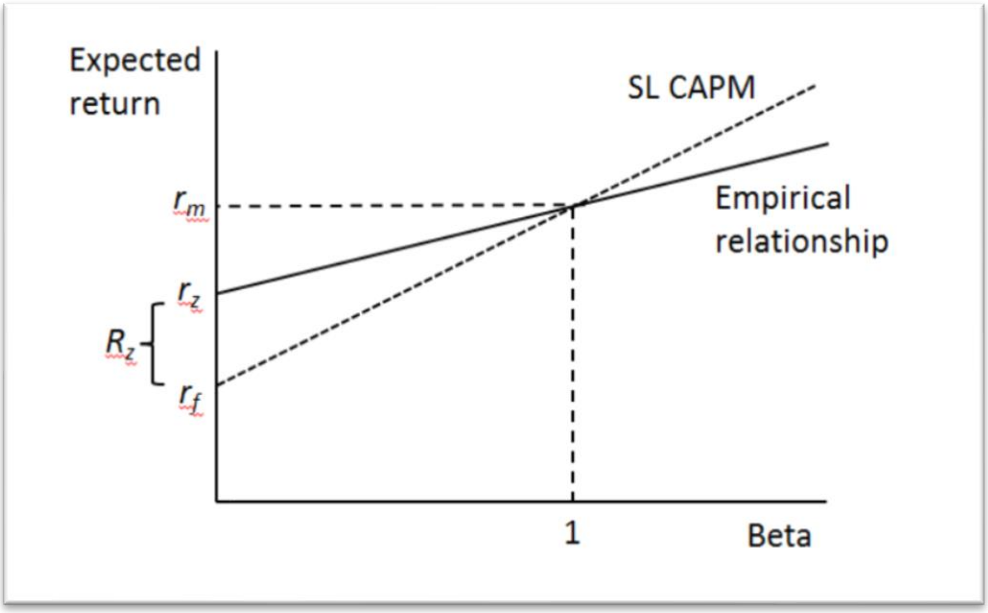
One of the most highly debated topics within the finance academic community has been the inefficiency of the CAPM to predict actual portfolio returns. A large portion of the discussion has been over the highly restrictive assumptions of the CAPM.

The assumptions that are used in deriving the abovementioned model include market efficiency, homogenous investor risk behavior and opinions, unrestricted trading in all assets within a given market, as well as unconstrained leverage. In his paper "Capital Market Equilibrium with Restricted Borrowing" (1972), Black has suggested that the most restrictive and unrealistic of the assumptions to derive the CAPM is the unconstrained access to risk-free borrowing and lending.

Indeed, Black was able to prove that, with restrictive leverage, the slope of the line relating to the expected return of any risky asset is smaller than it is when there are no restrictions. What is more, the intercept of the line increases well above the risk- free rate, thus formulating a flatter SML than the one described in the CAPM.

In other words, the traditional model overestimates the performance of risky high beta assets, while at the same time undervaluing low beta assets, and thus, creating a beta arbitrage.

Figure 3: Traditional and empirical SML



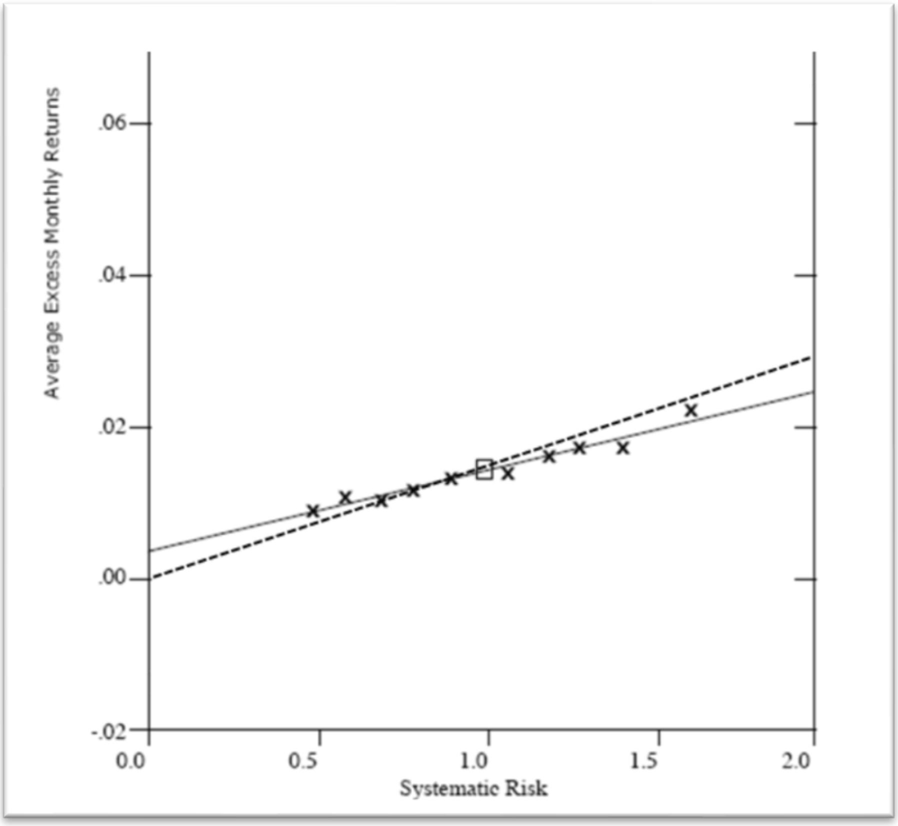
Source Ergon.com.au. (2019). [online]

In the above figure (figure 3), the dotted line represents the traditional CAPM. The intercept of the traditional SML is the risk-free rate denoted as r_f, whereas empirical findings dictate that zero beta assets require a return of r_z. The subtraction of r_z and r_f is the excess return R_z.

Furthermore, in his paper, he reports that the CAPM has little empirical explanatory power. Friend & Blume (1970) observe that high risk portfolios tend to have poor performance, while low risk portfolios tend to over-perform when evaluated against the traditional CAPM (Friend and Blume 1970).

Further strengthening the inadequacy of the CAPM, Black, Jensen, & Sholes (1972) find that during the 1946-1966 post war period, the average returns of portfolios are not consistent with the one-factor model.

Figure 4: Results of Black, Jensen, & Scholes (1972)



Source: Black, Jensen &Scholes (1972), Figure 1, p. 21. A dashed line has been added for the Sharpe-Linter CAPM.

Moving onto more recent literature and the basis of our master thesis, Frazzini & Pedersen (2014) constructed betting-against-beta portfolios that go long low beta assets and short high beta assets and found a significant beta anomaly in US & International Equities as well as in other asset classes such as Bonds, Credit Indices and Commodities, among others. Baker, Bradley and Wurgler (2011) report that “high-beta and high-volatility stocks have long underperformed low-beta and low volatility stocks”. Ang et al (2006, 2009), analyzed US and Intrenational stock returns and detected that firms with high idiosyncratic volatility have extremely low average returns. Finally, Liu, Stambaugh, & Yuan, (2018)[7] provide new insights regarding beta anomaly by introducing a betting-against-volatility strategy. Specifically, they find that the systematic risk of an asset is not the ordinary characteristic

[7] We will further dwell on their article under our Further Research section since it is closely related to Frazzini & Pedersen’s.

driving beta anomalies, but it is rather the positive correlation of idiosyncratic volatility and beta that causes beta anomalies (Liu et al. 2018).

As indicated by Black, borrowing constraints are -to this day- one of the most unrealistic assumptions of the CAPM, especially if we take into consideration modern financial environments. Credit crunches created by events such as those of 2007 naturally increased borrowing constraints. Capital Buffers have been increased, margin requirements still remain in effect, bankruptcy laws seem to have shifted against lenders, and deductions for interest expense have been tightened (Black 1992). The borrowing restrictions still remain valid to this day, thus rendering the beta-anomaly phenomenon one of the most alluring topics among the academia and the modern trading world.

2.4 BETTING AGAINST BETA

In this section, we will refer to the basic theoretical concepts behind the BAB factor as well as present the three propositions we are going to later examine and test. Throughout the description, we will be using the same notation as the authors.
The model developed by Frazzini & Pedersen extends the restricted CAPM model. In particular, they developed a dynamic model of leverage constaints which features three main types of agents. The first type consists of agents who cannot use leverage, thus overweighting high beta assets and causing those assets to offer lower returns despite the increased risk. The second type of agents may use leverage, but are subject to margin constraints. A margin is defined as the collateral an agent has to deposit in order to cover for some of the risk taken by a counterparty, thus creating a "margin account". This account has to be reclaimed every time it falls beneath a predetermined benchmark. Lastly, unconstrained agents short sell high beta assets and take long positions on low beta assets using leverage. On a last note, not only are some agents precluded from using leverage, but they are also required to have some of their wealth in cash. These agents may be, among others, mutual funds -required to have some cash in order to meet daily redemptions- or individual investors in need for cash in order to cover unforeseen expenses. The model implies a flatter Security Market Line, where the slope depends on the tightness of the funding constraints. Hence, the model predicts a beta anomaly:

higher beta securities deliver lower alphas (Proposition 1). Mathematically[8], the expected return of security s is

$$E_t(r_{t+1}^s) = r^f + \psi_t + \beta_t^s \lambda_t$$

Where $\lambda_t = E_t(r_{t+1}^M) - r^f - \psi_t$ is the risk premium, $E_t(r_{t+1}^M)$ is the expected return of the market portfolio, r^f is the risk-free rate, β_t^s is the asset beta and ψ_t measures the tightness of funding constraints. Rearranging the terms in the abovementioned equation leads to the following expression for a security's alpha with respect to the market:

$$\alpha_t^s = \psi_t(1 - \beta_t^s)$$

From the last equation, it is easy to see that alpha declines in beta and increases in ψ_t. As a result, "tighter portfolio constraints (i.e., a larger ψ_t) flatten the security market line by increasing the intercept and decreasing the slope λ_t" (Frazzini and Pedersen 2014).

In order to test Proposition 1, the authors formulate portfolios sorted on their betas, and find that alphas and Sharpe Ratios are (monotonically) declining in beta[9]. Indeed, this finding of beta anomaly provides concrete evidence that the flatness of the security market line should be a persistent phenomenon across all markets. More specifically, the authors report that tighter portfolio constraints increase the intercept well above the risk-free rate and decrease the SML slope.

In order to illustrate the asset pricing effect of the funding friction, the authors construct a self-financing market-neutral portfolio[10] that holds low beta assets, leveraged to an estimated (ex –ante) beta of one, and that shortshells high beta assets de-leveraged to an ex-ante beta of one. A betting against beta portfolio (BAB) is constructed as:

[8] For analytical proofs of the mathematical expressions as well as the theoretical premises of the model refer to pages 3-4, 21-24 "Betting Against Beta", Frazzini and Pedersen (2014)
[9] The authors present tests for various asset classes; US and International Stocks tests show that alphas decline in betas though not monotonically while tests of other asset classes result in monotonic decreace. For more information see Figure 1, page 11, "Betting Against Beta", Frazzini and Pedersen (2014)
[10] A market-neutral portfolio has a market beta equal to zero

$$r_{t+1}^{BAB} = \frac{(r_{t+1}^{L} - r_f)}{\beta_t^L} - \frac{(r_{t+1}^{H} - r_{f,})}{\beta_t^H}$$

Where: r_{t+1}^{L} are the returns of a portfolio of low beta assets and, similarly, r_{t+1}^{H} are the returns of a high beta asset portfolio. The betas of the above-mentioned portfolios are correspondingly denoted as β_t^L and β_t^H where $\beta_t^L < \beta_t^H$.

The model predicts a positive expected excess return of the BAB factor (Proposition 2)

$$E_t(r_{t+1}^{BAB}) = \frac{\beta_t^L - \beta_t^H}{\beta_t^L \beta_t^H} \psi_t \geq 0$$

the magnitude of which depends on the ex-ante spread of the betas (indicated as $\frac{\beta_t^H - \beta_t^L}{\beta_t^L \beta_t^H}$) and the funding tightness ψ_t. An increase in the beta spread as well as the funding tightness leads to higher gains for the BAB factor.

In order to examine proposition 2, the authors construct and empirically test BAB factors for differenet asset classes and markets. They report significant positive returns as well as highly significant risk adjusted returns for the BAB factor. Their results are mostly consistent across asset classes, thus strengthening the validity of Proposition 2.

Lastly, the model implements the effects of funding liquidity shocks to portofolio constraints. During periods when funding liquidity deteriorates, such as credit or financial crises, some leveraged agents may hit their margin constraints, and are forced to de-leverage their BAB positions. It is in such times, that the model predicts the BAB factor realizes losses. Additionally, funding shocks lead to an increase in the factor's future required return. (Proposition 3). To test the time series predictions of proposition 3, the authors use the TED Spread as a proxy of funding conditions. A positive change in the TED spread is directly associated with low contemporaneous BAB returns. The TED Spread is the difference between the three-month Eurodollar LIBOR rate and the three-month US Treasury Bill rate.

3. DATA AND METHODOLOGY

In this section, we will cover the choice of data samples we used to construct the BAB factor. Then, we will formally explain and provide specific information about the BAB factor construction and the computations for the factor's performance evaluation.

3.1 DATA SAMPLES

In the first section, we describe our sources, the indices we chose for each country, the frequency of our data observations as well as the sample period we chose to limit our data. Furthermore, we will provide an informative, descriptive statistics table, offering information about our data sample for each country.

Our data were collected from multiple sources. The Eurozone Equity Indices and their constituents were all collected from DataStream, with daily observations beginning from 1999 until 2019. All returns are in EUR and the excess returns are calculated on top of the German 3-month short term interest rate. For each of the 10 counties within Eurozone, and Denmark, a benchmark index was chosen with a fluctuating range of constituent stocks. Furthermore, the EuroStoxx 50 was used as a continental index that covers 18 European countries. As an aggregate, our dataset is composed of approximately 400 stocks and a total of 1,500,000 data observations. The return of each constituent stock, as well as the returns of the market portfolio are calculated as follows:

$$r_{t+1}^{i} = \frac{RI_{t+1} - RI_t}{RI_t}$$

Where RI[11] is the daily dividend adjusted total return index which was collected from DataStream and calculated as:

$$RI_t = RI_{t-1} * \frac{PI_t}{PI_{t-1}} * \left(1 + \frac{DY * f}{n}\right)$$

Where:

RI_t = return index on day t

[11] Datastream Global Equity Indices, User Guide Issue 5.

RI_{t-1} = return index on day t-1

PI_t = price of the index on day t

PI_{t-1} = price of the index on day t-1

DY = dividend yield of the price index

f = grossing factor (normally 1)

n = number of days within the financial year (normally 260)

The MSCI Europe Index, downloaded from Datastream on a daily frequency starting from 1999 through to 2019, was used as the common market index in all of the instruments for which we constructed the BAB factor. Betas were calculated with respect to this market index throughout our computations. We used historical exchange rates to convert the US currency to EUR. The original USD total return index values were multiplied with the corresponding USD/EUR historical exchange rates (also retrieved from Datastream) to compute the EURO values.

Moreover, in order to evaluate the performance of the constructed factor, we used three different risk factors to test the statistical significance of the expected return of BAB, namely the size factor -the self-financing return of equity Small Minus Big (SMB)-, the value factor, which contains the self-financing returns of equity High Minus Low (HML), and the momentum factor Up Minus Down (UMD). All the aforementioned factor-return data were collected from the AQR website on a monthly basis and were originally in USD[12]. Subsequently, we used the historical USD/EUR exchange rates, with monthly observations (primo 1999 and ultimo 2019) from Datastream, to convert the factors to EUR. The converted returns were calibrated as: $r_{EUR} = (1 + r_{USD})\left(1 + r_{USD/EUR}\right) - 1$, where $r_{USD\,/EUR} = \frac{USD/EUR_t}{USD/EUR_{t-1}} - 1$.

Lastly, to test Proposition 3 we inserted a number of new datasets. We used a European-constructed TED spread as a proxy of funding constraints. The original spread used by the authors is the difference between the 3-month LIBOR Eurodollar rate and the 3-month US

[12] We chose to retrieve the risk factors from AQR instead from French's online data repository since we needed those factors on a country basis

Treasury bill rate. However, since our research is focused upon the Eurozone, we used a slightly different spread to capture the funding constraints within the Eurozone: the subtraction of the German 3-month short term interest rate (downloaded from the OECD Database on a monthly frequency from 1999 to 2019) from the 3-month EURO LIBOR interbank rate, which was downloaded from Datastream.

Additionally, the Harmonized Index of Consumer Prices for the Eurozone (19 countries) was used as an external control variable to complete the evaluation of Proposition 3. The CPI was downloaded on a monthly frequency from the Federal Reserve database. The Inflation rate was calculated as $r_t^{infl} = \frac{CPI_t}{CPI_{t-1}} - 1$. Web links for all our external sources are referenced in table 1 below.

We used Excel to calculate the daily returns for the BAB portfolio, the beta sorted portfolio construction, and the calibration of monthly returns. In order to evaluate the performance of the aforementioned portfolios we used the statistical program Stata. The methodology we followed is included under our Methodology section. The results of the regressions against the CAPM, the Fama and French 3 factor model and its extension, the four factor model (which includes the momentum factor) are reported analytically under our Results & Analysis Section. All our datasets, results and Stata files are included in the USB drives attached onto the physical copies of this paper.

Table 1: Overview Of Datasets

Asset Class	Instrument	Index Name	Sample Period (start-end)	Frequency	Currency	Source
Equity Indices	Austria	ATX	1999-2019	Daily	EUR	Datastream
	Belgium	BEL 20	1999-2019	Daily	EUR	Datastream
	Denmark	OMX COPENHAGEN 20	1999-2019	Daily	DKK[13]	Datastream
	Europe	MSCI EUROPE	1999-2019	Daily	USD[14]	Datastream
	Euro	EUROSTOXX 50	1999-2019	Daily	EUR	Datastream
	France	CAC 40	1999-2019	Daily	EUR	Datastream
	Gemany	DAX 30	1999-2019	Daily	EUR	Datastream
	Greece	FTSE/ATEX Large Cap	1999-2019	Daily	EUR	Datastream
	Ireland	ISEQ ALL SHARE	1999-2019	Daily	EUR	Datastream
	Netherlands	AEX INDEX	1999-2019	Daily	EUR	Datastream
	Portugal	PSI ALL SHARE	1999-2019	Daily	EUR	Datastream
	Spain	IBEX 35	1999-2019	Daily	EUR	Datastream
	Italy	FTSE MIB	1999 -2019	Daily	EUR	Datastream
Other	Risk Factors		2002-2019	Monthly	USD[15]	AQR Datasets[16]
	Short Term German Interest Rate		1999-2019	Monthly[17]	EUR	OECD Library[18]
	EURO LIBOR(3M)		2002-2019	Daily,Monthly	EUR	Datastream
	Consumer Price Index /Inflation		1999-2019	Monthly	EUR	Federal Reserve Economic Data[19]

[13] Converted to EUR using historical exchange rates
[14] Converted to EUR using historical exchange rates
[15] Converted to EUR using historical exchange rates
[16] https://www.aqr.com/Insights/Datasets
[17] Converted to daily returns, from monthly frequency
[18] https://www.oecd-ilibrary.org/
[19] https://fred.stlouisfed.org/series/CP0000EZ19M086NEST, original source Eurostat

METHODOLOGY

In this section, we will analytically present the methodology that we followed in order to construct and test the BAB factor. Firstly, we will explain how we estimated the ex-ante betas, and then describe the portfolio formation. In the last section, we will provide more information as to how we evaluated the performance of the formulated portfolios.

3.2 DATA PROCESSING - ESTIMATING BETAS

To estimate our betas, we first used standard deviations to estimate the volatilities of each individual stock (within the benchmark chosen index), as well as of the market portfolio, the MSCI Europe Index. The aforementioned market index is used as a market portfolio for all the countries we chose to focus on (as well as for Eurostoxx 50). We acknowledge the fact that this index is not the most diversified market portfolio. However, the authors report through a robustness test that even with a limited and less diversified market portfolio the results were found to be robust and consistent; thus, we believe that the choice of our market portfolio will not have much effect on our results.

In line with Frazzini & Pedersen, correlations were estimated separately from volatilities. The reasoning behind this action is that correlations tend to move slower than volatilities; consequently, we require a larger rolling window for correlations. Specifically, we used a one year (260-day) rolling window for volatilities, requiring at least six months (130 days) of non-missing data and a five year (1,300-day) window for correlations, requiring at least three years (780 days) of non-missing data. It is worth reporting that, within a financial year, there is a small difference of 20 trading days between our computations and Frazzini & Pedersen's article. The reason for this is that the authors assume as a given that, annually, there are 240 trading days, whereas our data from datastream have been pre-calculated with 260 trading days annually. However, we do not believe that this difference will have an impact on our results.

High frequency data were preferred for superior precision and consistency. However, share prices have a certain delay upon which they react to new information (Hou and Moskowitz

2005). Factors, such as limited stock market participation, incomplete markets and information capacity constraints, all cause a delay in asset prices response. In order to overcome possible biases, correlations were estimated on top of an overlapping three-day log return, $r_{i,t}^{3rd} = \sum_{k=0}^{2} \ln(1 + r_{t+k}^{i})$, so that any information delays are embedded, while volatilatilities were calculated using simple one-day log returns. The ex-ante betas are estimated using the aforementioned rolling windows for volatilities and correlations as:

$$\hat{\beta}^{ts} = \hat{\rho}\frac{\hat{\sigma}_i}{\hat{\sigma}_m}$$

Where σ_i is the estimated volatility of asset i , σ_m is the estimated volatility of the market portfolio and ρ is the estimate of the correlation given by the ratio of the covariance of the return of i^{th} asset with the return of the market, divided by the product of their corresponding volatilities.

Securities with low beta estimates are likely to understate systematic risk and high beta securities tend to overstate it (Gray et al. 2013). Thus, to account for this bias, the authors adjust the estimated betas towards the cross sectional mean, following Vasicek's model. Specifically: $\beta_i = w_i\beta_i^{TS} + (1 - w_i)\beta^{XS}$, where β^{XS} is the cross sectional average market beta, set to 1 and w_i is the shrinkage factor coefficient of the i'th asset estimated beta β_i^{TS} .[20] Even though our datasets cover different markets from those originally covered by the authors, for the sake of simplicity and the ease of data processing, we also chose to use a fixed shrinkage factor w = 0,6 in line with Frazzini & Pedersen. We also attempted an alternative calculation of betas. Following Vasicek(1973) we calculated betas using a dynamic Bayesian shrinkage factor calculated as:

$$w_i = 1 - \frac{\sigma^2_{\beta_i^{TS}}}{(\sigma^2_{\beta_i^{TS}} + \sigma^2_{\beta^{XS}})}$$

[20] According to Gray & Hall, shrinkage factors are generated by popular databases -such as Datastream and Bloomberg- to account for the aforementioned bias by placing some weight, denoted as w, on the beta estimate and some other weight, denoted as (1-w), on the market average beta.

Where $\sigma^2_{\beta_i^{TS}}$ is the variance of the estimated beta for stock i and $\sigma^2_{\beta^{XS}}$ is the cross-sectional variance of betas. However, since the results did not differ dramatically compared to using fixed parameters[21], we proceeded with the Frazzini-Pedersen's approach.

3.3 BAB PORTFOLIO CONSTRUCTION

The methodology we use to construct the BAB portfolios is similar to Frazzini & Pedersen's approach. We construct two portfolios: a long portfolio, consisting of low beta assets, and a short portfolio, consisting of high beta assets. All stocks are sorted in ascending order on the basis of their estimated beta. The ranked stocks are then assigned to one of the portfolios (low beta & high beta) so that the low/high beta portfolio is composed of all stocks with a beta below/above its regional median respectively. In each of the aforementioned portfolios, securities are weighted based on their ranked betas of the last day of the previous month and are rebalanced monthly. Formally, the weight of security i within the high or low portfolio is given by:

$$\omega_{H,i} = k(z_i - \bar{z})+, \qquad if\ z_i > \bar{z}$$

$$\omega_{L,i} = k(z_i - \bar{z})-, \qquad if\ z_i < \bar{z}$$

Where k is a normalizing constant that sets the aggregate weights of each portfolio equal to 1 ($\omega_H = \omega_L = 1$), z_i is the rank of i^{th} asset on the basis of its beta and $\bar{z}$ is the regional rank median among the examined assets.

Both portfolios are rebalanced monthly, and they are rescaled to have an ex ante beta of one. The long low beta portfolio is leveraged, while the short high beta portfolio is deleveraged, so as to achieve a market exposure neutrality. The return of the BAB portfolio is given by:

$$r_{t+1}^{BAB} = \frac{(r_{t+1}^{L} - r_{f,borrowing})}{\beta_t^L} - \frac{(r_{t+1}^{H} - r_{f,lending})}{\beta_t^H}$$

[21] For further information on the results of the alternative calculation of shrinkage factors see section 4.6 Robustness

On a final note, as $r_{f, borrowing}$, we used the 3 month EURO LIBOR rate, while as $r_{f,lending}$ remains the German 3-month short-term interest rate.

3.4 BETA-SORTED PORTFOLIO CONSTRUCTION

The beta sorted portfolios were constructed in line with the methodology that Frazzini & Pedersen employed. For the EuroStoxx 50 index, we constructed five portfolios, while for the individual countries, three. Based on the same ranking that was used for the construction of BAB, each stock was then assigned to the corresponding portfolio, with P_1 including the lowest beta stocks and P_{max} including the highest beta stocks. The placement of each stock in its respective portfolio was based on its beta, with a view to having the same (or approximately the same) number of stocks in each portfolio. Stocks are equally weighted and the portfolios are rebalanced each month, based on the beta rankings at the end of the previous month.

Following the construction of the time series of BAB and beta-sorted portfolio daily returns, we then converted those to monthly returns as:

$$r_t = \prod_{t_k}^{t_n} (1 + r_{t_n}) - 1$$

Where t is the time series of months within the examined period and t_n is the number of days within each month.

3.5 PERFORMANCE EVALUATION

Starting from proposition 1 (high beta portfolios deliver low alphas), in order to estimate the risk adjusted returns (alphas), we tested the beta-sorted portfolio returns against the three popular asset pricing models presented earlier in our thesis: the CAPM model, the Fama-French three-factor model, and the four-factor model containing an extra risk factor, namely

Carhart's (1997) momentum factor[22]. Specifically, for each beta-sorted portfolio P in each instrument, the following OLS[23] regressions were performed[24]:

$$r_t^P - r_f = \alpha_t^P + \beta^M MKT_t$$

$$r_t^P - r_f = \alpha_t^P + \beta^M MKT_t + \beta^{SMB} SMB_t + \beta^{HML} HML_t$$

$$r_t^P - r_f = \alpha_t^P + \beta^M MKT_t + \beta^{SMB} SMB_t + \beta^{HML} HML_t + \beta^{UMD} UMD_t$$

Where r_t^P is the beta-sorted portfolio return, r_f is the German three-month short term interest rate, β^i is the loading on the risk factors SMB, HML and UMD and MKT is the excess return of the market portfolio over the German three-month short term interest rate[25]. The risk factors are country-specific, while a common market index (MSCI Europe) was used for all countries.

The ex-ante betas of each portfolio were estimated as the average beta at portfolio formation, i.e. the average of betas on the last day of the previous month. Realized betas were estimated from the regression of the beta-sorted portfolio excess return on the market excess return. Furthermore, to complement the testing of proposition 1, annualized Sharpe ratios were calculated and evaluated against betas[26].

Turning now to proposition 2 (positive expected excess return of BAB), we first calculated the average (excess) returns of the BAB factor[27] which, according to the model, should be positive and significant. BAB returns were also tested against the above-mentioned models in order to estimate the corresponding intercepts:

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[22] For further informarion refer to section 2.2 ArBitrage Pricing Theory & Multi-factor Models
[23] OLS stands for Ordinary Least Squares
[24] The regressions were performed in Stata, while all the previous calculations of volatilities, correlations betas, BAB and beta-sorted portfolio returns etc. were performed in excel.
[25] Monthly returns of all variables are used in the regressions.
[26] Annual Sharpe ratios were calculated as:
$SR^{annual} = ((1+Average(r^P - r_f))^{12} -1) / (Standard Deviation(r^P - r_f)*sqrt(12))$
[27] Since BAB returns are constructed using differences of excess returns (low beta portfolio excess return and high beta portfolio excess return), they are themselves excess returns; therefore, there is no need to subtract the risk-free rate (Frazzini & Pedersen, 2014).

$$r_t^{BAB} = \alpha_t^{BAB} + \beta^M MKT_t$$

$$r_t^{BAB} = \alpha_t^{BAB} + \beta^M MKT_t + \beta^{SMB} SMB_t + \beta^{HML} HML_t$$

$$r_t^{BAB} = \alpha_t^{BAB} + \beta^M MKT_t + \beta^{SMB} SMB_t + \beta^{HML} HML_t + \beta^{UMD} UMD_t$$

Lastly, we performed two final regressions of the BAB excess return on the beta spread and the lagged beta spread as:

$$r_t^{BAB} = \alpha_t^{BAB} + \delta \beta SPD_t$$

$$r_t^{BAB} = \alpha_t^{BAB} + \delta \beta SPD_{t-1}$$

Where $\beta SPD = \frac{\beta_t^H - \beta_t^L}{\beta_t^L \beta_t^H}$ and measures the ex-ante beta difference between the long and short leg of the BAB portfolios. The variables β_t^H and β_t^L are the betas at portfolio formation. According to the model, the beta spread should positively predict the BAB excess return. The second regression on the lagged beta spread was performed in order to check the robustenss of the coefficient's sign.

Proposition 3 states that funding shocks lead to tighter portfolio constraints and, therefore, negatively affect the contemporaneous BAB return. In order to test this, we performed the following regression[28]:

$$r_t^{BAB} = \alpha_t^{BAB} + \gamma_1 TED_{t-1} + \gamma_2 \Delta TED_t$$

However, in line with Frazzini and Pedersen, the above test relies upon the assumption that current funding conditions, proxied by the TED spread, change while everything else remains unchanged. To partially address this issue, we provided an additional test when controlling

[28] Monthly frequencies of all variables are used in the regressions

for a number of other variables. The control variables are the market return, the ex ante beta spread, the one month lagged BAB return, and the one month lagged inflation.

$$r_t^{BAB} = \alpha_t^{BAB} + \gamma_1 TED_{t-1} + \gamma_2 \Delta TED_t + \gamma_3 \beta SPD_t + \gamma_4 BAB_{t-1} + \gamma_5 CPI_{t-1} + \gamma_6 MKT_t$$

Where TED is the difference between the 3-month Euro Libor rate and the German 3-month short term interest rate, ΔTED equals $TED_t - TED_{t-1}$, βSPD = $\frac{\beta_t^H - \beta_t^L}{\beta_t^L \beta_t^H}$ is the beta spread, BAB is the return on the betting against beta portfolio (the same as r^{BAB}), and CPI is the percentage change of the consumer price index (inflation). Frazzini & Pedersen (2014) interpret the TED spread as a measure of the tightness of funding constraints. According to proposition 3, the regression estimates of the coefficients of the lagged TED spread (TED_{t-1}) and the change in the TED spread (ΔTED) should be positive and negative respectively.

4. RESULTS AND ANALYSIS

The following sections will present the results of our analysis for all the countries we chose to focus on. Specifically, our analysis encompasses the following countries:

Table 2: Summary of the Data samples

Instrument	Number of stocks
Belgium	20
Austria	20
Denmark	20
France	40
Germany	30
Portugal	40
Greece	25
Italy	40
Spain	35
Ireland	42
Netherlands	25
Euro	50
Total	387

4.1 ORGANIZATION

Propositions 1 & 2

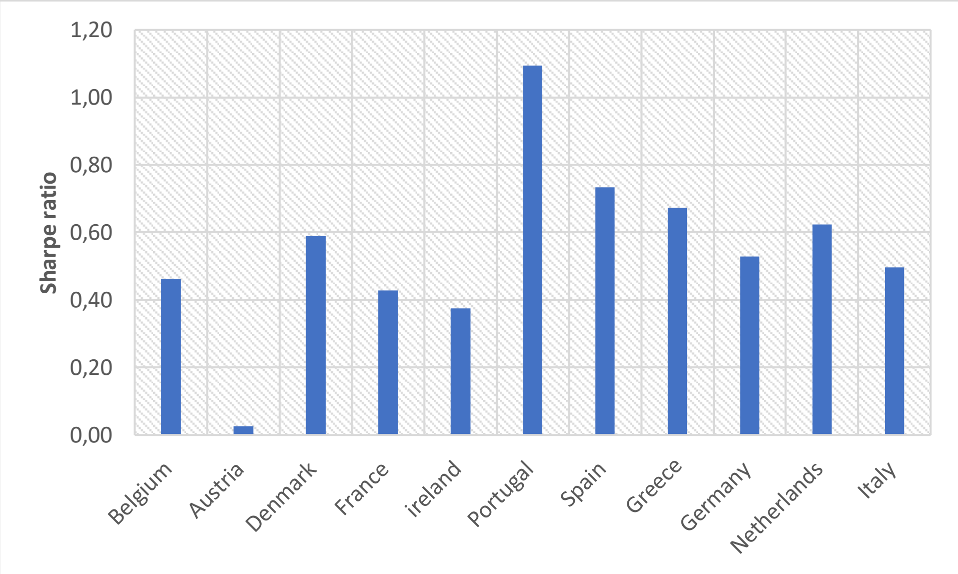
Since the results of Propositions 1 & 2 are intertwined, we chose to present those two propositions collectively and, subsequently, move on to Proposition 3. We have grouped our results for the countries of Southern Europe and Northern & Central Europe. Finally, we will present the results of the EuroStoxx50 continental index.

For the sake of cohesion, all our tables are exhibited in the same manner. A detailed description of the contents will be presented here. The leftmost column reports returns of the zero beta BAB portfolio. To construct the BAB factor, at the beginning of each month all stocks are assigned to one of two portfolios: low beta and high beta based on the beta ranking at the end of the previous month. The low/high beta portfolio is composed of all stocks with a beta below/above its regional median respectively. These portfolios are rebalanced each month. Both portfolios are rescaled to have a beta of one, thus achieving market neutrality. The betting against beta factor is the self-financing portfolio going long the low beta portfolio and short the high beta portfolio.

Beta-sorted portfolio returns are exhibited from the left to the right. Based on its ranked beta, each stock is assigned to one of the portfolios. P_1 includes the lowest beta stocks, while P_{max} includes the high beta stocks. The securities are equally weighted, and the portfolios are rebalanced monthly. Excess return is the average return of the portfolio's monthly returns throughout the time period examined. Alphas are the intercepts of the OLS regressions of the monthly excess returns on a number of explanatory variables. These include the market excess return, the Fama-French size and value factors, and the Carhart momentum factor, corresponding to the estimated CAPM Alpha, Three Factor alpha and Four Factor Alpha respectively. The factors were retrieved from AQR's database, on a country basis. For more precise illustration, alphas and BAB excess returns are shown in percentage points. Ex-ante betas are calculated as the average of the betas at portfolio formation. Excess returns and alphas are reported in a monthly frequency. A 5% statistical significance is indicated in bold. T-statistics are presented below the excess returns and alphas, indicated in *italics*. Volatilities and Sharpe Ratios are annualized. All returns are in EUR, and excess returns are calculated above the German 3-month short term interest rate.

Figure 5 presents all the BAB Sharpe ratios for our 11 countries.

Figure 5: Sharpe Ratios organised by country



In the rightmost columns of each table presented in each country, we display the coefficients of the OLS regression of monthly BAB returns on the beta spread and the lagged beta spread. Significant values are indicated in bold, and a 5% statistical significance is used. T-statistics are presented below the coefficients, indicated in italics. At the end of this section, we have included a summary table for all instruments and comprehensive trend line graphs for the alphas.

Proposition 3

According to the authors, the hypothesis for proposition 3 is that a tighter portfolio constraint leads to a contemporaneous loss for the BAB factor and an increase in its future required return. Tables for Proposition 3 are all constructed in the same way, composed of two columns. In the first column, we simply regress the BAB factor on the lagged level of the TED spread and the contemporaneous change in the TED spread[29]. The lagged TED spread

[29] As mentioned under our Methodology section, we use the European TED Spread as a proxy for the funding conditions at a given time t.

is the TED spread at the end of the month $t-1$ and the change of the TED spread is defined as the TED spread at the end of month t minus the TED spread at time $t-1$. According to the model's theory, the coefficient for the lagged TED spread should be positively related to BAB returns, since investors will ask an increased required return, whereas the coefficient of the change in the TED spread should be negatively related to BAB returns. It is worth noting that the authors have provided an additional interpretation of the TED spread. If a high TED spread indicates that the agents' funding constraints are worsening, then a high TED spread could indicate that banks are credit-constrained, and that banks tighten other investors' credit constraints over time, leading to a deterioration of BAB returns over time (if investors do not foresee this) (Frazzini & Pedersen, 2014, p. 16). Thus, under this interpretation, the coefficient for both the lagged TED spread and the change in the TED spread would be negatively related to the BAB return. For consistency reasons, we view the TED spread as a tightness of funding constraints henceforth.

In the second column, we add a number of new control variables in order to reduce the OVB (omitted variable bias). More information about the control variables that we introduce can be found under our Methodology section. The t-statistics are shown below the coefficients and are presented in italics. A statistical significance of 5% is indicated in bold.

4.2 NORTHERN AND CENTRAL EUROPE

4.2.1 DENMARK

Propositions 1 & 2

In Table 3, the regression results for Denmark are exhibited. In line with Black's restricted borrowing CAPM (Jensen et al. 1972), our results indicate the inadequacy of the traditional CAPM, as the alpha of the BAB return is different than zero and significant, thus increasing the intercept of the SML creating a flatter line. Consistent with Black's theory, it can be inferred that zero-beta assets require returns in excess of the risk-free rate: specifically in our case, 0.0137 or 1.37% above the risk-free rate.

Further strengthening the evidence of a flatter SML is the fact that the average excess returns of the beta-sorted portfolios are similar (Frazzini & Pedersen, 2014, p. 10).

Table 3: Regression Results – Propositions 1 and 2 – Denmark

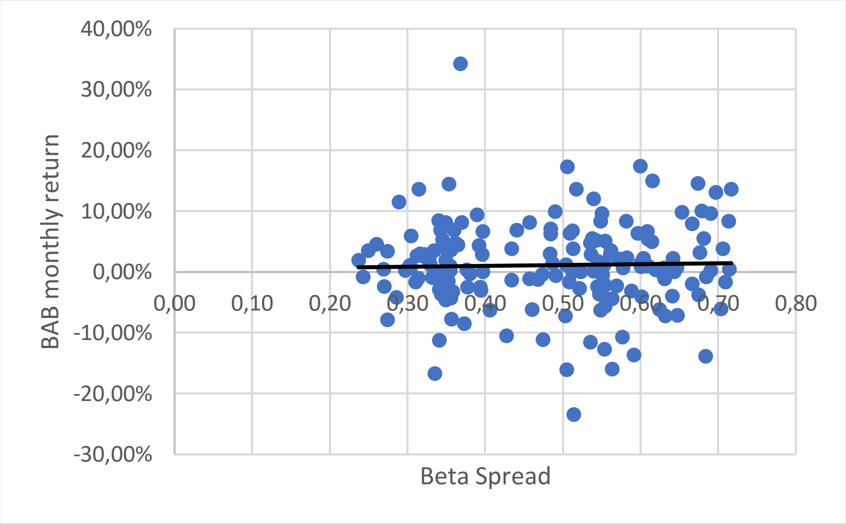
Portfolio	BAB	P1 (Low Beta)	P2	P3 (High Beta)
Excess Return	**1.122%**	**1.692%**	**1.017%**	**1.817%**
	2.14	*5.07*	*2.32*	*3.29*
CAPM Alpha	**1.371%**	**1.399%**	0.483%	**1.100%**
	2.69	*4.79*	*1.51*	*2.94*
Three Factor Alpha	**1.443%**	**1.442%**	0.485%	**1.093%**
	3.00	*5.26*	*1.53*	*2.90*
Four Factor Alpha	0.499%	**1.195%**	0.509%	**1.803%**
	1.07	*4.17*	*1.51*	*4.92*
Beta (ex-ante)	0.00	0.69	0.82	1.00
Volatility	0.243	0.155	0.203	0.256
Sharpe Ratio	0.590	1.441	0.634	0.943

Portfolio	BAB	BAB
Beta Spread	0.016	
	-0.41	
Lagged Beta Spread		0.009
		-0.23

Moving on to proposition 1 of the Frazzini & Pedersen model, we observe that in the three factor model alphas are declining (though not monotonically), while in the four-factor model, the opposite result is observed: the alphas are increasing with beta. Turning our attention to the statistical significance, two of the three alphas are significant in both the three and four-factor model. Therefore, we cannot draw any concrete conclusions for proposition 1; however, it is quite evident that there is an absence of beta arbitrage.

We now focus upon the BAB portfolio in order to discuss proposition 2. Our monthly rebalanced constructed BAB portfolio provides a statistically significant monthly average excess return of 1.1%. Furthermore, as can be detected from the right-most part of table 3 as well as the graphically illustrated scatterplot provided below (Figure 6), the coefficient of the beta spread is positive, meaning that the BAB return increases in the beta spread. Lastly, the abnormal returns estimated from the evaluations of BAB against the three models are positive, which complements the results found for proposition 2. Concluding, we can fully accept proposition 2 for Denmark.

Figure 6: Scatterplot chart of monthly BAB returns and Beta Spread - Denmark



Proposition 3

Table 4 provides our findings for the third Proposition. In the first column, we present the results for the regression of the lagged TED Spread and the change in TED Spread. The ΔTED Spread is indeed negatively related to the BAB return, consistent with the model's theory. However, our lagged TED Spread coefficient is also negatively related to the BAB return, inconsistent with the Proposition's hypothesis. Adding our control variables of market return, beta spread, lagged BAB return and lagged Inflation, we observe similar results. On a last note, none of our coefficients are statistically significant; thus, we cannot draw any concrete conclusions since we cannot reject the null hypothesis.

Table 4: Regression Results – Proposition 3 – Denmark

Portfolio	BAB	BAB
Market return		**-0.487**
		-3.67
Lagged TED spread	-0.154	-0.065
	-1.18	*-0.49*
Change in TED spread	-0.170	-0.091
	-1.17	*-0.63*
Beta spread		0.048
		-1.20
Lagged BAB return		0.004
		-0.05
Lagged inflation		0.943
		-0.88

4.2.2 AUSTRIA

Propositions 1 & 2

Table 5 demonstrates our results for Austria.

Table 5: Regression Results – Propositions 1 and 2 – Austria

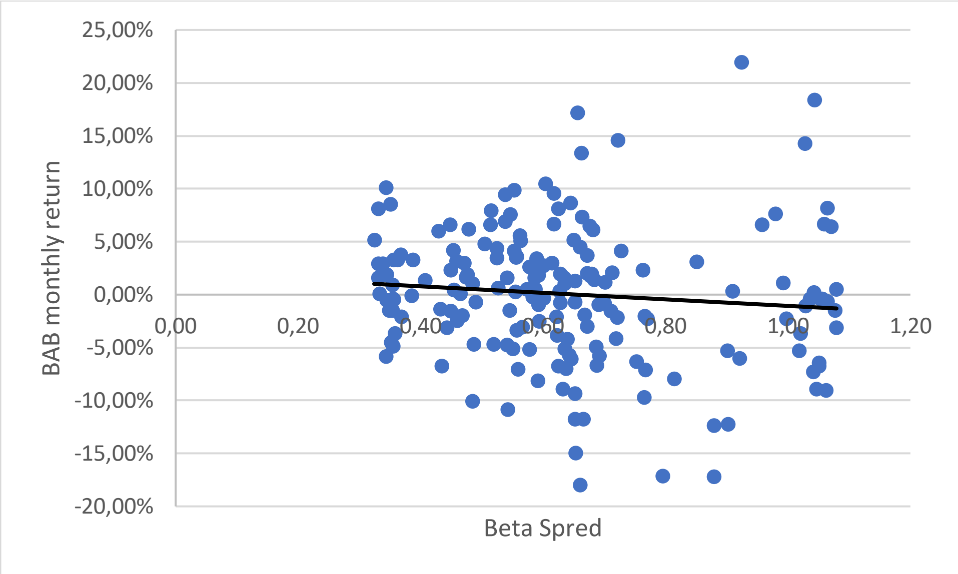
Portfolio	BAB	P1 (Low Beta)	P2	P3 (High Beta)
Excess Return	0.046%	**0.846%**	0.784%	**1.306%**
	0.10	*2.29*	*1.63*	*1.97*
CAPM Alpha	0.133%	0.395%	0.123%	0.401%
	0.28	*1.47*	*0.41*	*0.96*
Three Factor Alpha	0.032%	0.458%	0.256%	0.577%
	0.07	*1.69*	*0.84*	*1.40*
Four Factor Alpha	-0.101%	0.446%	0.296%	**0.808%**
	-0.22	*1.64*	*0.97*	*2.21*
Beta (ex-ante)	0.00	0.66	0.85	1.08
Volatility	0.222	0.172	0.223	0.307
Sharpe Ratio	0.025	0.620	0.440	0.550

Portfolio	BAB	BAB
Beta spread	-0.029	
	-1.28	
Lagged beta spread		-0.032
		-1.40

Unfortunately, our results are mixed, at best. We can detect a small abnormal return of 0.133% above the risk-free rate; however, the alpha is not statistically significant. Thus, we cannot reject the null hypothesis of zero abnormal returns. Moreover, even though we detect a decline of the Sharpe ratio in the beta-sorted portfolios, we cannot accept Proposition 1 since the fourth factor alphas are not declining as the beta increases. We observe the same phenomenon for the regression on the three-factor model. This is mainly due to the statistically significant value of the 0.8% abnormal return of the high beta asset portfolio (P3). Thus and so, our results are inconsistent with Proposition 1 for Austria, due to the upward trending slope trend in abnormal returns.

Our monthly rebalanced constructed BAB portfolio exhibits a positive 0.05% return. Be that as it may, we observe a negative related coefficient between the beta spread and the BAB portfolio, further illustrated in the scatterplot below (Figure 7).

Figure 7: Scatterplot chart of monthly BAB returns and Beta Spread - Austria



The abnormal returns of the BAB portfolio are positive when tested against the CAPM and the three-factor model, but not statistically significant. Finally, we note a negative risk-adjusted return when the momentum (UMD) factor is added. Concluding, we cannot accept Proposition 2 for Austria due to several inconsistencies.

<u>Proposition 3</u>

Table 6 summarizes our findings for the timeseries regressions for Proposition 3.

Table 6: Regression Results – Proposition 3 – Austria

Portfolio	BAB	BAB
Market return		-0.191
		-1.57
Lagged TED spread	0.164	0.205
	-1.38	*-1.67*
Change in TED spread	-0.098	-0.052
	-0.74	*-0.39*
Beta spread		-0.030
		-1.30
Lagged BAB return		0.021
		-0.28
Lagged inflation		1.081
		-1.09

The first regression shows somewhat promising results. Consistent with the model, we observe a coefficient positively related to the BAB return, and a negatively related change in the TED spread coefficient.

Adding the rest of the control variables, we monitor a consistency in the signs of the coefficients. The positive and negative relation is maintained for the lagged TED Spread and the ΔTED spread. However, none of our coefficients are statistically significant. We can see some consistency with the model, but no definite decision can be made for Proposition 3.

4.2.3 BELGIUM

Propositions 1 & 2

Table 7 displays our results for Belgium.

Firstly, we identify a statistically significant abnormal return of 1.2% when we test the model against the CAPM, accentuating the inadequacy of the CAPM's explanatory power.

Table 7: Regression Results – Propositions 1 and 2 – Belgium

Portfolio	BAB	P1 (Low Beta)	P2	P3 (High Beta)
Excess Return	0.805%	**1.067%**	**1.288%**	0.906%
	1.71	*4.05*	*3.40*	*1.57*
CAPM Alpha	**1.218%**	**0.830%**	**0.810%**	0.050%
	2.95	*3.63*	*3.04*	*0.16*
Three Factor Alpha	**1.209%**	**0.833%**	**0.826%**	0.062%
	2.92	*3.63*	*3.12*	*0.20*
Four Factor Alpha	0.639%	**0.750%**	**0.956%**	**0.662%**
	1.68	*3.20*	*3.55*	*2.63*
Beta (ex-ante)	0.00	0.68	0.84	1.12
Volatility	0.218	0.122	0.176	0.268
Sharpe Ratio	0.463	1.113	0.945	0.426

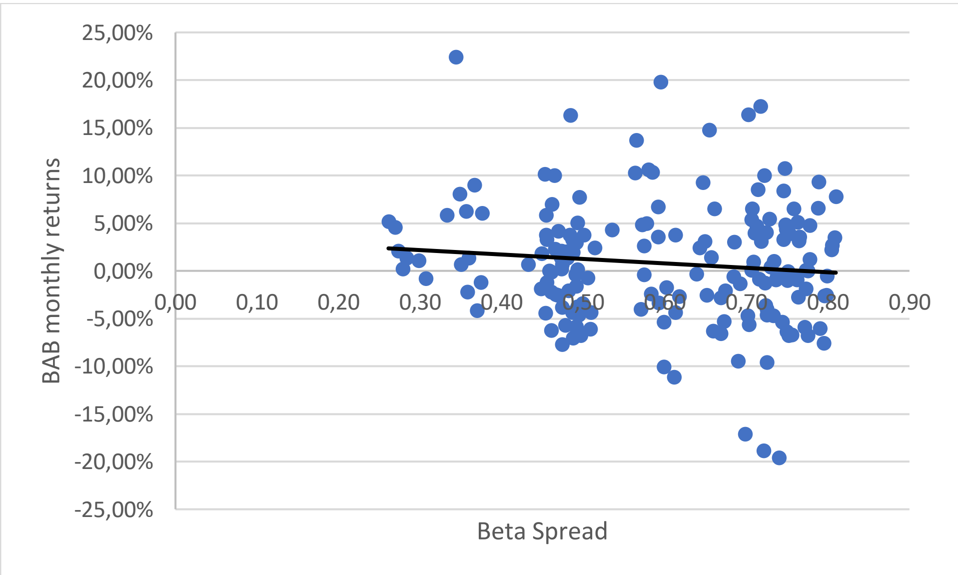
Portfolio	BAB	BAB
Beta spread	-0.048	
	(-1.48)	
Lagged beta spread		-0.054
		(-1.67)

We can clearly detect a decline in the alphas as the beta of the portfolios increases. Indeed, our findings underline an abnormal return with statistical significance in all the beta-sorted portfolios, for the regression against the four-factor model. Specifically, there is a 0.833% monthly risk-adjusted return for the low beta portfolio and a 0.662% monthly risk-adjusted return for the high beta portfolio. The argument is further validated for the three-factor model, where we detect a sharp decline in alphas as beta increases. On a last remark, we detect that the Sharpe ratio is declining as the beta of the portfolios increases (P1-P3). The empirical results allows us to accept the formation of a beta anomaly for the Belgian market; thus, we can accept Proposition 1.

Turning our focus onto our BAB constructed portfolio, we observe a positive 0.8% average excess return and a statistically significant risk-adjusted return of 1.2% against the three factor model.

The alpha of the four-factor regression continues to remain positive, though not statistically significant. Due to the lack of significance, we cannot reject the null hypothesis of a zero excess return on the BAB portfolio. Moreover, as depicted in figure 8, the BAB return is not increasing in the beta spread (negative coefficient of the beta spread -BAB regression).Thus, we cannot accept Proposition 2 for Belgium.

Figure 8: Scatterplot chart of monthly BAB returns and Beta Spread - Belgium



<u>Proposition 3</u>

In Table 8, we can observe that both the coefficient of the lagged TED spread and the coefficient of the ΔTED Spread are negative. This changes when we enter the rest of the Control Variables. Though the sign of the coefficient of the lagged TED spread is consistent with the model's theory, we cannot say the same for the coefficient of the ΔTED.

Furthermore, the fact that neither coefficient is significant limits our ability to draw any conclusions; thus, we cannot accept Proposition 3.

Table 8: Regression Results – Proposition 3 – Belgium

Portfolio	BAB	BAB
Market return		**-0.812**
		-7.68
Lagged TED spread	-0.013	0.181
	-0.11	*-1.69*
Change in TED spread	-0.042	0.117
	-0.32	*-1.00*
Beta spread		-0.019
		-0.65
Lagged BAB return		0.049
		-0.74
Lagged inflation		-0.164
		-0.19

4.2.4 FRANCE

Propositions 1 & 2

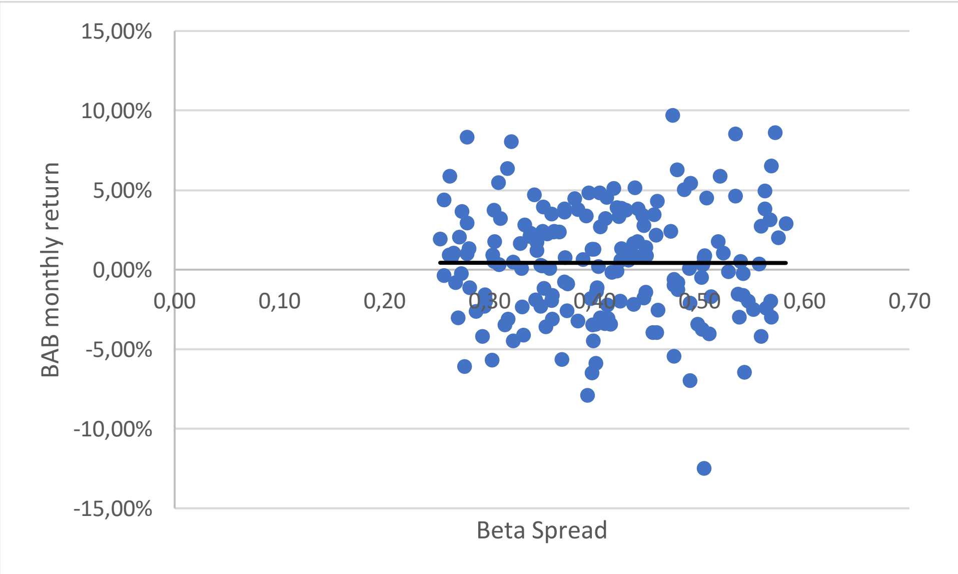
Table 9: Regression Results – Propositions 1 and 2 – France

Portfolio	BAB	P1 (Low Beta)	P2	P3 (High Beta)
Excess Return	0.427%	**0.919%**	**0.848%**	0.806%
	1.61	*3.29*	*2.39*	*1.55*
CAPM Alpha	**0.548%**	**0.491%**	**0.295%**	0.008%
	2.12	*3.57*	*1.98*	*0.03*
Three Factor Alpha	**0.552%**	**0.503%**	0.288%	0.013%
	2.12	*3.68*	*1.76*	*0.05*
Four Factor Alpha	0.110%	**0.357%**	**0.355%**	0.380%
	0.48	*2.68*	*2.11*	*1.65*
Beta (ex-ante)	0.00	0.82	0.99	1.22
Volatility	0.123	0.130	0.165	0.241
Sharpe Ratio	0.428	0.895	0.647	0.421

Portfolio	BAB	BAB
Beta spread	-0.005	
	(-0.18)	
Lagged beta spread		-0.003
		(-0.09)

Table 9 above summarizes our findings for France. Once again, we observe a significant abnormal return (0.54%) when we run a regression of the model against the CAPM. Further dwelling upon our results, we observe that the alphas of the four factor regression are increasing between portfolio P1 and P3, thereby contradicting the model's theory. However, we should note that the alphas are declining monotonically on the three-factor model as the beta increases. However, due to the insignificance of portfolios two and three (for the three-factor model) and of portfolio 3 (for the four-factor model), we cannot draw any conclusions. We do detect that the Sharpe Ratio is declining as beta increases, though. Concluding, we cannot accept Proposition 1 for the French Market since we do not have concrete evidence of a beta anomaly. Moving on to Proposition 2, we monitor a positive average return of the BAB portfolio (0.42%) and a positive abnormal return in regards to the four-factor model (0.11%). Due to the fact that the BAB return is also declining in the beta spread as shown in Figure 9, we cannot accept Proposition 2 for the French market.

Figure 9: Scatterplot chart of monthly BAB returns and Beta Spread - France



<u>Proposition 3</u>

Table 10 provides all the information about our timeseries test of Proposition 3.

The coefficients of both the Lagged TED Spread and the ΔTED Spread are positive. More interestingly, though, we observe a significant positive coefficient of the Lagged TED Spread when we account for the control variables providing some consistency with the model's Proposition. The sign of the ΔTED spread remains positive yet insignificant through our second regression, leaving us with no strong evidence. Therefore, we can not accept Proposition 3 for the French market

Table 10: Regression Results – Proposition 3 – France

Portfolio	BAB	BAB
Market return		**-0.267**
		-4.03
Lagged TED spread	0.079	**0.148**
	-1.19	*-2.21*
Change in TED spread	0.033	0.087
	-0.45	*-1.20*
Beta spread		0.019
		-0.65
Lagged BAB return		0.027
		-0.36
Lagged inflation		-0.097
		-0.18

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4.2.5 GERMANY

<u>Propositions 1 & 2</u>

Table 11 presents our results for Germany. Firstly, we do observe a significant 0.88% abnormal return when we test the model against the CAPM, again indicating the inadequacy of the traditional one-factor model to explain asset returns.

Table 11: Regression Results – Propositions 1 and 2 – Germany

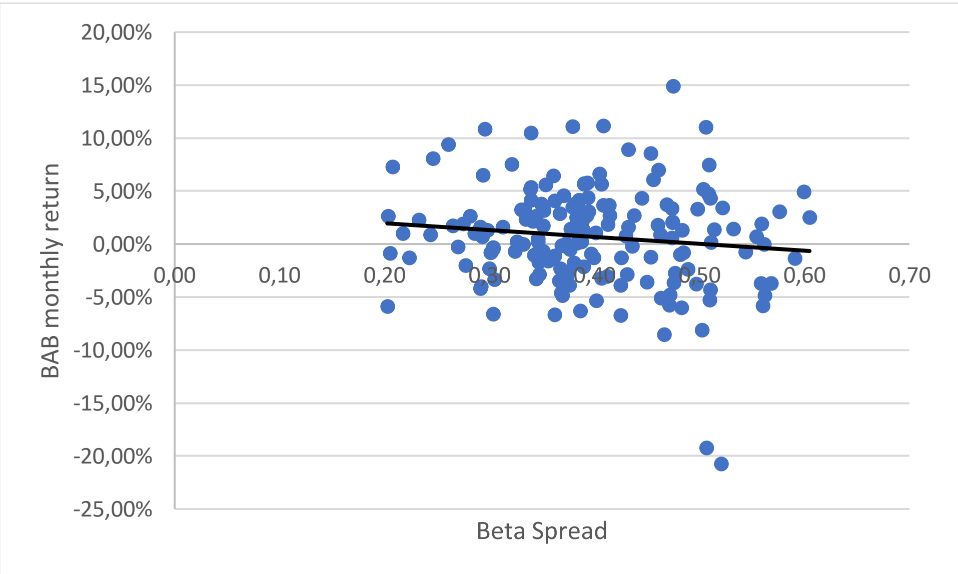
Portfolio	BAB	P1	P2	P3
		(Low beta)		(High Beta)
Excess Return	**0.693%**	**1.156%**	**1.010%**	0.914%
	1.97	*3.89*	*2.46*	*1.64*
CAPM Alpha	**0.880%**	**0.741%**	**0.386%**	0.082%
	2.60	*4.10*	*1.98*	*0.28*
Three Factor Alpha	**0.827%**	**0.747%**	**0.398%**	0.134%
	2.49	*4.09*	*2.10*	*0.48*
Four Factor Alpha	0.095%	**0.472%**	**0.640%**	**0.715%**
	0.31	*2.59*	*3.32*	*2.71*
Beta (ex-ante)	0.00	0.80	0.97	1.14
Volatility	0.163	0.138	0.190	0.258
Sharpe Ratio	0.529	1.075	0.674	0.446

Portfolio	BAB	BAB
Beta spread	-0.067	
	-1.66	
Lagged beta spread		-0.070
		-1.76

Turning to Proposition 1, as far as the four factor alphas are concerned, we find no evidence of a beta anomaly in the German market since alphas do not decline as beta increases. However, when we look at the three-factor abnormal returns, we find a monotonic decline in alphas as beta increases. Finally, the Sharpe Ratios of the beta sorted portfolios decrease monotonically as the systematic risk increases. With our four factor-results, we cannot accept Proposition 1. However, it is worth noting that, when we look at our three-model risk-adjusted return, we detect a clear phenomenon of beta anomaly.

Regarding Proposition 2, we can detect a significant 0.7% monthly excess return on the BAB portfolio and significant abnormal returns – except when we test the model against the four-factor model, where the abnormal return loses its significance. However, the sub-proposition of Proposition 2 is not satisfied since the BAB returns are not increasing in the beta Spread (Figure 10). All in all, due to the insignificance of the coefficient of the beta spread as well as the significance of the BAB excess return we are able to partially accept proposition 2 of the model.

Figure 10: Scatterplot chart of monthly BAB returns and Beta Spread - Germany



<u>Proposition 3</u>

The Lagged TED spread coefficient is indeed positively related to BAB returns, consistent with the model's theory, and the ΔTED spread coefficient negatively related to BAB returns. Their signs remain consistent even when we add the control variables, leading us to accept Proposition 3. All our results are summarized in table 12 below.

Table 12: Regression Results – Proposition 3 – Germany

Portfolio	BAB	BAB
Market return		**-0.362**
		-4.10
Lagged TED spread	0.023	0.092
	-0.26	*-1.02*
Change in TED spread	-0.078	-0.023
	-0.79	*-0.24*
Beta spread		-0.044
		-1.08
Lagged BAB return		0.010
		-0.14
Lagged inflation		-0.349
		-0.49

4.2.6 IRELAND

Propositions 1 &2

All our results discussed here are presented in table 13. As far as Proposition 1 is concerned, we cannot detect an increase in the alphas, mostly due to the significant value of the risk-adjusted abnormal return of 2.2% of the high beta portfolio. Even though we once again detect a decline in the Sharpe Ratio as the beta increases, we cannot accept Proposition 1 for Ireland, since we cannot detect any sign of beta anomaly.

As far as Proposition 2 is concerned, we observe a positive average excess Return on the BAB portfolio; however, due to its insignificance, we cannot reject the null hypothesis of zero excess returns.

Table 13: Regression Results – Propositions 1 and 2 – Ireland

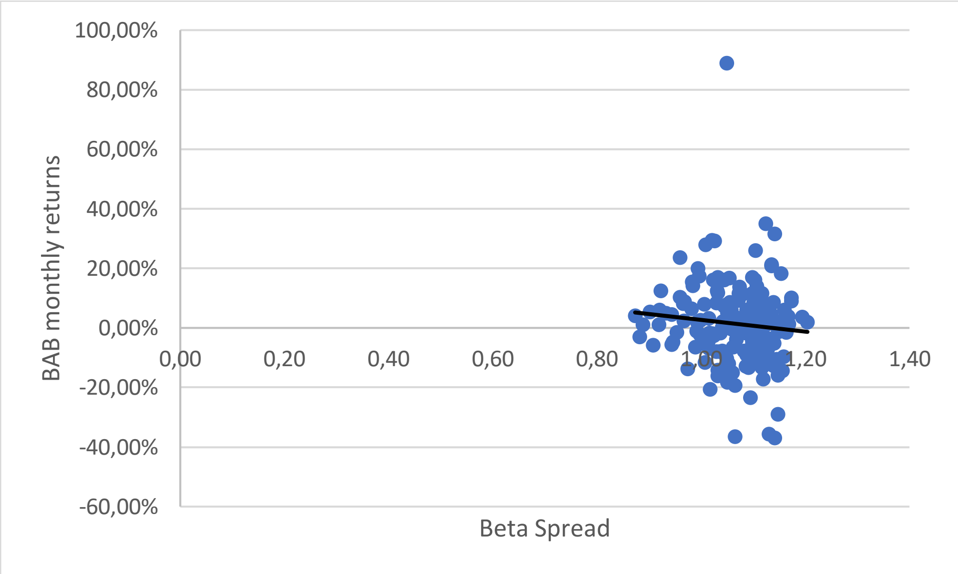
Portfolio	BAB	P1 (Low Beta)	P2	P3 (High Beta)
Excess Return	1.357%	**2.114%**	**1.398%**	**2.469%**
	1.35	*3.88*	*3.06*	*2.83*
CAPM Alpha	1.162%	**1.599%**	**0.866%**	**1.550%**
	1.15	*3.45*	*2.51*	*2.20*
Three Factor Alpha	1.040%	**1.559%**	**0.805%**	**1.572%**
	1.03	*3.44*	*2.35*	*2.24*
Four Factor Alpha	0.379%	**1.511%**	**0.981%**	**2.212%**
	0.38	*3.29*	*2.90*	*3.40*
Beta (ex-ante)	0.00	0.50	0.68	1.07
Volatility	0.467	0.252	0.212	0.405
Sharpe Ratio	0.375	1.131	0.857	0.840

Portfolio	BAB	BAB
Beta spread	-0.216	
	-1.42	
Lagged beta spread		-0.283
		-1.90

All the abnormal returns remain statistically insignificant.

Moreover, the BAB Return is decreasing in the beta Spread, illustrated further in Figure 11. It is worth noting that the decreasing trend of the beta spread for Ireland is the highest among our findings. We, therefore, can not accept Proposition 2 for Ireland.

Figure 11: Scatterplot chart of monthly BAB returns and Beta Spread - Ireland



<u>Proposition 3</u>

The Lagged TED spread coefficient is positively related to BAB returns, consistent with the model. However, the coefficient of the ΔTED spread is also exhibiting a positive relationship with the BAB return, inconsistent with the theory.

Table 14: Regression Results – Proposition 3 – Ireland

Portfolio	BAB	BAB
Market return		0.351
		-1.36
Lagged TED spread	0.215	0.145
	-0.85	*-0.55*
Change in TED spread	0.361	0.282
	-1.28	*-1.00*
Beta spread		-0.217
		-1.4
Lagged BAB return		0.021
		-0.27
Lagged inflation		-3.862
		-1.82

The coefficients remain positively related to the BAB return, even after the introduction of our control variables. Nevertheless, the insignificance of our coefficients does not allow us to make firm assumptions; thus, we cannot accept Proposition 3 for Ireland.

4.2.7 NETHERLANDS

Propositions 1 & 2

The last country for the northern subregion of Europe is Holland. Our results for the Netherlands are summarized in table 15. To start with, we observe a significant abnormal return of 1.07%. Consistent with Black's theory, we find that the intercept of the SML is higher than the one predicted by the traditional CAPM.

In order to examine Proposition 1, we have to observe the trend line of the alphas on the beta sorted Portfolios. We notice an increase between P1 and P2 (0.6% and 0.8%); however, the abnormal return sharply declines in the highest beta portfolio. Even though our value is not significant, we can see that the alphas decrease as the beta increases. Further strengthening the evidence is the fact that the Sharpe Ratio also declines (though not monotonically) between P1 and P3; thus, we are able to accept Proposition 1 for the Netherlands.

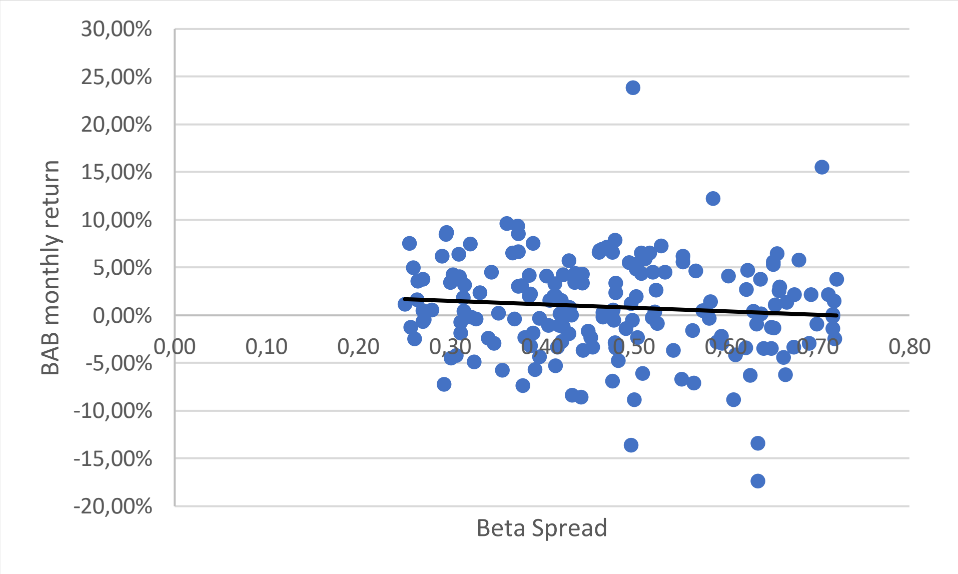
Table 15: Regression Results – Propositions 1 and 2 – Netherlands

Portfolio	BAB	P1 (Low Beta)	P2	P3 (High Beta)
Excess Return	**0.881%**	**1.090%**	**1.403%**	0.747%
	2.30	*3.49*	*3.51*	*1.33*
CAPM Alpha	**1.068%**	**0.686%**	**0.832%**	-0.104%
	2.87	*3.21*	*3.55*	*-0.36*
Three Factor Alpha	**1.042%**	**0.680%**	**0.872%**	-0.102%
	2.81	*3.16*	*3.76*	*-0.37*
Four Factor Alpha	**0.849%**	**0.618%**	**0.875%**	0.053%
	2.60	*2.96*	*3.75*	*0.22*
Beta (ex-ante)	0.00	0.77	0.92	1.20
Volatility	0.178	0.145	0.185	0.261
Sharpe Ratio	0.624	0.959	0.982	0.358

Portfolio	BAB	BAB
Beta spread	-0.037	
	-1.22	
Lagged beta spread		-0.042
		-1.40

Moving on to Proposition 2, we initially note a significant 0.9% average monthly return of the BAB portfolio. Furthermore, all alphas are positive and significant. Even though the BAB portfolio excess return is not increasing in the beta spread as shown in Figure 12, we find concrete evidence that Proposition 2 is partially satisfied.

Figure 12: Scatterplot chart of monthly BAB returns and Beta Spread - Netherlands



<u>Proposition 3</u>

Table 16 displays our findings for Proposition 3. We monitor a positive Lagged TED spread coefficient, meaning that investors will require an additional required return after an increased tightness in funding constraints. In addition, the change in the TED spread is negatively related to the BAB return portfolio. Even after we insert the rest of our control variables, the signs of the coefficients remain the same (positive for the lagged TED spread and negative for the ΔTED spread); therefore, we can accept Proposition 3 for the Netherlands.

Table 16: Regression Results – Proposition 3 – Netherlands

Portfolio	BAB	BAB
Market return		**-0.373**
		-3.84
Lagged TED spread	0.056	0.139
	-0.59	*-1.43*
Change in TED spread	-0.158	-0.094
	-1.49	*-0.9*
Beta spread		-0.013
		-0.43
Lagged BAB return		-0.019
		-0.26
Lagged inflation		-0.151
		-0.2

4.3 SOUTHERN EUROPE

4.3.1 PORTUGAL

Propositions 1 &2

Table 17 presents the results of the regressions of the BAB and beta-sorted portfolios on the risk factors mentioned at the beginning of this section. On a general note, we can see that the alphas and average excess returns for portfolios P_1 and P_2 are significant and positive, while for portfolio P_3, neither the alphas nor the excess returns are significant. It is also interesting to observe that the average excess returns of the three beta-sorted portfolios are dissimilar, with the lowest beta portfolio (P_1) having the largest return, and the excess return declining in P_2 and P_3. Furthermore, the CAPM abnormal return of BAB is significant and positive, indicating the inadequacy of the model to correctly predict the interecept of the SML.

Regarding Proposition 1, we can see that in all three asset-pricing models, the alphas as well as the Sharpe ratios of the beta sorted porfolios are declining monotonically in beta, indicating the presence of a beta anomaly. Even though the t-statistics of the P_3 abnormal returns render those alphas insignificant, we can still accept Proposition 1 since the trend in alphas is downward in all three models.

Table 17: Regression Results – Propositions 1 and 2 – Portugal

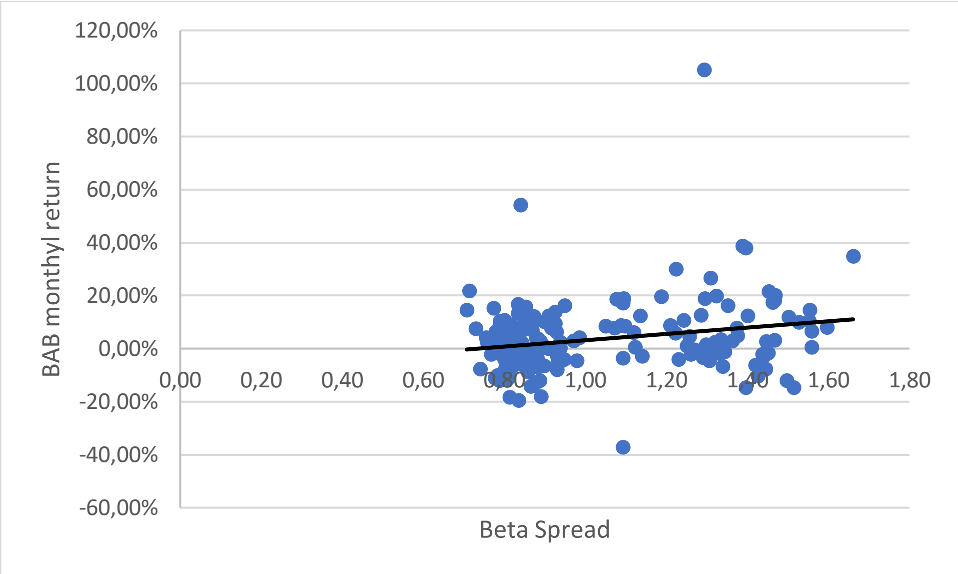
Portfolio	BAB	P1 (Low Beta)	P2	P3 (High Beta)
Excess Return	**3.517%**	**2.232%**	**1.314%**	1.017%
	3.47	*4.26*	*2.69*	*1.62*
CAPM Alpha	**3.624%**	**1.943%**	**0.836%**	0.348%
	3.54	*3.86*	*2.04*	*0.69*
Three Factor Alpha	**3.651%**	**1.900%**	**0.847%**	0.255%
	3.55	*3.79*	*2.05*	*0.52*
Four Factor Alpha	**3.074%**	**1.983%**	**1.109%**	0.914%
	2.92	*3.82*	*2.64*	*1.95*
Beta (ex-ante)	0.00	0.48	0.72	0.95
Volatility	0.470	0.243	0.227	0.290
Sharpe Ratio	1.09	1.25	0.75	0.45

Portfolio	BAB	BAB
Beta spread	**0.118**	
	-3.05	
Lagged beta spread		**0.109**
		-2.79

Turning now to proposition 2, the average monthly excess return of BAB is positive and significant, at a value of 3.52%. Furthermore, the CAPM, three-factor and four-factor alphas are also positive and significant, with values ranging from 3.07% to 3.65%. The regression of BAB on the beta spread resulted in a positive (and significant) coefficient, in line with Frazzini and Pedersen's proposition 2, meaning that the expected return of the betting against beta portfolio increases in the beta spread.

This can also be confirmed by examining the trend line in figure 13, where a scatterplot of the monthly BAB returns versus the beta spread is illustrated. In summary, the previous statements lead us to accept proposition 2 for Portugal.

Figure 13: Scatterplot chart of monthly BAB returns and Beta Spread – Portugal



<u>Proposition 3</u>

Table 18 demonstrates the coefficients and t-statistics of the BAB regression on the lagged TED spread and change in the TED spread as well as the same results for the augmented regression that includes the control variables. In both regressions, the coefficient of the lagged TED spread is positive, which partially fulfills proposition 3. The coefficients of the change in the TED spread are also positive, which is in disagreement with the model's theory. For this reason as well as the fact that the coefficients are insignificant, we cannot make concrete conclusions upon proposition 3 for Portugal.

Table 18: Regression Results – Proposition 3 – Portugal

Portfolio	BAB	BAB
Market return		-0.284
		-1.12
Lagged TED spread	0.320	0.405
	-1.26	*-1.58*
Change in TED spread	0.051	0.060
	-0.18	*-0.21*
Beta spread		**0.116**
		-2.90
Lagged BAB return		-0.054
		-0.71
Lagged inflation		-3.58
		-1.72

4.3.2 GREECE

<u>Propositions 1 & 2</u>

Table 19 shows the average monthly excess returns and alphas of the BAB and beta-sorted portfolios for Greece.

The CAPM alpha is positive and significant, indicating that the CAPM does not hold for the Greek market, since the intercept renders the SML flatter. Regarding the beta-sorted portfolios, most of the coefficients of the excess returns and alphas are insignificant, with the exception of the return of P_1 and the four-factor alphas of P_1 and P_2. Nevertheless, the alphas are declining in all three models and the Sharpe ratios follow the same trend. Though we do not observe a clear monotonic decline, we can accept proposition 1 since the trend is downward between the beta-sorted portfolio 2 and 3.

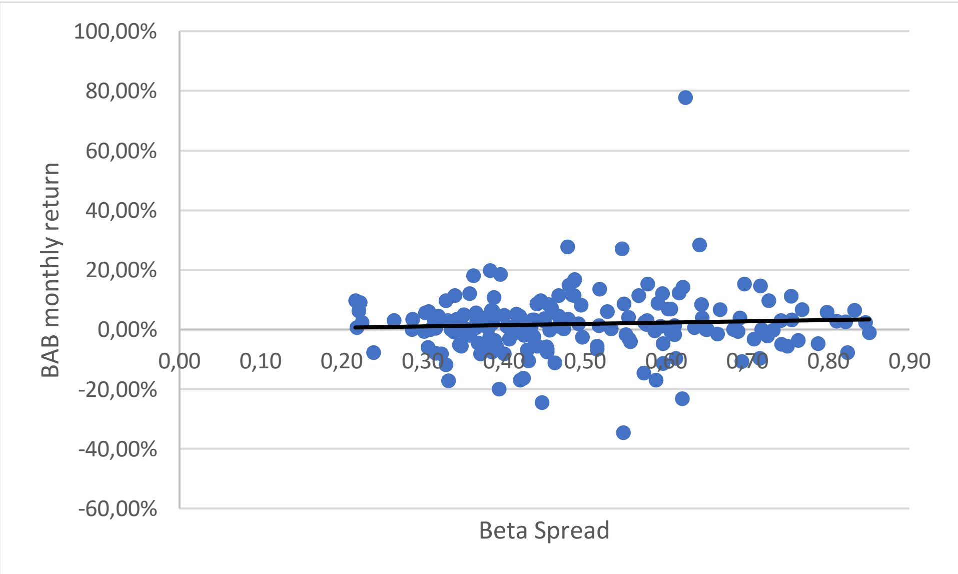
Regarding proposition 2, the excess return of BAB is positive and significant, with an average return of 1.86% per month. In addition, the alphas are also positive and statistically significant. In accordance with the model's theory, the coefficient of the beta spread is positive. However it should be noted that we do not observe a significant relationship between the BAB returns and the beta spread. Thus and so, we can partially accept proposition 2.

Table 19: Regression Results – Propositions 1 and 2 – Greece

Portfolio	BAB	P1 (Low Beta)	P2	P3 (High Beta)
Excess Return	**1.858%**	**1.174%**	1.295%	0.117%
	2.34	*1.97*	*1.80*	*0.10*
CAPM Alpha	**1.965%**	0.537%	0.591%	-0.952%
	2.46	*1.12*	*0.98*	*-0.92*
Three Factor Alpha	**2.166%**	0.667%	0.822%	-0.979%
	2.73	*1.69*	*1.89*	*-1.08*
Four Factor Alpha	**1.548%**	**0.942%**	**1.097%**	0.204%
	2.11	*2.54*	*2.64*	*0.31*
Beta (ex-ante)	0.00	0.74	0.88	1.17
Volatility	0.368	0.276	0.334	0.554
Sharpe Ratio	0.673	0.545	0.500	0.025

Portfolio	BAB	BAB
Beta spread	0.040	
	-0.77	
Lagged beta spread		0.033
		-0.63

Figure 14: Scatterplot chart of monthly BAB returns and Beta Spread – Greece



Proposition 3

Table 20 submits the coefficients and statistical significance of the two regressions for testing the effect of funding constraints on the betting against beta factor. As to the simple BAB regression on the lagged TED spread and the change in the TED spread, the coefficient of the former is negative, while the coefficient of the latter is positive. This is in complete contrast to what proposition 3 suggests. What is more, the same pattern is also observed in the augmented regression. However, since the coefficients are insignificant we cannot draw any conclusions regarding the ramifications of funding constraints proxied by the TED spread on the Greek BAB factor.

Table 20: Regression Results – Proposition 3 – Greece

Portfolio	BAB	BAB
Market return		-0.168
		-0.80
Lagged TED spread	-0.304	-0.272
	-1.55	*-1.33*
Change in TED spread	0.116	0.15
	-0.53	*-0.67*
Beta spread		0.0463
		-0.87
Lagged BAB return		0.004
		-0.05
Lagged inflation		0.442
		-0.27

4.3.3 ITALY

Propositions 1 &2

Table 21 presents the regression results of the Italian BAB and beta-sorted portfolios. The positive and significant CAPM alpha of the BAB factor indicates that the CAPM predicts a steeper SML compared to the empirical finding. Examining the alphas of the beta-sorted portfolios, we can see that in all three models the alphas are declining, though not monotonically in the four-factor model. Furthermore, we get statistical significance only in the values for portfolio P_1. However, since the trend is downward in all three regressions, we can accept proposition 1 regarding the reverse relationship between alpha and beta.

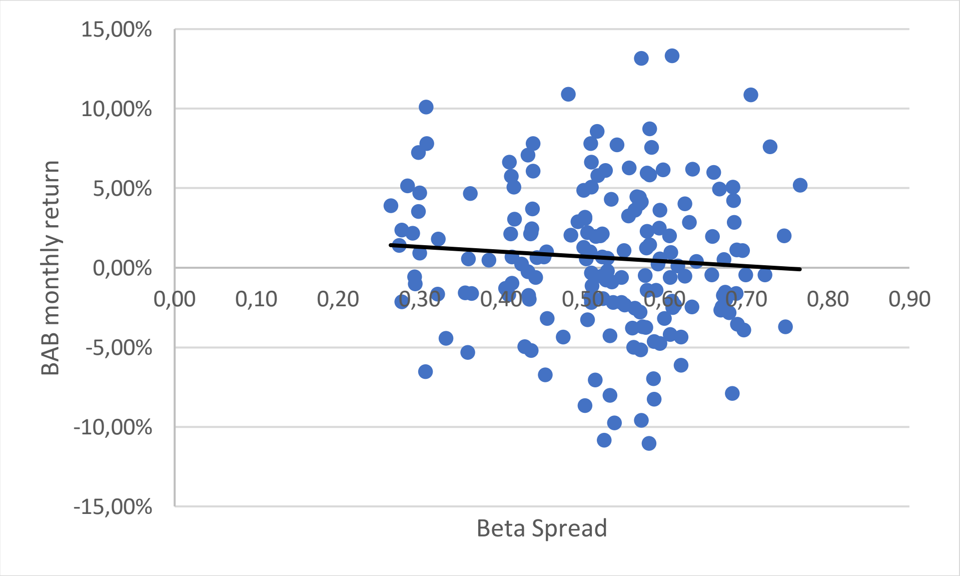
Table 21: Regression Results – Propositions 1 and 2 – Italy

Portfolio	BAB	P1	P2	P3
		(Low Beta)		(High Beta)
Excess Return	0.631%	**0.957%**	0.512%	0.720%
	1.85	*2.86*	*1.09*	*1.19*
CAPM Alpha	**0.724%**	**0.513%**	-0.163%	-0.119%
	2.13	*2.32*	*-0.60*	*-0.32*
Three Factor Alpha	**0.742%**	**0.512%**	-0.210%	-0.165%
	2.18	*2.31*	*-0.81*	*-0.45*
Four Factor Alpha	0.351%	**0.625%**	0.172%	0.531%
	1.07	*2.77*	*0.73*	*1.76*
Beta (ex-ante)	0.00	0.76	1.00	1.22
Volatility	0.158	0.155	0.217	0.280
Sharpe Ratio	0.497	0.780	0.290	0.321

Portfolio	BAB	BAB
Beta spread	-0.032	
	-1.08	
Lagged beta spread		-0.042
		-1.43

Focusing now on the BAB excess return and alphas, the factor presents a positive but insignificant monthly return of 0.63%. The alphas are also positive, but significant only in the CAPM and three-factor regression. The results from the regression of the factor on the beta spread are not promising either, since the coefficient is negative and insignificant. The clear downward trend can also be observed in figure 15. Overall, we cannot accept proposition 2 for the Italian betting against beta factor.

Figure 15: Scatterplot chart of monthly BAB returns and Beta Spread - Italy



<u>Proposition 3</u>

Table 22 reports the TED spread regression results.

Table 22: Regression Results – Proposition 3 – Italy

Portfolio	BAB	BAB
Market return		**-0.194**
		-2.22
Lagged TED spread	0.019	0.065
	-0.22	*-0.74*
Change in TED spread	-0.045	-0.016
	-0.48	*-0.17*
Beta spread		-0.031
		-1.03
Lagged BAB return		-0.097
		-1.28
Lagged inflation		-0.065
		-0.09

The signs of the coefficients for the lagged TED spread and the change in the TED spread are in accordance with the model's hypotheses in both regressions. However, since all coefficients are insignificant, we cannot draw any concrete conclusions regarding the effect of funding constraints on the returns of the Italian BAB factor.

4.3.4 SPAIN

Propositions 1 & 2

Table 23 reports the results of our tests for the Spanish BAB and beta-sorted portfolios. The CAPM alpha for BAB, as in most countries analyzed so far, is positive and significant, indicating the inadequacy of the model to correctly predict the SML.

Furthermore, the beta-sorted portfolio alphas are declining in beta, a tendency observed in all three regressions. Even though only the P_1 alphas are significant, we can still accept proposition 1 since, as mentioned before, there is a common downward trend among the three models. This is also reinforced by the fact that the Sharpe ratios are declining as we move from the low to the high beta portfolio.

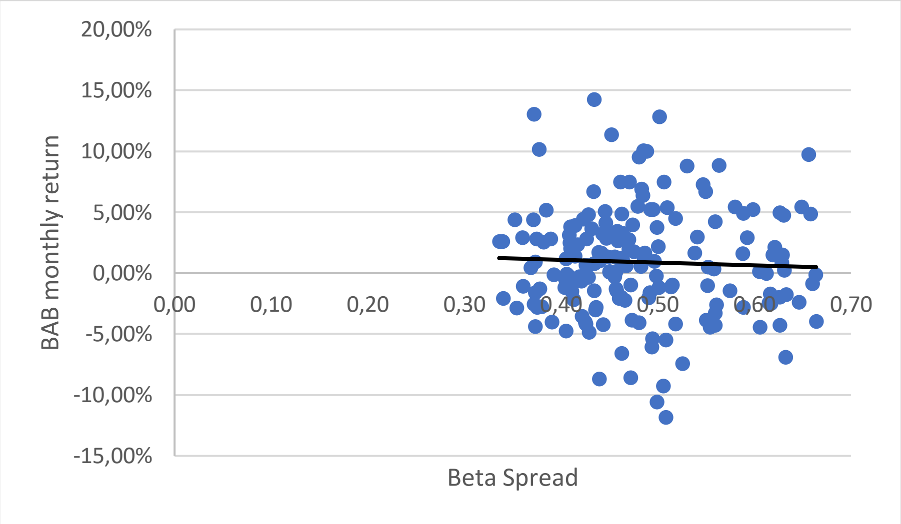
Table 23: Regression Results – Propositions 1 and 2 – Spain

Portfolio	BAB	P1 (Low Beta)	P2	P3 (High Beta)
Excess Return	**0.901%**	**1.106%**	0.581%	0.567%
	2.70	*3.31*	*1.38*	*1.05*
CAPM Alpha	**1.010%**	**0.691%**	0.007%	-0.190%
	3.04	*2.90*	*0.03*	*-0.58*
Three Factor Alpha	**1.015%**	**0.664%**	-0.028%	-0.220%
	3.04	*2.86*	*-0.12*	*-0.71*
Four Factor Alpha	0.590%	**0.774%**	**0.447%**	0.443%
	1.80	*3.22*	*2.04*	*1.64*
Beta (ex-ante)	0.00	0.75	0.93	1.14
Volatility	0.155	0.155	0.195	0.249
Sharpe Ratio	0.734	0.912	0.369	0.281

Portfolio	BAB	BAB
Beta spread	-0.022	
	-0.52	
Lagged beta spread		-0.002
		-0.06

The BAB factor achieves a significant and positive monthly excess return of 0.90%. The CAPM and three factor alphas are also positive and significant, while the four-factor alpha is positive but insignificant. By looking at the regression of BAB with the beta spread, as well as figure 16, we can detect that the BAB excess return declines in beta spread contrary to what proposition 2 of the model predicts. Nevertheless, due to the insignificance of the beta-spread's coefficient, we can accept the proposition's hypothesis that the average excess return of BAB is positive, but we cannot make any statements regarding the relation of BAB with the beta spread.

Figure 16: Scatterplot chart of monthly BAB returns and Beta Spread – Spain



<u>Proposition 3</u>

Table 24 shows the results of the regression of BAB on the lagged TED spread and the change in the TED spread as well as the results for the regression including the control variables.

Table 24: Regression Results – Proposition 3 – Spain

Portfolio	BAB	BAB
Market return		-0.23
		-2.68
Lagged TED spread	0.051	0.102
	-0.61	*-1.18*
Change in TED spread	0.014	0.056
	-0.15	*-0.59*
Beta spread		-0.008
		-0.2
Lagged BAB return		0.036
		-0.47
Lagged inflation		0.100
		-0.14

In both regressions, the coefficients of the variables in interest are positive (but statistically insignificant). This is an affirmative result for the lagged TED spread, since proposition 3 suggests that it should positively predict BAB returns. The coefficients of the change in the TED spread are also positive, which is in disagreement with the hypothesis that the change in the TED spread is negatively related to the BAB return. For this reason and considering the fact that the coefficients are statistically insignificant, we cannot accept proposition 3 for Spain.

4.4 EURO STOXX 50 INDEX

Propositions 1 & 2

Table 25 summarizes our results for the Eurozone general Index. Our analysis was mostly identical to that of the individual countries, with the exception of the construction of five beta-sorted portfolios instead of three. Once again, we are able to provide strong evidence of a flatter security market line since the intercept exceeds the risk free rate by approximately 0.52% for zero beta assets, consistent with Black's restricted borrowing CAPM (Jensen et al. 1972).

Along similar lines to our previous findings, we will examine Proposition 1 by observing the trend of the alphas as the systematic risk increases in our beta-constructed portfolios.

Table 25: Regression Results – Proposition 1 – EuroStoxx

Portfolio	BAB	P1 (Low Beta)	P2	P3	P4	P5 (High Beta)
Excess Return	0.409%	**1.042%**	**0.860%**	**0.935%**	0.734%	1.005%
	1.52	*3.88*	*2.78*	*2.67*	*1.85*	*1.86*
CAPM Alpha	**0.522%**	**0.669%**	**0.392%**	**0.395%**	0.104%	0.210%
	1.98	*4.05*	*2.50*	*2.36*	*0.62*	*0.71*
Three Factor Alpha	**0.523%**	**0.665%**	**0.402%**	**0.374%**	0.086%	0.209%
	1.97	*3.99*	*2.78*	*2.31*	*0.51*	*0.73*
Four Factor Alpha	-0.163%	**0.325%**	0.245%	**0.492%**	0.241%	**0.845%**
	-0.72	*2.09*	*1.65*	*2.92*	*1.38*	*3.22*
Beta (ex-ante)	0.00	0.77	0.89	0.98	1.07	1.25
Volatility	0.124	0.125	0.143	0.162	0.184	0.250
Sharpe Ratio	0.404	1.064	0.756	0.728	0.499	0.510

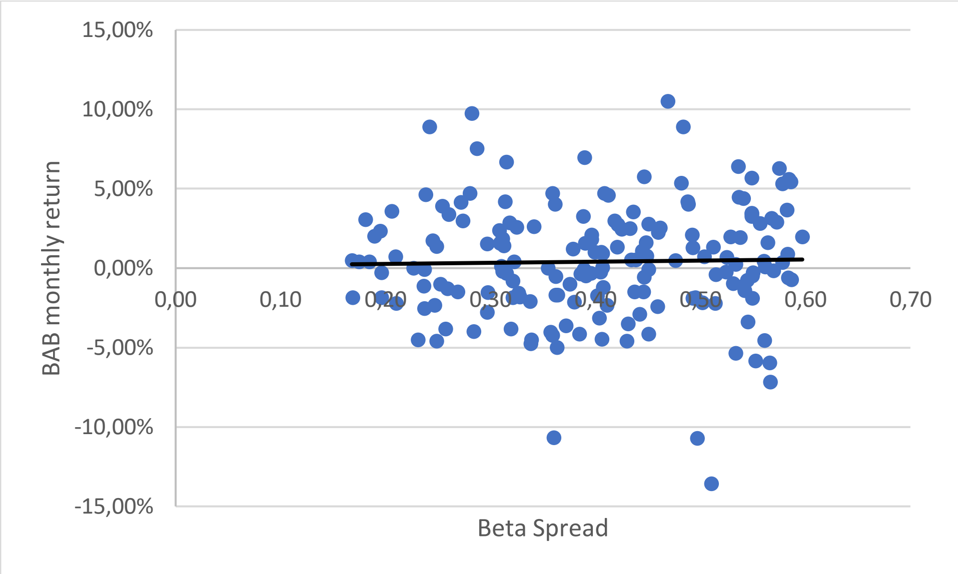
Table 26: Regression Results – Proposition 2 – EuroStoxx

Portfolio	BAB	BAB
Beta Spread	0.006	
	-0.25	
Lagged Beta Spread		0.003
		-0.14

For the four-factor model, we get a contradictory result. We notice an increase in the alphas as the beta increases. Mainly due to the significant value of the abnormal return of the fifth portfolio, we are unable to accept Proposition 1.Nevertheless, we can spot a monotonic decrease in the alphas as the beta increases when we estimate abnormal returns using the Fama & French three-factor model. The fact that the Sharpe ratios also decline as the beta increases can be regarded as concrete evidence of a beta anomaly again, for the three-factor model.

Turning our focus onto Proposition 2 and the BAB portfolio, we find an insignificant value of 0.4% monthly average excess return on our BAB portfolio. Therefore, we cannot reject the null hypothesis of zero excess return. Furthermore, we monitor a significant value of abnormal returns when we test the BAB portfolio against the CAPM and the three-factor model. However, the four-factor model alpha is negative, yet insignificant. Combining all the aforementioned observations with the fact that the BAB return is increasing in the beta spread, graphically illustrated in Figure 17, leaves us with some promising results, especially when we look at the three-factor risk-adjusted return. Yet, we are unable to accept Proposition 2, mainly due to the insignificant value of the average monthly return of the BAB portfolio.

Figure 17: Scatterplot chart of monthly BAB returns and Beta Spread - EuroStoxx



<u>Proposition 3</u>

According to table 27, the lagged TED spread coefficient is positively related to the BAB returns, meaning that, after funding shocks, investors will indeed entail an additional required return. It is worth noting that we find a significant value of the lagged TED spread coefficient when we include our control variables. Notwithstanding the article's theory, the change in the TED spread is positively related to the BAB returns in both our regression tests. Thus and so, we cannot accept Proposition 3 for the Eurozone Index.

Table 27: Regression Results – Proposition 3 – EuroStoxx

Portfolio	BAB	BAB
Market return		**-0.254**
		-3.73
Lagged TED spread	0.067	**0.137**
	1.00	*2.00*
Change in TED spread	0.032	0.080
	-0.43	*-1.08*
Beta spread		0.020
		-0.85
Lagged BAB return		-0.028
		-0.38
Lagged inflation		-0.189
		-0.34

4.6 ROBUSTNESS

Appendix tables 1 to 12 present the regression results for propositions one and two using Vasicek's dynamic shrinkage factors for the calculation of betas[30]. On a general note, the results are quite similar to our main findings of the previous section. Regarding the alpha-beta relation (proposition 1), the robustness tests revealed no new information that could alter the assessment of the existence or not of beta arbitrage; for most instruments, the magnitude and statistical significance of alphas were close to the findings using fixed shrinkage factors. More importantly, we did not find any changes in the trend of the alpha-beta relation. However, it should be noted that we found some interesting improvements as far as proposition 2 is concerned. Specifically, for Italy, Belgium and Ireland the usage of dynamic shrinkage factors resulted in significant BAB excess returns contraty to our statistically insignificant fixed shrinkage factor results.

4.7 FACTOR LOADINGS

In order to dive deeper into the risk-profile of the BAB portfolios we now examine the factor loadings estimated from the OLS regression of BAB monthly excess return against the four-factor model. Table 28 presents the coefficients of the risk factors (MKT, SMB HML and UMD) as well as the abnormal return (alpha) per country. Alphas are in monthly percent and t-statistics are reported in brakets. A 5% statistical significance is illustrtated in bold.

Starting from the most interesting results, the UMD loadings are significant and positive for all the examined instruments, with relatively high t-statistics. This indicates that the stocks comprising the low beta leg of the BAB portfolios achieve higher returns compared to those included in the short leg (high beta), over the timespan of the last 12 months. It is clear from the table that the significance of coefficients of the momentum factor, which is present in *all* our focused instruments, signals that variations in BAB's excess return are captured up to an extent by the UMD factor.

[30] We do not present the regression results for proposition 3 since the use of dynamic shrinkage factors did not lead to any improvement in the significance of the coefficients.

Table 28: BAB portfolio risk-factor coefficients and alphas per instrument (Four-Factor Model)

	MKT	SMB	HML	UMD	alpha
Denmark	-0.188	**0.349**	**-0.367**	**0.552**	0.499%
	(-1.62)	*(-3.16)*	*(-3.71)*	*(-6.07)*	*(-1.07)*
Austria	0.005	**0.340**	-0.172	**0.222**	-0.101%
	(-0.04)	*(-3.16)*	*(-1.82)*	*(-3.18)*	*(-0.22)*
Belgium	**-0.492**	-0.162	-0.089	**0.445**	0.639%
	(-4.85)	*(-1.53)*	*(-0.93)*	*(-6.66)*	*(-1.68)*
France	-0.049	-0.095	**-0.181**	**0.421**	0.110%
	(-0.82)	*(-1.28)*	*(-2.25)*	*(-7.98)*	*(-0.48)*
Germany	-0.010	0.164	**-0.376**	**0.504**	0.095%
	(-0.12)	*(-1.86)*	*(-3.86)*	*(-7.43)*	*(-0.31)*
Ireland	**0.852**	0.178	-0.158	**0.366**	0.379%
	(-3.22)	*(-1.20)*	*(-1.21)*	*(-4.00)*	*(-0.38)*
Netherlands	-0.026	0.030	**-0.287**	**0.467**	**0.849%**
	(-0.28)	*(-0.37)*	*(-3.64)*	*(-7.22)*	*(-2.60)*
Portugal	-0.114	0.050	-0.253	**0.363**	**3.070%**
	(-0.44)	*(-0.23)*	*(-1.26)*	*(-2.18)*	*(-2.92)*
Greece	0.093	**-0.357**	-0.250	**0.532**	**1.550%**
	(-0.49)	*(-2.73)*	*(-1.82)*	*(-5.93)*	*(-2.11)*
Italy	-0.035	0.014	-0.124	**0.301**	0.351%
	(-0.42)	*(-0.14)*	*(-1.45)*	*(-5.13)*	*(-1.07)*
Spain	-0.061	-0.054	-0.076	**0.260**	0.590%
	(-0.73)	*(-0.73)*	*(-0.94)*	*(-4.67)*	*(-1.80)*
EuroStoxx	0.049	-0.085	**-0.402**	**0.553**	-0.163%
	(-0.81)	*(-0.92)*	*(-3.86)*	*(-9.72)*	*(-0.72)*

Moving on to the HML loadings, the results are quite mixed. We only get significant coefficients for five out of twelve countries, namely Denmark, France, Germany, Netherlands and the Eurostoxx index, yet the factor loading is negative for all instruments. This illustrates the tilting of the BAB portfolios towards growth stocks (Pederen, 2015), meaning towards stocks with high book-to-market ratio. Contrary to the UMD findings, we cannot observe a similar explanatory power of the HML factor upon BAB returns.

Regarding the size factor, we observe only three significant coefficients; those of Denmark, Austria and Greece. In general, the sign of the factor loadings varies among the countries, thus providing no clear collective exposure of the BAB portfolio towards small or large market cap stocks.

Lastly, *for* the data samples we analyzed, we can see that the abnormal returns for most countries become insignificant after controlling for all four factors, with the exception of Netherlands, Portugal and Greece.

4.8 SUMMARY

In line with Frazzini and Pedersen's article, we present a summary table in order to compare the values of the average monthly excess returns for the BAB portfolio, constructed for each country (and the Euro Index). Table 29 presents the summary of our findings.

Table 29: Eurozone equity Returns by Country

Country	Excess Return	t-Statistic (Excess Return)	Four Factor Alpha	t-Statistic (4 F Alpha)	Three Factor Alpha	t-Statistic. (3 F Alpha)	Volatility	Sharpe Ratio
Denmark	**1.12%**	2.14	0.50%	1.07	**1.44%**	3.00	24.27%	0.5903
Austria	0.05%	0.10	-0.10%	-0.22	0.03%	0.07	22.18%	0.0251
Belgium	0.80%	1.71	0.64%	1.68	**1.21%**	2.92	21.83%	0.4626
France	0.43%	1.61	0.11%	0.48	**0.55%**	2.12	12.26%	0.4279
Germany	**0.69%**	1.97	0.10%	0.31	**0.83%**	2.49	16.31%	0.5293
Ireland	1.36%	1.35	0.38%	0.38	1.04%	1.03	46.75%	0.3755
Netherlands	**0.88%**	2.30	**0.85%**	2.60	**1.04%**	2.81	17.77%	0.6243
Portugal	**3.52%**	3.47	**3.07%**	2.92	**3.65%**	3.55	46.98%	1.0944
Greece	**1.86%**	2.34	**1.55%**	2.11	**2.17%**	2.73	36.75%	0.6726
Italy	0.63%	1.85	0.35%	1.07	**0.74%**	2.18	15.79%	0.4966
Spain	**0.90%**	2.70	0.59%	1.80	**1.01%**	3.04	15.50%	0.7337
EuroStoxx	0.41%	1.52	-0.16%	-0.72	**0.52%**	1.97	12.44%	0.4039

We are able to present firm evidence of a significant average excess return in five out of ten Eurozone Countries and Denmark. When we look at our three-factor model results, including the size, value, and market risk factors, we find several countries with positive and significant abnomal returns, namely Denmark, Belgium, France, Germany, the Netherlands, Portugal, Greece, Italy, Spain and the Euro stock Index, indicating strong signs of profitable betting against beta strategy opportunities within Europe. However, when we add the momentum risk factor, the statistical significance declines sharply. We are only able to prove beta arbitrage opportunities in the Netherlands, Portugal and Greece. The drop in the number of countries with statistically significant four-factor alphas can be attributed to the addition of the momentum risk factor as was presented in section 4.7, which captures a large part of variation in BAB returns.

Regarding Proposition 1 (Figures 18a-29b), when we view our three-factor model abnormal returns, we mostly find a consistent beta anomaly phenomenon throughout the Eurozone, apart from Austria and Ireland. However, when we insert the momentum-risk factor (UMD) in our beta-sorted Portfolios, our results change dramatically. That is to say, we are only able to observe a possible beta anomaly phenomenon in: Belgium, the Netherlands, Portugal, Greece, Spain, and Italy. For our beta-sorted portfolios, we have included alpha-trend lines for all the countries we examined, as well as for the Euro Index, for both the three-factor and the four-factor models, as a comprehensive illustration of our previously analyzed findings.

Finally, regarding the third proposition, our statistically insignificant findings do not allow us to make any concrete decisions. The only countries where our coefficients were in accordance with the model's theory were Germany, Italy and Austria. Once again, though, we cannot make any factual statements since, even in these countries, our results remain statistically insignificant. Hypothetically, with a larger dataset, we could make solid assumptions.

Figure 18a: Denmark - 4 factor alpha trend line

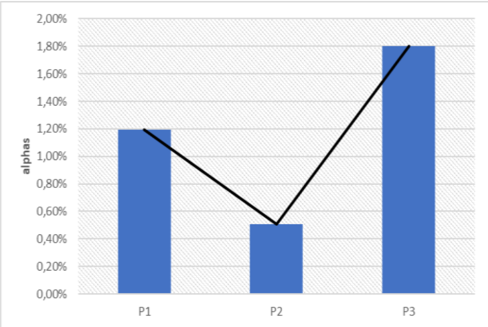


Figure 18b: Denmark - 3 factor alpha trend line

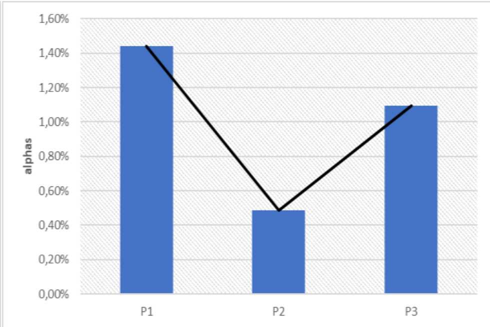


Figure 19a: Belgium - 4 factor alpha trend line

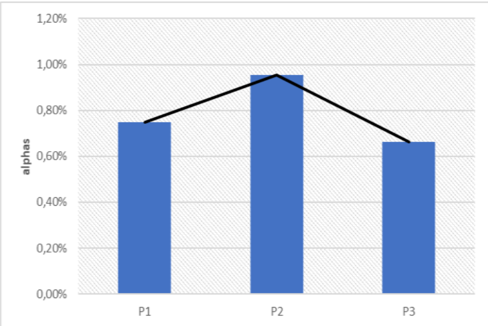


Figure 19b: Belgium - 3 factor alpha trend line

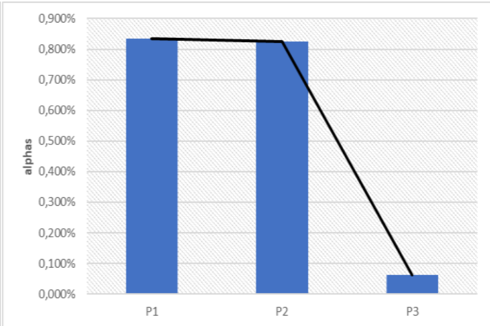


Figure 20a: Austria - 4 factor alpha trend line

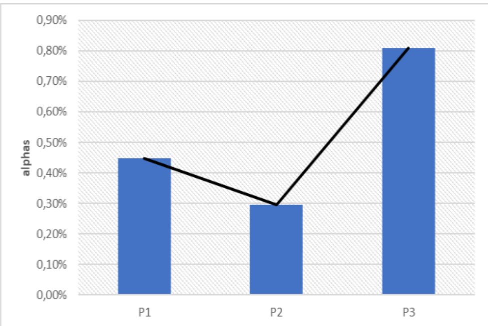


Figure 20b: Austria - 3 factor alpha trend line

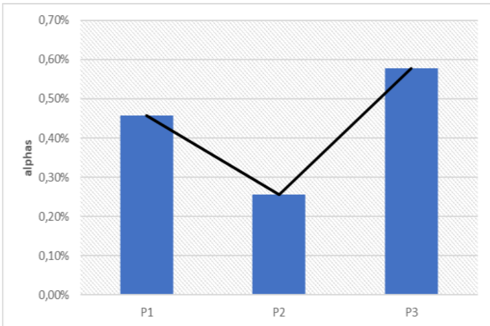


Figure 21a: France - 4 factor alpha trend line

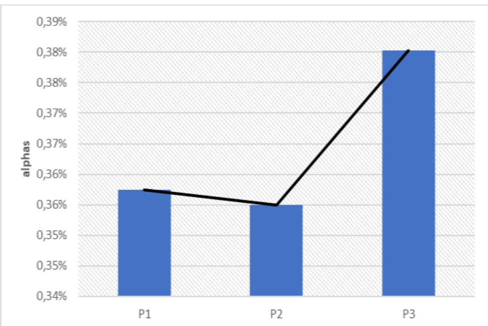


Figure 21b: France - 3 factor alpha trend line

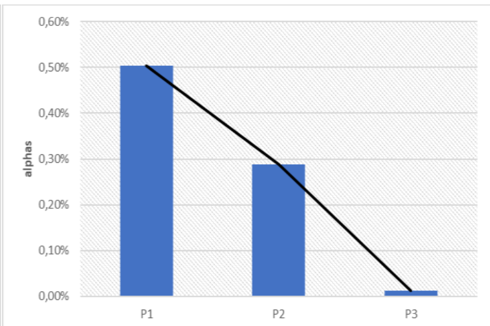


Figure 22a: Germany - 4 factor alpha trend line

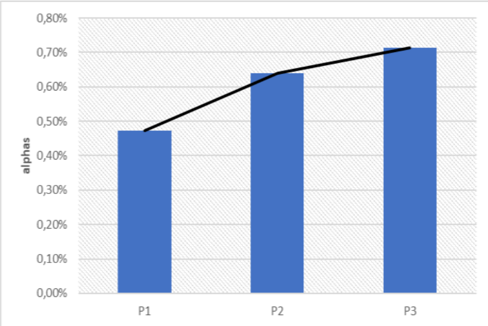


Figure 22b: Germany - 3 factor alpha trend line

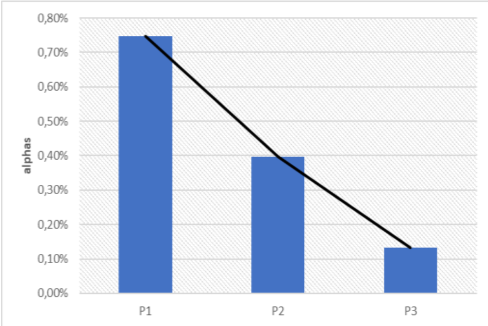


Figure 23a: The Netherlands - 4 factor alpha trend line

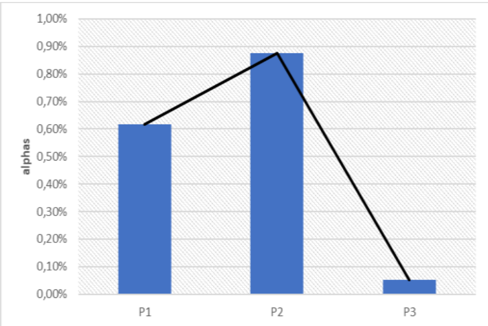


Figure 23b: The Netherlands - 3 factor alpha trend line

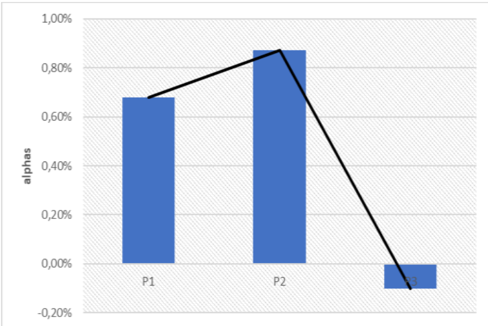


Figure 24a: Portugal - 4 factor alpha trend line

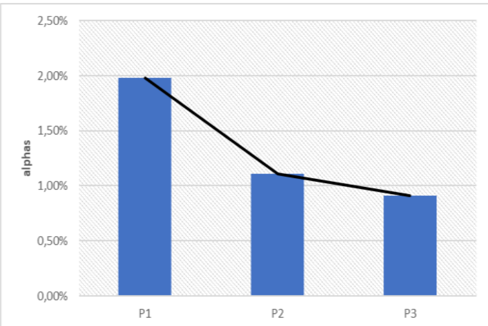


Figure 24b: Portugal - 3 factor alpha trend line

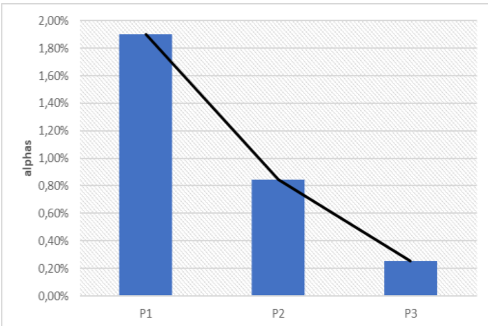


Figure 25a: Greece – 4 factor alpha trend line

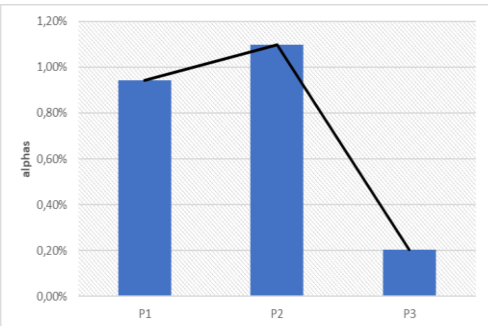


Figure 25b: Greece - 3 factor alpha trend line

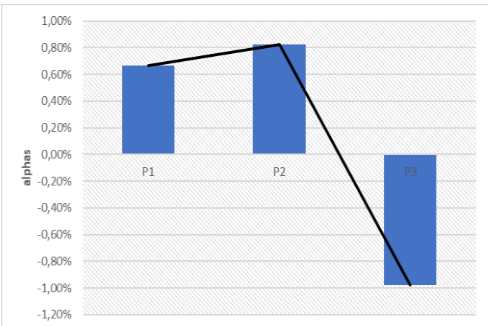


Figure 26a: Ireland - 4 factor alpha trend line

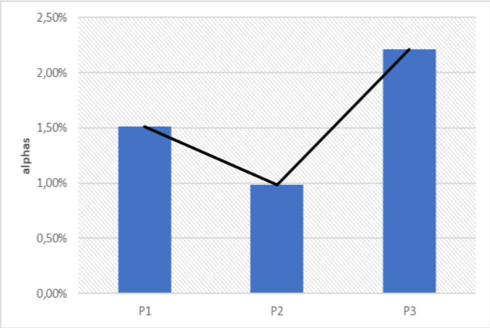


Figure 26b: Ireland - 3 factor alpha trend line

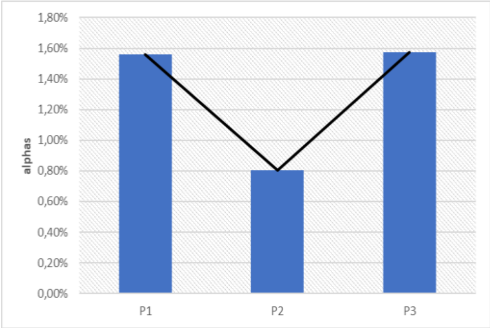


Figure 27a: Spain - 4 factor alpha trend line

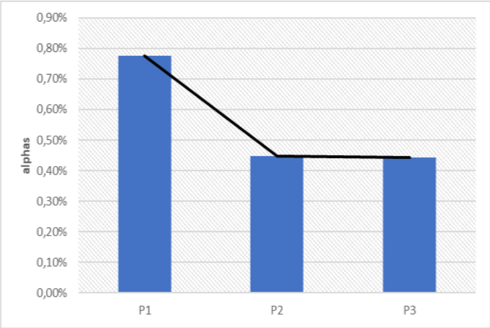


Figure 27b: Spain - 3 factor alpha trend line

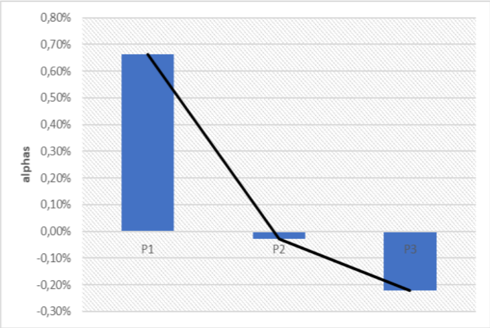


Figure 28a: Italy - 4 factor alpha trend line

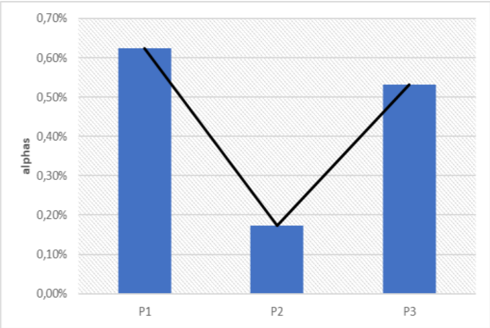


Figure 28b: Italy - 3 factor alpha trend line

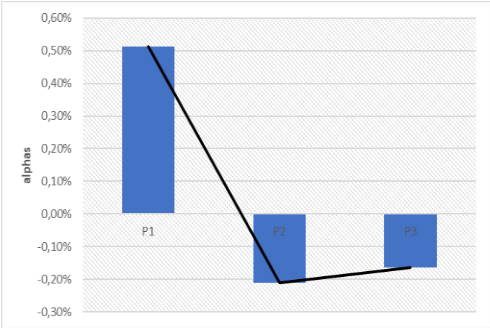


Figure 29a: EuroStoxx - 4 factor trend line

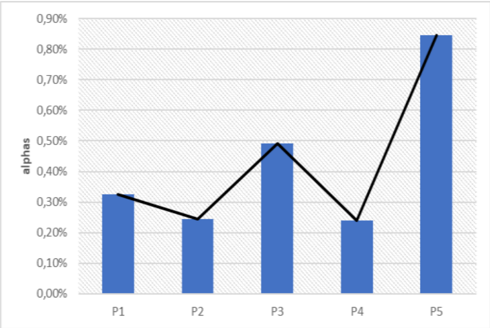
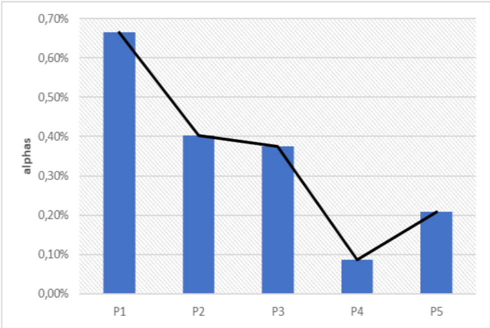


Figure 29b: EuroStoxx - 3 factor alpha trend line



5. DISCUSSION & FURTHER RESEARCH

In this section, we will try to intepret our results as cohesively as possible. We will also place them in perspective of our limitations and challenges and offer further suggestions on future empirical studies upon the beta anomaly phenomenon.

5.1 DISCUSSION

In the thorough examination that was presented, we were able to confirm the inefficiency of the CAPM to fully explain the returns of assets. We were able to find statistically significant abnormal returns in 9 countries of our dataset, and the EuroStoxx Index when we tested Betting against beta portfolios against the CAPM. Our results validate the fact that the SML is in fact flatter than the one predicted by the CAPM.

When investors are constrained on the leverage they can take, they overweigh risky assets, bidding up their prices and reducing their returns. This may create profitable arbitrage oppurtunities for unconstrained agents who can buy low beta assets using leverage and shortsell high beta assets.

In 6 countries, we confirmed the presence of beta arbitrage opportunities (also refer to figures 18a-29a). We found an increase in abnormal returns as the systematic risk of portfolios was decreasing, meaning that investors who chose to sink their capital onto low beta assets will receive greater abnormal returns than those who chose to invest in high beta/ riskier assets. Remarkably, we were also able to confirm that in all the instruments of our dataset, the risk-adjusted returns (Sharpe Ratio) of our beta sorted portfolios are declining as the systematic risk of the portfolio increases. The aforementioned finding confirms the fact that investors that are venturing capital on high beta assets are not compensated enough for the additional risk they obtain.

Along the same line, we were also able to find significant average *excess* returns in 6 countries within the subregion of Europe in which we conducted our study.

According to Proposition 2, the magnitude of the BAB excess return is dependant on the beta spread. However, we were not able to make concrete conclusions upon this, since most of our results regarding the positive relation of BAB excess return and beta spread are mostly statistically insignificant. Having said that, we see a positive tendency between the beta spread and BAB returns for Denmark, Greece, Portugal and Eurostoxx 50 so we can confirm a partial consistency with the model's theory.

Unfortunately, we were not able to provide ample outcomes for Proposition 3 either. When investors face stricter funding constarints, they must deleverage, and during such states of the economy, the BAB portfolios face contemporaneous losses. We used a European constructed TED Spread (equivalent to the 3-month Euro Libor minus the German short-term interest rate) to approximately quantify these funding conditions. Our results remained statistically insignificant throughout our study, leaving a lot of room for speculation.

As we stated under our limitations and biases section, our empirical research was subject to a couple of constraints. Firstly, our datasets were realtively long, covering the timespan of 20 years, yet rather narrow. We were able to prove similar results to those of previous literature, such as the persistence of the flatter SML and the presence of beta arbitrage opputrunities among European markets. However, it is only natural that a wider dataset would provide additional information and possibly cover the areas that we were not able to firmly confirm (BAB and beta spread relation, negative relation between BAB returns and a tightness to funding constraints).

Moreover, the survorship bias explained in section 1.2 has had an impact upon our results. Ignoring the firms that opted out of the indices, at a certain point, we collected leads to distorted conclusions. Generally, it is perceived that survivorship biases lead to overoptimistic results; however, we do not believe that this applies to our research. Since the beta of the constituent stocks within an Index were of a crucial importance throughout our empirical study, we simply cannot know how our results would have been impacted by the full knowledge of the historic lists of the Indices, simply because the systematic risk of a given asset is quite hard to correctly estimate, let alone speculate.

Lastly, we would now like to touch upon the effect that microcaps might have upon our analysis. Microcaps are firms with a small market capitalization. Each stock exchange or index sets different thresholds regarding the cutoff value, meaning the percentile under which all firms are classified as microcaps. The definition varies and usually depends on the threshold that each index sets. In general, it is recommended to control for microcaps when conducting asset pricing analyses since the inclusion of these stocks might lead to erroneous statistical significance of coefficients (Hue, Xue and Zhang, 2016). Since, in our thesis, microcaps are not excluded, the results that we report should be viewed with caution as they might be prone to the aforementioned bias.

5.2 FURTHER RESEARCH

Our results indicate that the European market shows firm signs of beta anomaly, at least within the equity market. It would be intriguing to conduct similar studies upon different asset classes, such as government and corporate bonds, or derivative products, like futures and forwards, within the Eurozone. Another interesting area of research would be a similar empirical study on different market segments. Reaseach within the Far East, the Middle East or South America will help the academia obtain a more thorough view on the phenomenon of beta anomaly within the financial world.

Under our Literature Review section, we mentioned the article of Liu, Stambaugh, & Yuan, (2018), who provided new findings for the beta anomaly phenomenon. According to their study, beta is not the nucleus characteristic driving the beta anomaly. Instead, they were able to identify that the idosyncrantic volatility (IVOL) of an asset and its correlation to its systematic risk is the factual (according to the Authors) drive behind the beta anomaly. By examining the IVOL's role in the betting against beta strategy, which we also followed in our thesis and was proposed by Frazzini & Pedersen, they concluded that the strategy's profits can be divided into two terms.

The BAB strategy buys low-beta stocks and shorts high-beta stocks, consistent with exploiting the beta anomaly. At the same time, however, the strategy takes a levered net-long position to achieve a zero beta, thereby creating a component of the BAB strategy unrelated to the beta anomaly. Consequently, the betting against beta strategy may produce positive alphas when there are no signs of beta anomaly within a market and vice versa. Even though we do not want to delve deeper into their published work, additional betting against IVOL empirical studies upon the Eurozone would be fascinating as they would likely offer informative explanations for the beta anomaly.

Last but not least, in our thesis we did not examine the effects that short selling fees and trading costs may have upon BAB performance. Short selling fees could pose a notable friction upon the BAB strategy. In addition, profitable BAB strategies could be rendered non-profitable after the substraction of trading costs. What is more, investors may find microcap equities difficult or even expensive to trade. Thus, an alternative path of research upon the beta anomaly phenomenon would be the study of the aforementioned frictions.

6. CONCLUSION & FINAL REMARKS

The Capital Asset Pricing Model assumes that all investors within a given market hold the market portfolio and use unconstrained borrowing and lending in order to match the expected return to their risk preferences. However, this is an unrealistic assumption. In the real world, not all investors have access to unrestricted leverage due to regulatory requirements or poor creditworthiness. Even when they have the option of debt financing, some agents may recoil from obtaining leverage due to personal behavioral drives. When faced with leverage constraints, agents look upon riskier assets in order to achieve the optimal risk-return relationship, causing higher beta assets' returns to decline and thereby creating a disequilibrium. Unconstrained agents may use this opportunity by resorting to debt financing in order to buy low beta assets and short high beta assets. The above mentioned exploitation of asymmetry is quoted as the betting against beta strategy.

In our Thesis, we conducted an empirical study of the Betting against Beta strategy upon a subregion of the Eurozone in an attempt to shed more light on the beta anomaly and present detailed information for each country.Our analysis extends the literature by expanding onto international equity markets that had not been investigated by (Frazzini and Pedersen 2014), while also providing detailed information about the three Propositions we examined. Following the framework developed by Frazzini & Pedersen (2014) and (in extension) Fisher Black (1972), we constructed BAB portfolios for 12 different instruments, including 10 countries within the Eurozone, a general Euro Index and Denmark, because of the adjoined connection between the Danish Krone and the Euro.

Our results are consistent with the restricted borrowing CAPM (proposed by F. Black in 1972). The intercept rises well beyond the risk free rate, for our zero beta constructed BAB portfolio, indicating a factual flatter SML than the one predicted by the traditional CAPM. Our findings further suggest that there are signs of beta anomaly within the European market implying that the beta phenomenon is not limited to a specific market segment.

Additionally, experienced investors who remain unconstrained in terms of leverage can exploit the anomaly with significant excess returns by constructing BAB portfolios that go long low beta assets and short high beta assets. Indeed, we were able to show that BAB excess returns are positive in all our datasets, with 6 countries indicating statistical significance. When examining funding shocks and the effect they may have upon BAB returns we found insignificant relationship, with the exception of Portugal and the EuroStoxx Index. However, this may be due to our limited dataset, especially when considering that the Authors presented stong and robust results.

Our study functions as a supplement for the ever growing academic research upon the beta anomaly, and serves as an extension to the international literature studying the performance of arbitrage opputrunities and evaluating them outside of the US market. The results are engaging since we were able to present that the BAB strategy can result in positive gains for sophisticated investors within the Eurozone who wish for alternate profitable strategies.

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APPENDIX

PANEL A – ALTERNATIVE CALCULATION OF BETAS RESULTS PROPOSITION 1 &2

Appendix Table 1: Regression Results - Proposition 1 & 2 Belgium;P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR. The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	**1.23%**	**1.03%**	**1.37%**	0.86%
	2.35	*3.93*	*3.55*	*1.50*
CAPM Alpha	**1.58%**	**0.80%**	**0.88%**	0.01%
	3.22	*3.49*	*3.25*	*0.05*
Three Factor Alpha	**1.57%**	**0.80%**	**0.90%**	0.03%
	3.18	*3.48*	*3.34*	*0.08*
Four Factor Alpha	**1.01%**	**0.71%**	**1.04%**	**0.62%**
	2.14	*3.02*	*3.80*	*2.46*
Beta (ex-ante)	0.00	0.54	0.75	1.04
Volatility	24.26%	12.19%	17.92%	26.65%
Sharpe Ratio	0.65	1.08	0.99	0.41

Appendix Table 2: Regression Results – Propositions 1 and 2 – Austria: P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	0.45%	**1.21%**	0.72%	1.08%
	0.89	*3.04*	*1.49*	*1.69*
CAPM Alpha	0.45%	**0.73%**	0.06%	0.20%
	0.89	*2.51*	*0.19*	*0.51*
Three Factor Alpha	0.43%	**0.82%**	0.15%	0.39%
	0.86	*2.77*	*0.50*	*1.01*
Four Factor Alpha	0.24%	**0.77%**	0.24%	0.61%
	0.50	*2.62*	*0.80*	*1.74*
Beta (ex-ante)	0.00	0.58	0.79	0.99
Volatility	23.17%	18.44%	22.43%	29.56%
Sharpe Ratio	0.24	0.84	0.40	0.47

Appendix Table 3: Regression Results – Propositions 1 and 2 – Denmark: P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	**1.23%**	**1.64%**	**1.13%**	**1.75%**
	2.20	*5.03*	*2.42*	*3.39*
CAPM Alpha	**1.46%**	**1.32%**	0.55%	**1.10%**
	2.67	*4.82*	*1.65*	*3.04*
Three Factor Alpha	**1.53%**	**1.35%**	0.57%	**1.08%**
	2.94	*5.14*	*1.74*	*3.00*
Four Factor Alpha	0.41%	**1.10%**	0.63%	**1.77%**
	0.82	*4.02*	*1.79*	*5.05*
Beta (ex-ante)	0.00	0.58	0.70	0.87
Volatility	25.86%	15.09%	21.71%	23.95%
Sharpe Ratio	0.61	1.42	0.67	0.97

Appendix Table 4: Regression Results – Propositions 1 and 2 – France: P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR. The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	0.46%	**0.94%**	**0.82%**	0.82%
	1.81	*3.42*	*2.27*	*1.58*
CAPM Alpha	**0.58%**	**0.52%**	0.26%	0.02%
	2.33	*3.75*	*1.53*	*0.08*
Three Factor Alpha	**0.59%**	**0.53%**	0.26%	0.02%
	2.33	*3.82*	*1.53*	*0.10*
Four Factor Alpha	0.15%	**0.37%**	**0.34%**	0.38%
	0.70	*2.75*	*2.01*	*1.68*
Beta (ex-ante)	0.00	0.80	1.00	1.22
Volatility	11.85%	12.71%	16.83%	23.92%
Sharpe Ratio	0.48	0.93	0.61	0.43

Appendix Table 5: Regression Results – Propositions 1 and 2 – Ireland:P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks.

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	**3.39%**	**1.47%**	**2.07%**	**2.45%**
	2.14	*3.47*	*3.48*	*2.82*
CAPM Alpha	2.60%	**1.06%**	**1.44%**	**1.53%**
	1.69	*2.97*	*3.01*	*2.19*
Three Factor Alpha	2.42%	**1.06%**	**1.34%**	**1.55%**
	1.59	*3.03*	*2.85*	*2.23*
Four Factor Alpha	1.67%	**1.05%**	**1.48%**	**2.19%**
	1.10	*2.96*	*3.11*	*3.41*
Beta (ex-ante)	0.00	0.26	0.50	0.88
Volatility	73.48%	19.55%	27.60%	40.34%
Sharpe Ratio	0.67	0.98	1.01	0.84

Appendix Table 6: Regression Results – Propositions 1 and 2 – Germany: P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR. The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	**0.78%**	**1.16%**	**1.04%**	0.88%
	2.19	*3.92*	*2.53*	*1.59*
CAPM Alpha	**0.96%**	**0.75%**	**0.41%**	0.06%
	2.78	*4.15*	*2.05*	*0.19*
Three Factor Alpha	**0.91%**	**0.75%**	**0.42%**	0.11%
	2.69	*4.14*	*2.34*	*0.38*
Four Factor Alpha	0.15%	**0.48%**	**0.66%**	**0.69%**
	0.49	*2.65*	*3.60*	*2.61*
Beta (ex-ante)	0.00	0.76	0.95	1.13
Volatility	16.46%	13.73%	19.02%	25.78%
Sharpe Ratio	0.59	1.08	0.69	0.43

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Appendix Table 7: Regression Results – Propositions 1 and 2 – Netherlands: P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR. The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	**1.00%**	**1.09%**	**1.35%**	0.80%
	2.53	*3.52*	*3.27*	*1.45*
CAPM Alpha	**1.13%**	**0.69%**	**0.76%**	-0.03%
	2.89	*3.26*	*3.14*	*-0.12*
Three Factor Alpha	**1.11%**	**0.68%**	**0.79%**	-0.03%
	2.85	*3.21*	*3.34*	*-0.10*
Four Factor Alpha	**0.92%**	**0.62%**	**0.79%**	0.13%
	2.63	*3.01*	*3.32*	*0.55*
Beta (ex-ante)	0.00	0.69	0.88	1.17
Volatility	18.31%	14.31%	19.10%	25.75%
Sharpe Ratio	0.69	0.97	0.91	0.39

Appendix Table 8: Regression Results – Propositions 1 and 2 – Italy: P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR. The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	**0.76%**	**0.95%**	0.44%	0.80%
	2.24	*2.89*	*0.89*	*1.38*
CAPM Alpha	**0.89%**	**0.52%**	-0.26%	-0.02%
	2.64	*2.35*	*-0.89*	*-0.06*
Three Factor Alpha	**0.91%**	**0.52%**	-0.31%	-0.06%
	2.73	*2.34*	*-1.10*	*-0.19*
Four Factor Alpha	0.55%	**0.60%**	0.17%	0.55%
	1.69	*2.68*	*0.69*	*1.94*
Beta (ex-ante)	0.00	0.77	1.02	1.21
Volatility	15.70%	15.26%	23.04%	26.88%
Sharpe Ratio	0.60	0.79	0.24	0.37

Appendix Table 9: Regression Results – Propositions 1 and 2 – Portugal: P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR. The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	***6.45%***	***1.76%***	***1.99%***	*0.82%*
	3.56	*4.38*	*3.19*	*1.38*
CAPM Alpha	***6.09%***	***1.46%***	***1.51%***	*0.17%*
	3.34	*3.97*	*2.66*	*0.36*
Three Factor Alpha	***6.03%***	***1.42%***	***1.49%***	*0.11%*
	3.30	*3.92*	*2.61*	*0.23*
Four Factor Alpha	***5.59%***	***1.59%***	***1.76%***	*0.66%*
	2.96	*4.27*	*3.01*	*1.48*
Beta (ex-ante)	0.00	0.26	0.56	0.77
Volatility	83.98%	18.58%	28.94%	27.45%
Sharpe Ratio	1.33	1.25	0.92	0.37

Appendix Table 10: Regression Results – Propositions 1 and 2 – Spain; P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR. The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	**1.06%**	**1.24%**	0.43%	0.60%
	3.15	*3.83*	*0.97*	*1.11*
CAPM Alpha	**1.19%**	**0.84%**	-0.16%	-0.16%
	3.59	*3.59*	*-0.57*	*-0.50*
Three Factor Alpha	**1.19%**	**0.82%**	-0.20%	-0.19%
	3.58	*3.58*	*-0.75*	*-0.61*
Four Factor Alpha	**0.70%**	**0.85%**	**0.33%**	0.49%
	2.18	*3.57*	*1.39*	*1.85*
Beta (ex-ante)	0.00	0.72	0.91	1.11
Volatility	15.57%	14.97%	20.44%	24.94%
Sharpe Ratio	0.87	1.06	0.26	0.30

Appendix Table 11: Regression Results – Propositions 1 and 2 – Greece: P1,P2,P3 represent three beta sorted portfolios with P3 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR . The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

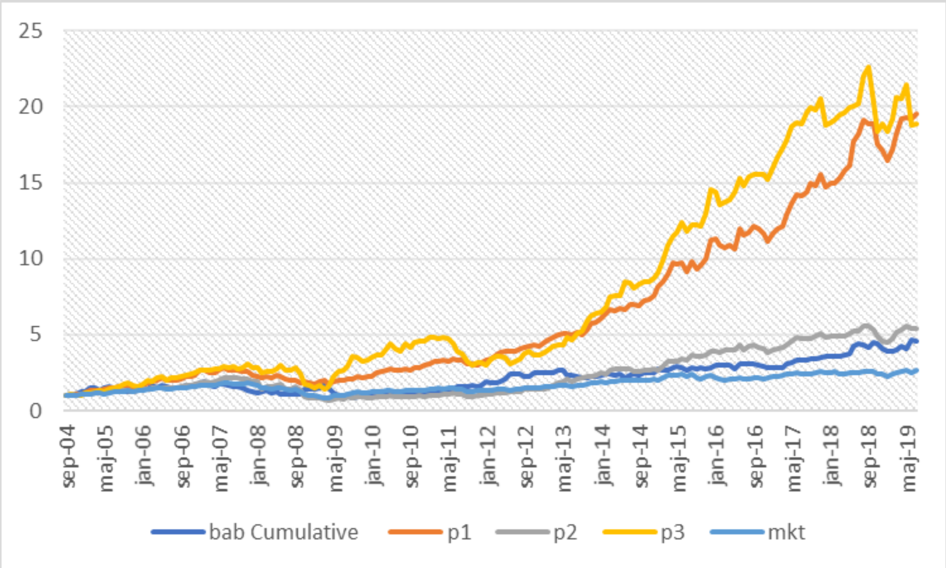
Portfolio	BAB	P1 (Low)	P2	P3 (High)
Excess Return	**2.06%**	**1.41%**	1.00%	0.18%
	2.52	*2.44*	*1.31*	*0.15*
CAPM Alpha	**2.16%**	0.81%	0.25%	-0.88%
	2.63	*1.72*	*0.38*	*-0.86*
Three Factor Alpha	**2.35%**	**0.94%**	0.49%	-0.92%
	2.86	*2.35*	*1.06*	*-1.04*
Four Factor Alpha	**1.77%**	**1.17%**	**0.89%**	0.19%
	2.29	*3.01*	*2.14*	*0.28*
Beta (ex-ante)	0.00	0.69	0.88	1.10
Volatility	37.85%	26.80%	35.52%	54.51%
Sharpe Ratio	0.73	0.68	0.36	0.04

Appendix Table 12: Regression Results – Propositions 1 and 2 – Eurostoxx: P1,P2,P3,P4,P5 represent five beta sorted portfolios with P5 consisting with assets that have the most systematic risk. Excess Returns are calculated on top of a 3 month short term interset rate, alphas are monthly abnormal returns,5% statistical significance is indicated in bold, volatilities and Sharpe Ratios are annualized.All Returns are in EUR. The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks

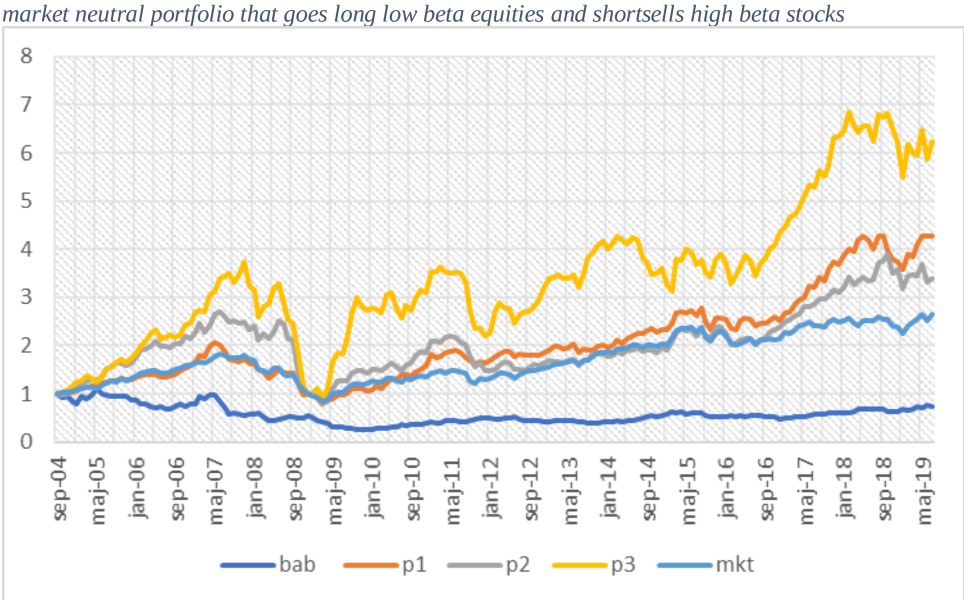
Portfolio	BAB	P1 (Low)	P2	P3	P4	P5 (High)
Excess Return	0.50%	**0.96%**	**0.92%**	**0.96%**	0.72%	1.02%
	1.88	*3.64*	*2.99*	*2.68*	*1.85*	*1.87*
CAPM Alpha	**0.61%**	**0.59%**	**0.46%**	**0.40%**	0.10%	0.21%
	2.34	*3.68*	*2.83*	*2.37*	*0.61*	*0.72*
Three Factor Alpha	**0.60%**	**0.59%**	**0.47%**	**0.38%**	0.09%	0.20%
	2.31	*3.61*	*3.13*	*2.32*	*0.55*	*0.71*
Four Factor Alpha	-0.06%	0.26%	0.30%	**0.52%**	0.23%	**0.84%**
	-0.28	*1.73*	*1.96*	*3.01*	*1.33*	*3.25*
Beta (ex-ante)	0.00	0.75	0.87	0.97	1.07	1.24
Volatility	12.21%	12.26%	14.28%	16.54%	17.95%	25.37%
Sharpe Ratio	0.50	0.99	0.81	0.73	0.50	0.51

PANEL B – CUMULATIVE RETURNS FOR BAB, MARKET AND BETA SORTED PORTFOLIOS

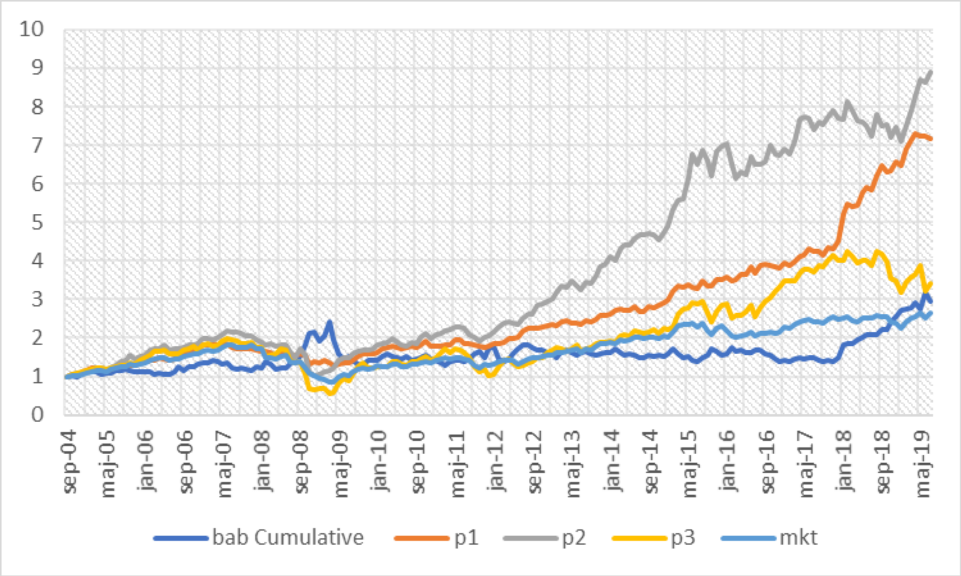
Appendix Figure 1 Cumulative BAB ,Market and beta sorted portfolio performance for Denmark:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



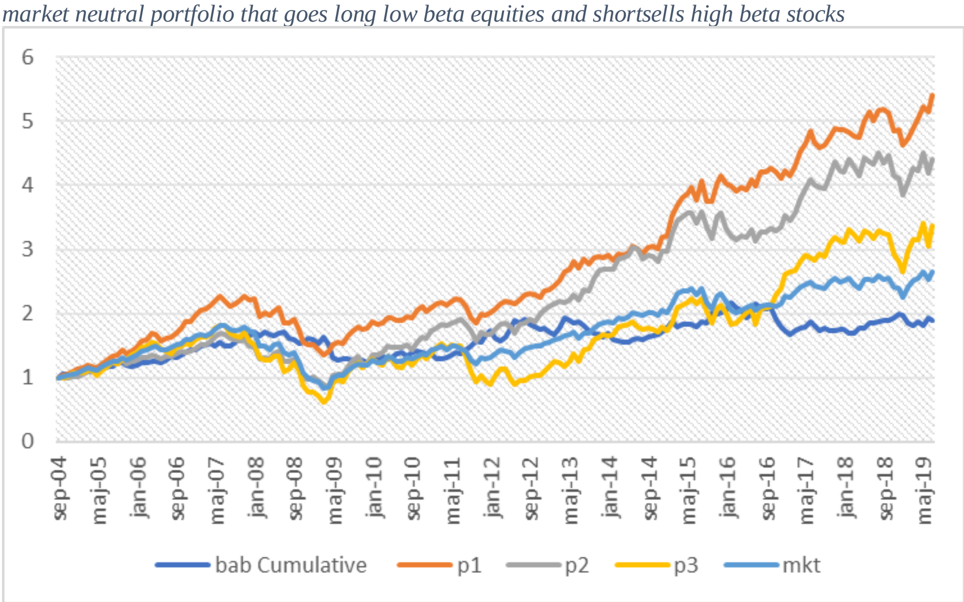
Appendix Figure 2 Cumulative BAB ,Market and beta sorted portfolio performance for Austria:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



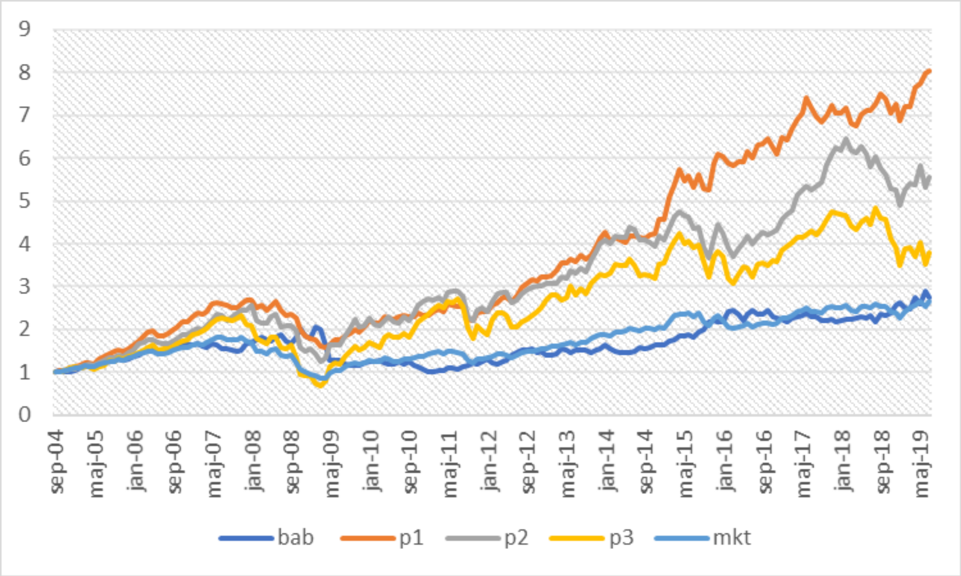
Appendix Figure 3 Cumulative BAB ,Market and beta sorted portfolio performance for Belgium:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



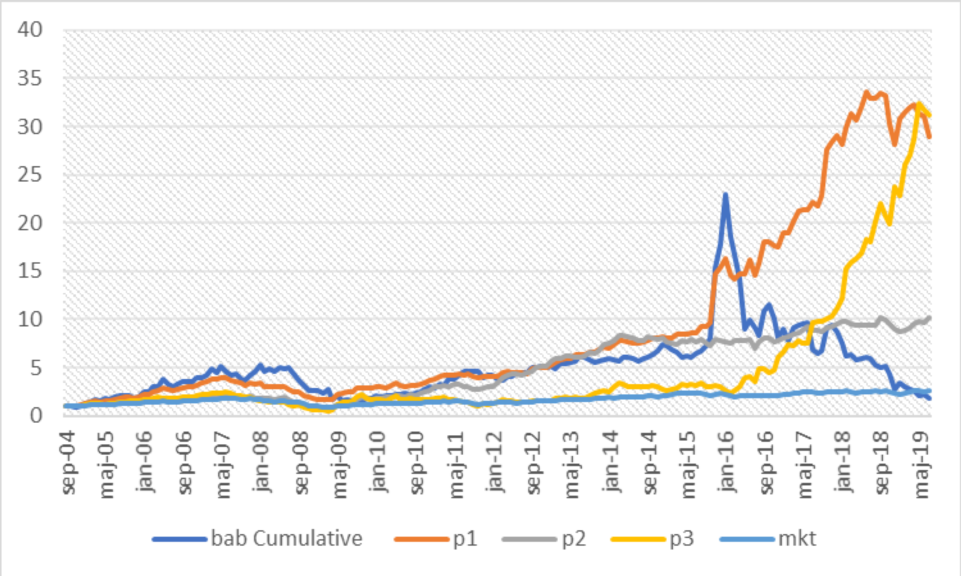
Appendix Figure 4 Cumulative BAB ,Market and beta sorted portfolio performance for France:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



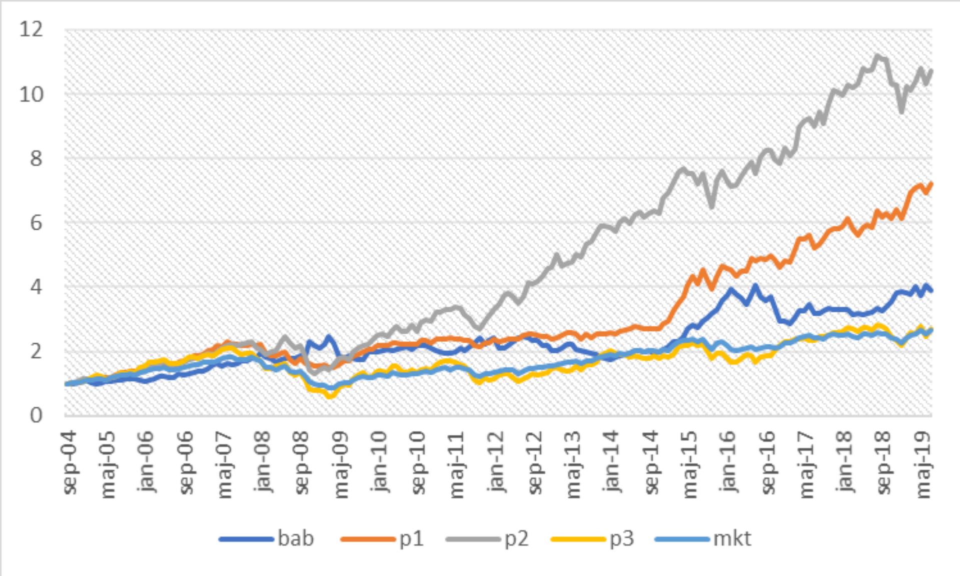
Appendix Figure 5 Cumulative BAB ,Market and beta sorted portfolio performance for Germany:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



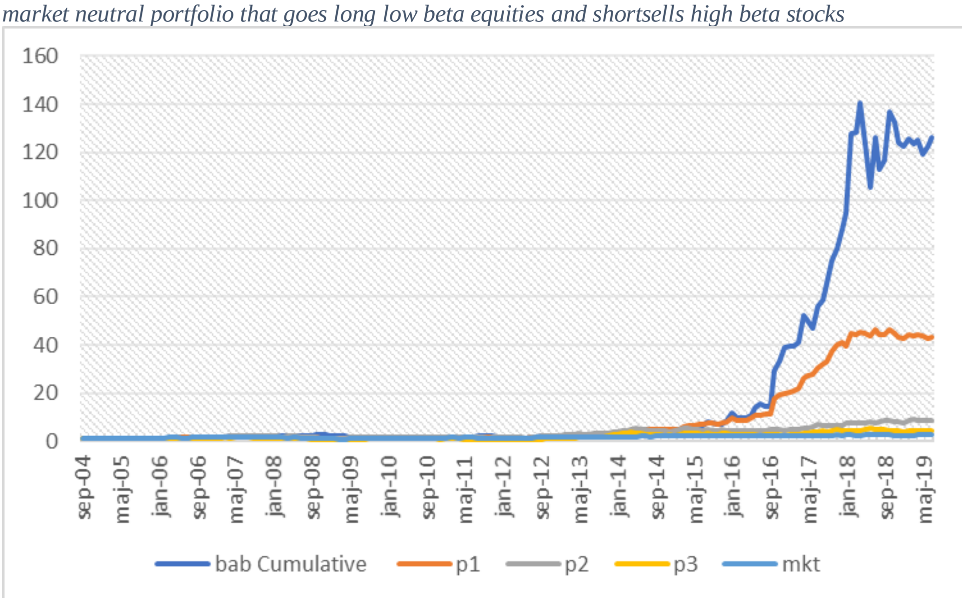
Appendix Figure 6 Cumulative BAB ,Market and beta sorted portfolio performance for Ireland:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



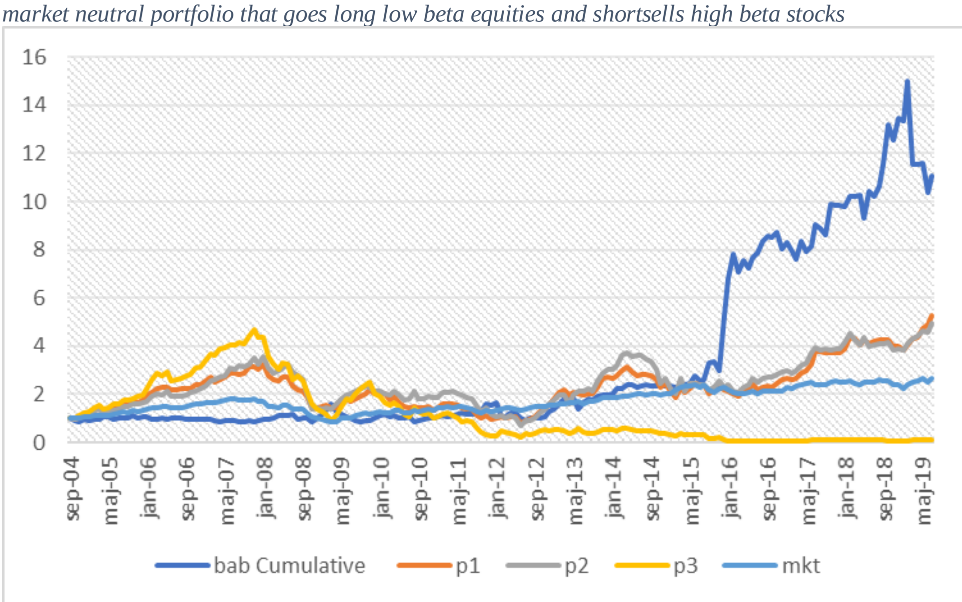
Appendix Figure 7 Cumulative BAB ,Market and beta sorted portfolio performance for the Netherlands:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



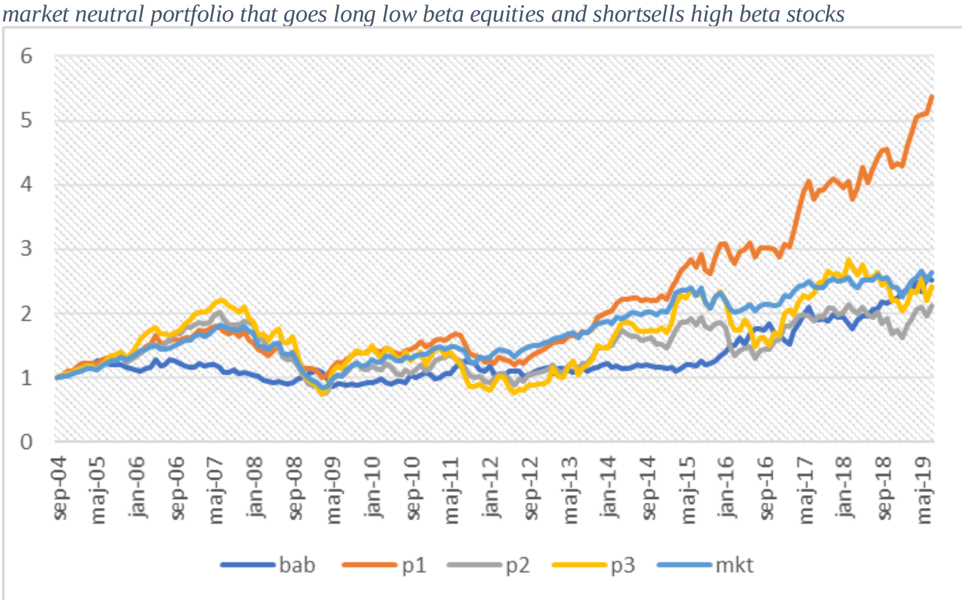
Appendix Figure 8 Cumulative BAB ,Market and beta sorted portfolio performance for Portugal:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



Appendix Figure 9 Cumulative BAB ,Market and beta sorted portfolio performance for Greece:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



Appendix Figure 10 Cumulative BAB ,Market and beta sorted portfolio performance for Italy:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



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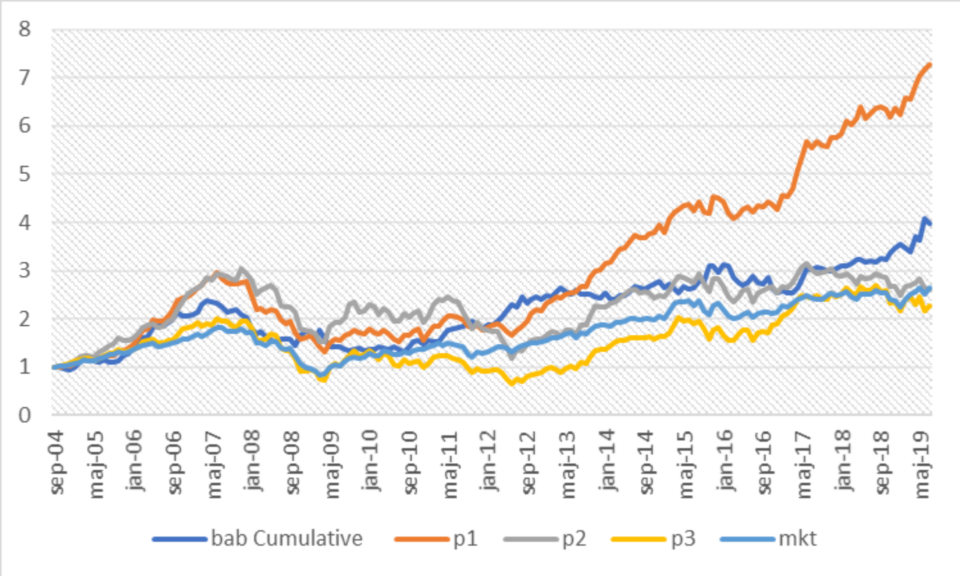
Appendix Figure 11 Cumulative BAB ,Market and beta sorted portfolio performance for Spain:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P3 are the three beta sorted portfolios with P1 containing low beta assets and P3 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks



Appendix Figure 12 Cumulative BAB ,Market and beta sorted portfolio performance for EuroStoxx50:The figure shows the growth of 1 EUR invested in each portfolio starting from 09/2004 until 07/2019. All variables are in monthly frequency.P1-P5 are the three beta sorted portfolios with P1 containing low beta assets and P5 containing high beta assets .The BAB portfolio is the self financing market neutral portfolio that goes long low beta equities and shortsells high beta stocks