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DYNAMIC RETURNS OF BETA ARBITRAGE

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Abstract

This thesis studies the patterns of the abnormal returns of the beta strategy. The topic can be helpful for professional investors, who intend to achieve a better performance in their portfolios. Following the methodology of Lou, Polk, & Huang (2016), the *COBAR* measure is computed in order to determine the levels of beta arbitrage in the market in each point in time. It is argued that beta arbitrage activity can have impact on the returns of the beta strategy. In fact, it is demonstrated that for very high levels of arbitrage in the market, the abnormal returns become negative.

Keywords: Beta Strategy, Arbitrage, Anomaly, COBAR

1. Introduction

The linear relationship between beta and return developed by Sharpe (1964) and Lintner (1965) described in the CAPM was thrown apart by several contemporary authors who disagree that beta is the only risk factor explaining securities' returns. Black (1972) was the first in line with the study of the beta anomaly. He was able to find empirical evidence that the security market line presented in the CAPM was too flat on average. Other authors added that the empirical results were particularly evident in periods of high expected *Inflation*, shown by Cohen, Polk & Vuolteenaho (2005), high *Disagreement* of investors regarding the expected return of the market, publicized by Hong & Sraer (2014), and investors' *Sentiment*, demonstrated by Antoniou, Doukas & Subrahmanyam (2013).

The impact on asset prices by arbitrageurs has been a long discussion, started by Keynes (1936) and Hayek (1945). It has been argued that arbitrage activity can contribute to market efficiency, defended by Friedman (1966). Others, such as Stein J. C. (1987), argued that it can have the opposite effect and push the prices away from their fundamentals. A third perspective defended by Lakonishok, Shleifer, & Vishny (1992) claims that the market is composed of investors with different views and goals that come together and offset each other. The aim of this thesis is to understand the role of arbitrage activity in the returns of investors who pursue beta arbitrage. Measuring such activity has been proved to be challenging, but recently Lou & Polk (2014), inspired by the comovement of stock prices presenting specific characteristics showed by Barberis & Shleifer (2003), developed the Comomentum which measures the outcome of the arbitrage process, by observing the correlation of price impacts. The principle behind this measure is the following: when arbitrageurs take a position on assets, their trades can have simultaneous impacts on prices, causing the returns to commove.

Lou, Polk, & Huang (2016) continued their previous study (Lou & Polk (2014)) to develop the measure *COBAR* for the comovement of stocks in the beta strategy. High (low) values of *COBAR* identify high (low) amounts invested in beta strategy. The aim of this thesis is to further develop the study of the *COBAR* measure, following and questioning the methodology used by Lou, Polk, & Huang (2016), and to better understand the impacts of arbitrage on the returns of the beta strategy.

In the first part of the thesis, the *COBAR* measure of Lou, Polk, & Huang (2016) is replicated. Additionally, the computation of *COBAR* is performed under different specifications, with the aim of understanding which specification of *COBAR* can measure beta arbitrage activity more accurately. The specifications are related to the Asset Price Model defined for the estimation of residuals, the decile of stocks used for the calculation of the measure and the exclusion of penny stocks from the sample.

In the second part of the thesis, the main findings of Lou, Polk, & Huang (2016) are questioned: when levels of beta-arbitrage are low, the returns of the strategy take longer to be realized and when the levels are higher, the returns are collected in a shorter term. When arbitrage activity is more crowded (measured by the 20% of the sample with higher values of *COBAR*) the abnormal returns of the strategy are recognized within the first six months. On the contrary, when arbitrage activity is low (measured by the 20% of the sample with higher values of *COBAR*), the returns take around 3 years to materialize. An understanding of what happens to the returns of the strategies after the 3 years period (until 5 years) will be added with the goal of having a long-run perspective of the relations explained above. The returns are created using the CAPM, 3 factors-, 4 factors-, 5 factors- and 6 factors Model to ensure consistency in the results observed.

In order to scrutinize the topic with more detail, some empirical evidence showed by Lou, Polk, & Huang (2016) will be tested. In particular, it is hypothesized that all else equal, the behavior of the beta strategy returns described above is more pronounced in the presence of relatively more leveraged stocks. The betting against beta strategy described by Frazzini & Pedersen (2014) can be associated with positive-feedback trading. In fact, as it has been characterized, it is difficult for investors to know how much beta arbitrage is being performed in the market. If an investor bets successfully on low-beta stocks, the price of the stock will rise. If the stock belongs to a company with relatively high levels of leverage, the increase in the price will cause the beta of the security to decrease even more. The leverage consideration is defined by Proposition II of Modigliani & Miller (1958). It claims that the variation in the leverage of companies causes their associated betas to change. As a result, if a lot of investors pursue the same set of stocks, arbitrageurs will be reinforcing the low-beta strategy signal with their collective bets on stocks: they may be crowding the market in the moments when there is a larger volume of arbitrage, contributing to lower returns of the strategy. Therefore, it will be tested whether the cross-sectional spread in betas increases when *COBAR* is high (high volume of arbitrage) as well as whether this spread is larger in the presence of relatively more leveraged stocks.

The thesis follows the approach of Lou, Polk, & Huang (2016). Henceforth, throughout the rest of it, this paper will be denominated by “main paper”. The thesis confirmed that the construction of *COBAR* as defined in the main paper is the best proxy of the beta strategy arbitrage in each point in time. Secondly, in order to extend the analysis to the most recent years, the used sample covers stocks from 1970 until 2015 while in the main paper’s sample includes only until 2010. When analyzing the relations between abnormal returns and the level of beta-arbitrage activity in the market with the extended sample, the conclusions were different from the ones drawn from the main paper. In fact, for periods with very high levels of *COBAR*, the abnormal returns (independently of the holding period considered) are always negative. Finally, the consideration of more leveraged stocks in the sample included in the beta strategy implying the cross-sectional beta spread to be wider in periods identified with higher values of *COBAR* can not be confirmed.

This topic is relevant in light of the field of market anomalies, what their causes are and how investors should take advantage of them. If investors were able to understand when there are moments of higher arbitrage activity (measured by the *COBAR*), which is information that is not publicly available, they could adequately set the timing of their beta strategies and particularly what type of stocks in which the strategy could result in higher abnormal returns.

The remainder of the study proceeds as follows. Section II reviews the existing literature on the explanations of the low-beta anomaly. Section III describes the data and presents the methodology used. Section IV contains the empirical results and its discussion. Finally, section V provides a conclusion.

2. Literature Review

According to Sharpe (1964) and Lintner (1965), the expected return of a security is equal to the risk-free rate plus a market risk-premium. The risk-return tradeoff is then represented by the CAPM, with the expected return having a linear relationship with the market beta. Later on, this pioneering approach of modeling asset prices based on risk was questioned by many experts.

Black, Jensen, & Scholes (1972) showed that the excess returns of high beta assets were lower and the excess returns of low beta assets were higher than what CAPM predicts. Afterward, Haugen & Heins (1975) found empirical evidence that, by using the U.S. equity market, the relation between returns and beta is flatter than what CAPM predicts. Following this line of study, Fama & French (1992) showed that there are other risks factors besides the market beta (such as size and book-to-market equity), which can explain the returns of stocks. With this study, the author confirmed that the relation between U.S. stocks and beta was flat during the period of 1963 – 1990. Blitz & Vliet (2007), and Blitz, Pang, & Villet (2012), Baker, Bradley, & Taliaferro (2013) showed that the low-beta anomaly is expandable to other markets besides the U.S. and in particular to emerging markets.

It was revealed important to find explanations for the low-beta anomaly and to understand how investors react towards it. Black (1972) relaxed the free borrowing and lending assumption of CAPM and developed a two-factor model that better explains the stocks' expected returns. Building on this, Frazzini & Pedersen (2014) found that investors, such as individuals, pension funds, and mutual funds overweight risky securities (high-beta securities) due to leverage constraints and as a result of higher demand causing them to gain lower returns than what CAPM predicts.

The study of the beta-anomaly was further developed by other authors. Based on the hypothesis formulated by Modigliani & Cohn (1979), which says that investors suffer from money illusion represented by discounting real cash flows with nominal discount rates, Cohen, Polk, & Vuolteenaho (2005) showed that in periods of high *Inflation*, the compensation for one unit of beta among stocks is larger and the security market line steeper than the rationally expected equity premium. These authors have empirically demonstrated that excess intercept (in relation to CAPM) of the security market line comoves positively and the excess slope (in relation to CAPM) negatively comoves with *Inflation*. The results, also in line with the study from Campbell & Vuolteenaho (2004), show that stocks are undervalued when *Inflation* is high and overvalued when *Inflation* is low.

Miller (1977) put in question the CAPM assumption of homothetic expectations, arguing that investors disagree on the expected return of the market portfolio. Building on this theory, Hong & Sraer (2014) show that when aggregate *Disagreement* about the common factor of firms' cash flows is high, high beta assets are over-priced compared to low beta ones. In the presence of short-sale constraints, pessimistic investors do not want to hold high-beta stocks (riskier) causing high-beta stocks to be more sensitive to the *Disagreement* factor. In light of the cumulative prospect theory depth by Barberis & Huang (2008), Bali, Cakici, & Whitelaw (2011) observe that investors have a preference for lottery-like stocks. They identify these stocks as low-priced stocks with high idiosyncratic volatility and high idiosyncratic skewness. Furthermore, Kumar (2009) argues that individuals, rather than institutional investors, are more likely to have such preferences and Antoniou, Doukas, & Subrahmanyam (2013) create a *Sentiment* variable that relates asset returns variations with optimistic and pessimistic periods. As carried out above, existing literature demonstrated empirical evidence and explanations for the phenomena that high-risk stocks underperform low-risk stocks.

This thesis, following closely Lou & Polk (2014) and Lou, Polk, & Huang (2016), aims to explain why professional investors who are aware of the existence of the low beta anomaly and are able to take on leverage and short selling at relatively low costs, do not take advantage of it, driving the market back to its equilibrium. Indeed, professional investors perform the beta strategy by buying low-beta stocks and selling high-beta stocks, but the returns of the strategy are not constant throughout time. The main paper presents a possible explanation in line with Hugonnier & Prieto (2015). The amount of capital invested in such strategy varies over time and investors cannot properly identify which periods have high activity on the strategy. This causes the security market line to be too flat in periods of low arbitrage activity and too steep in periods of high arbitrage activity.

The main difficulty of all studies is to measure beta arbitrage activity. While other anomalies, as size and value, arbitrage activity (Cohen, Polk, & Vuolteenaho (2005)) as well as mispricing of ADR (Stein J. (2009)) are more easily identified, the beta arbitrage does not have an obvious mechanism to measure. Lou, Polk, & Huang (2016) developed the *COBAR* measure which overcomes this issue being shown as a robust measure for beta arbitrage, grounded on the idea of return's comovements. The measure is based on the previous study of Barberis, Shleifer, & Wurgler (2005) in which return's comovements can be explained by correlations in news about the fundamental value of securities and by correlated investor demand shifts for securities.

3. Data and Methodology

Data

The stocks' returns were extracted from the Center for Research in Security Prices (CRSP), in particular, all common stocks listed on the NYSE from the beginning of 1970 until the end of 2015. The analysis starts in 1970, the year in which the low-beta anomaly was recognized by academics for the very first time. The factors to be included in the Asset Pricing Models – excess market return, size, value, momentum, profitability and investment – and the risk-free rate were obtained from the Kenneth R. French Data Library.

A list of variables that have been shown to predict future beta-arbitrage strategy returns was added: the expected *Inflation* index presented by Cohen, Polk, & Vuolteenaho (2005) which can be computed by calculating the exponential moving average CPI growth rate in the previous 100 months – obtained from the US. Bureau of Labor Statistics; the *Sentiment* index presented by Baker & Wurgler (2007) – obtained from the authors' Webpage; and the *Ted Spread* presented by Frazzini & Pedersen (2014) that can be calculated by making the difference between the LIBOR rate and the US Treasury bill rate – obtained from the US. Bureau of Labor Statistics.

To compute additional variables, the Book Debt to Equity ratio and the Book to Market ratio of each stock were extracted from the WRDS database.

The Data was treated in Matlab, controlling for entry and exit of stocks from NYSE, missing data in sample and outliers.

COBAR Measure

The *COBAR* Measure was computed in Matlab and it was used to access the level of arbitrage in the market. A brief description of its computation is presented below.

Firstly, the stocks are sorted into deciles at the last trading day of each month, based on the pre-ranking beta estimated for each. The pre-ranking betas are calculated using the daily returns of the prior twelve months. Five lags of the excess market return plus the actual excess market return are included in the regression to control for illiquidity and non-synchronous trading. The beta is then the sum of the six coefficients estimated under OLS. To compute the pairwise partial correlation among stocks, 52 weekly returns are used. To eliminate possible comovements among stocks originated by the known risk factors, the computation of the correlations is controlled for the three factors of Fama and French. By definition, *COBAR* is the average of the correlations previously computed in the lowest beta decile:

$$COBAR = \frac{1}{N}\sum_{i=1}^{N} partialCorr(retrf_i^L, retrf_{-i}^L \middle| mktrf, smb, hml)$$

The correlation of the 3-factors residual of each stock ($retrf_i^L$) with the 3-factor residual of the portfolio composed by all the other stocks in low beta decile ($retrf_{-i}^L$) is computed. The process is repeated for all stocks in the low beta decile. *COBAR* at time *t* is the average of all these correlations. For each month, the process is repeated so that in the end one value of *COBAR* per month is obtained for the whole sample.

The lowest beta decile is used since the stocks that belong to it are, in general, larger, more liquid and have lower idiosyncratic volatility. Thus, according to the main paper, the measure will be less impacted by asynchronous trading and measurement noise.

In this section, it was intended to elaborate a comparison between *COBAR* and other known arbitrage measures: aggregate institutional ownership (Inst Own) of the lowest beta decile and assets under management (AUM) of long-short equity hedge funds. These variables are considered proxies of arbitrage activity as they represent the typical arbitrage type of investors. The goal of this analysis was to understand whether *COBAR* could be considered a good proxy of beta-strategy arbitrage. As the variables were not possible to be computed, the analysis could no longer be performed.

To assess the *COBAR* measure, the *Inflation*, and *Sentiment* indices, as well as the Ted Spread defined above, were included, as they can have forecasting power over abnormal returns of the beta strategy.

Hypothesis 1: in high *COBAR* periods, returns realize after 6 months; in low *COBAR* periods returns realize after 2 to 3 years. What is the pattern for longer investment horizons?

After measuring *COBAR*, the beta strategy was computed: it consists of a zero-cost portfolio that shorts the value-weight portfolio in the highest market beta decile and longs the value-weight portfolio composed by the lowest market beta decile. The cumulative abnormal returns of the long-short portfolio are registered for the period under analysis: short-term (1, 3 and 6 months), medium term (1, 2 and 3 years) and long-term (4 and 5 years). This analysis is performed for the 5 quintiles of *COBAR*. The returns are adjusted for CAPM, for the three factors (market risk, size and value defined by Fama & French (1993), for the four factors (momentum defined by Carhart (1997)), and also for the five and six factors (profitability and investment defined by Fama & French (2014)).

Hypothesis 2: The dynamic behavior of the beta arbitrage returns stated above is more pronounced for leveraged stocks.

In this section, the relation between *Beta Spread* and *Leverage* of the stocks is further developed. The *Beta spread* is the dependent variable of the regression, and it is represented by the beta spread between the high-beta decile and low-beta decile in year t+1, ranked in year t. *Leverage* is the independent variable represented by a quintile dummy variable computed by averaging the value-weighted book leverage of the high and low-beta deciles. Lagged *COBAR* and the beta in time t are also included as independent variables in the regression.

The regressions are computed using Newey-West standard errors, parameterized with 12 legs to account for the serial correlation existing in variables. The values in bold in the regressions are significant at a 5% significance level, the variables with *** are significant at a 10% significance level, and the variables with ** are significant at a 15% significance level. The t-stats are the values below each estimate in the regressions. In the correlation matrixes, the p-values are stated below the coefficients.

4. Empirical Results

4.1 COBAR

Firstly, different specifications in building the arbitrage measure *COBAR* are compared with the ones proposed by the main paper. The correlation between the different specifications is measured to conclude which ones lead to similar results.

Additionally to the specification proposed by the main paper, *COBAR* based on the 5^{th} and 10^{th} decile of the beta of stocks is computed. One can expect Decile 5 *COBAR*, that is included as a check against the extreme deciles, to show little correlation with the other specifications, but as it can be seen in Table I.A it has a correlation of 0,5622 with Decile 1 *COBAR*. On the other hand, Decile 5 *COBAR* presents a correlation of 0,1378 with the Decile 10 *COBAR*. The correlation between Decile 1 and Decile 10 is only 0,1262. It can then be concluded that the results of the abnormal returns of the beta strategy will be different if *COBAR* is used based on 1^{st} decile or on 10^{th} decile. In this thesis it was chosen to build the *COBAR* measure with the 10^{th} decile because it can be capturing the trend not only of the long-short strategy but also of the long-only strategy, which, in general, is easier to implement.

	COBAR 1	COBAR 5	COBAR 10
COBAR 1	1		
COBAR 5	**0,5622**	1	
	0,0000		
COBAR 10	**0,1262**	**0,1378**	1
	0,0033	0,0013	

Table I.A - COBAR with different deciles of beta's stocks

COBAR is then computed using the entire sample and a sample that excludes penny stocks (stocks priced below $5). As it can be observed in Table I.B, the correlation between the two specifications is significantly high, 0,9854. For further research, *COBAR* was computed using the entire sample since excluding penny stocks is not expected to produce very different abnormal returns.

	COBAR	COBAR np
COBAR	1	
COBAR np	**0,9854**	1
	0,0000	

Table I.B - COBAR without penny stocks (<5$)

COBAR is computed based on the 3-factor and on the 6-factor model. As it can be observed in Table I.C, the two specifications are highly correlated (0,9907). It can be concluded that adjusting the measure for the 6-factor model will result in similar outcomes as compared to the usage of the 3-factor model. The main paper approach will be followed and the *COBAR* based on 3-factor model will be used.

	COBAR	COBAR 6f
COBAR	1	
COBAR 6f	**0,9907**	1
	0,0000	

Table I.C - COBAR with 3 factors of Fama & French and with 6 factors of Fama & French

Based on the previous conclusions, the following research will be based on the 3-factors model including all sample stocks and *COBAR* based on the 1^{st} decile. As it can be seen in Table II.A, *COBAR* shows variations along time. *COBAR* is a measure for the level of arbitrage activity, so there are clearly periods in which arbitrage activity is higher, reaching a maximum of 0,665 and others when it is lower, going until -0,035.

Variable	N	Mean	Std. Dev	Min	Max
COBAR	539	0,202	0,202	-0,035	0,665
Inflation	539	0,043	0,020	0,016	0,092
Sentiment	537	0,000	0,009	-0,023	0,031
Ted Spread	359	0,058	0,045	0,012	0,396

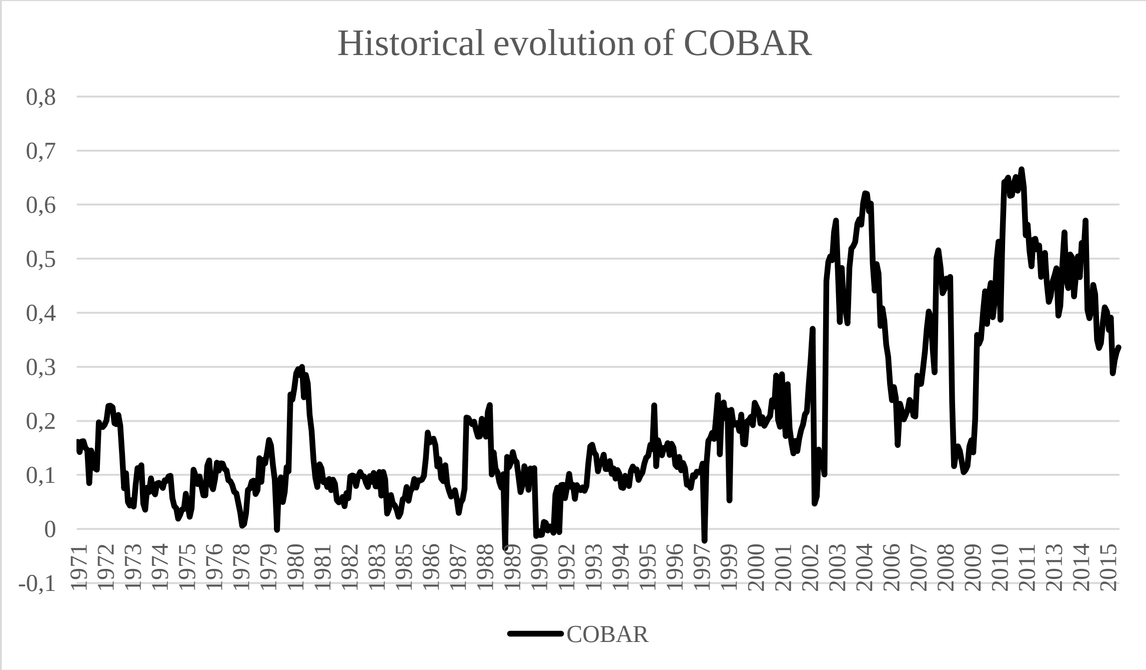
Table II.A – Summary Statistics

In addition, the thesis includes control variables that literature has shown to be associated with the variation of expected abnormal returns of the beta strategy throughout time. Based on the Correlation Matrix shown in Table II.B, it is possible to verify that the arbitrage measure has a negative correlation with *Inflation* and with *Ted Spread*, and almost no correlation with *Market Sentiment*.

	COBAR	Inflation	Sentiment	Ted Spread
COBAR	1			
Inflation	-0,584	1		
Sentiment	0,058	-0,082	1	
Ted Spread	-0,354	0,462	-0,014	1

Table II.B – Correlation Matrix

In Graph I it is observable that the sample's level of *COBAR* is much higher in the latest years than in the beginning. It is also possible to see that the measure presents cycles, for instance, peaks in the value of *COBAR* are usually followed by accentuated declines.



Graph I - Historical data of COBAR from 1970 until 2015

4.2 Dynamic Returns of Beta Strategy

After building *COBAR* the beta strategy is computed, which consists of going long on the bottom deciles of stocks and short on the highest decile of stocks. The abnormal returns of the strategy after 1 month, 6 months, 1 year, 3 years, and 5 years of the beta-arbitrage trade can be observed in Table III.C (in Tables III of the Appendixes, analysis with investment horizons of 3 months, 2 years and 4 years can be found). The abnormal returns are the alphas of the regressions using the 4-factors model of Carhart, Fama & French. For comparison and consistency of results, the abnormal returns are computed using as well the CAPM, the 3-factors, the 5-factors, and the 6-factors model, which can be found in Table III.A, Table III.B, Table III.D and Table III.E of the Appendixes.

		1 month		6 months		1 year		3 years		5 years	
Rank	**N**	**estim**	**t-stat**	**estim**	**t-stat**	**estim**	**t-stat**	**estim**	**t-stat**	**estim**	**t-stat**
1	96	-0,297%	-0,057	-0,141%	-0,078	0,074%	0,061	0,174%	0,281	0,220%	0,399
2	95	0,871%	0,165	0,296%	0,199	0,162%	0,148	0,144%	0,195	0,237%	0,405
3	95	-0,069%	-0,018	-0,040%	-0,025	0,143%	0,096	0,149%	0,158	0,161%	0,212
4	96	0,789%	0,134	0,475%	0,244	0,491%	0,442	0,194%	0,235	-0,039%	-0,055
5	96	-0,702%	-0,139	-1,264%	-0,476	-1,129%	-0,538	-0,670%	-0,472	-0,750%	-0,813
4-1		1,086%	0,123	0,615%	0,224	0,417%	0,256	0,020%	0,021	-0,259%	-0,327

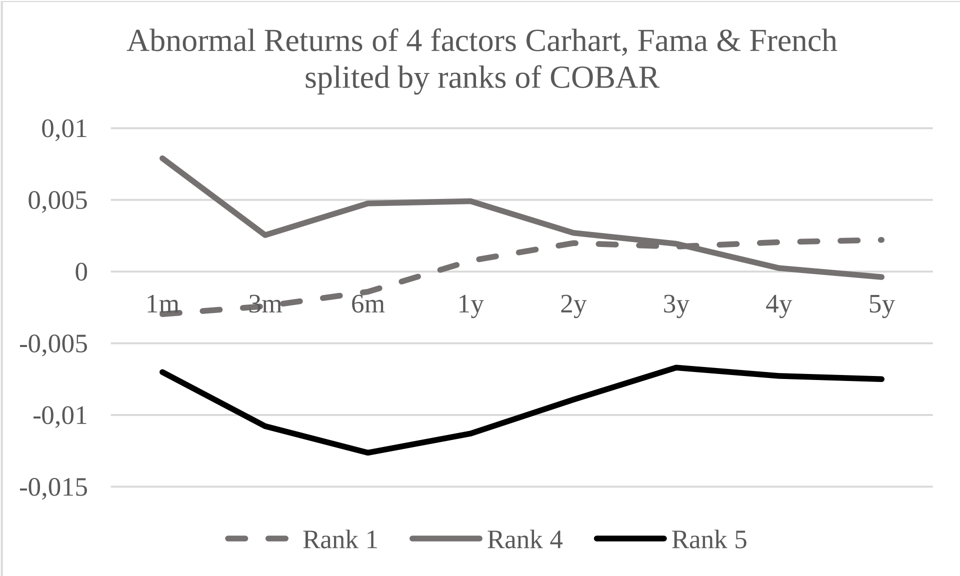
Table III.C - 4 factors Carhart, Fama & French alphas from beta strategy

The samples of abnormal returns of the different investment horizons (1 month, 6 months, 1 year, 3 years and 5 years) are ranked in values of *COBAR* with the lowest values identified as periods with lowest beta arbitrage activity, and the highest values identified as periods with highest beta arbitrage activity. Table III.C shows that for the lower values of *COBAR*, the average of the abnormal returns takes longer to materialize, being negative in the 1st (-0,297%) and 6th (-0,141%) months and become positive in the 1st year (0,074%), growing until the 5th years (0,220%). This pattern is similar to the one presented in the main paper. Yet, for the higher values of *COBAR*, the pattern is very different from the one presented in that paper. In fact, it can be observed that for a large volume of beta arbitrage in the market, the abnormal returns are always negative, independently of the time period considered. In the 1st month, the average abnormal return is -0,702%, in the 6th month it is -1,2264%, in the 1st year it is -0,670% and in the 5th year it is -0,750%. What can be comparable to the results of the main paper is the rank 4 sample of *COBAR*: the abnormal returns are positive in the short run (1st month = 0,789%; 1st year = 0,491%) and become negative if the investor keeps collecting returns from the strategy until the 5th year (-0,039%). These patterns can be easier understood in Graph II.

The main study argues that the abnormal 4-factor returns of the beta strategy need more time to materialize in periods with lower arbitrage volume (lower ranks), being only positive in the 2nd and 3rd years (in this thesis, the analysis is extended until the 5th year horizon). Moreover, for the ranks with the highest *COBAR*, the abnormal returns are already high in the 6th month. The authors conclude that these quicker and stronger abnormal returns face a reversal in the long run (3rd year).

The divergent results presented in this thesis can be explained in accordance with the ones presented in the main paper. In fact, it could be observed in Graph I that values of *COBAR* are much higher in the latest years of the sample, namely from 2010 until 2015. The main papers' sample covers the period from 1965 until 2010, while this thesis covers the one from 1970 until 2015. As a consequence the values of high *COBAR* must coincide with the sample period of 2010-2015, causing the pattern to be somewhat different. By analyzing Graph II, it can be concluded that when *COBAR* is very high, which translates into a very high volume of beta-arbitrage, investors cannot realize positive returns at least until the 5 years investment horizon. This can be explained by investors causing disruptions in prices which lead them to levels that don't coincide with their true value. After the investors pursuing the strategy and the stocks' price suffer a big jump, they will quickly return to its "equilibrium" price causing investors not to reach the expected profits from the strategy.

Additionally, it can be observed in Graph II that the relationship between *COBAR* and abnormal returns is similar to the one shown in the main paper for the ranks 1 and 4. In periods of low *COBAR*, there is a delay in the abnormal returns collected by investors. However, once more beta arbitrage investors participate in the market, these abnormal returns can be received in shorter periods, being reversed in the long run. This behavior is consistent with a price overshoot due to the signal transmitted to investors, who want to participate in the market in order to gain from the strategy. Since too many investors will want to take advantage of the strategy, the stock price will go above its equilibrium price (from the channel of demand, and not due to its fundamental value). Once the period with the high demand for the stocks passes, the price of stocks will start decreasing, causing investors to have negative abnormal returns if they decide to keep the strategy for a long period.



Graph II - Abnormal Returns of 4 Factors Carhart, Fama & French split by ranks of COBAR

In order to confirm the patterns shown above, a regression of the abnormal 4-factor returns on *COBAR* and other control variables that were shown to predict beta-arbitrage returns is included in Table V.A. Here, the Value Spread is included, which was computed following the approach of Cohen, Polk, & Vuolteenaho (2005) because it was argued by the authors that the value spread can have some impact on the returns of the beta strategy. The market volatility of the previous 12 months of each portfolio formation date is also included. The regressions do not only take into account the ordinal value of *COBAR* but also the cardinal values. Therefore, they seem to present the predictive power of the variables that literature demonstrated to impact beta-strategy returns in the presence of the innovative variable. In Table V.B of the Appendixes, the regressions are computed by using the abnormal returns with the 6-factor models as a dependent variable with the objective to ensure consistency in the results presented.

Regressions (1) to (3) forecast the time series variations in the abnormal 4-factor beta-arbitrage returns in the 6 months investment horizon following the portfolio formation. Regression (1) confirms that *COBAR* contributes negatively significantly (-0,0586) for the abnormal returns of the strategy. Regression (2) includes control variables that have data available for the sample under investigation. Regression (3) includes all variables. As it can be observed, only *COBAR* has statistical significance in forecasting the abnormal returns, and the sign of the coefficient remains negative in all regressions computed.

Regressions (4) to (6) forecast the abnormal 4-factor beta-arbitrage returns in the 3 years investment horizon. It can also be shown that the coefficient of *COBAR* remains significantly negative, yet with lower absolute value than in the previous regressions. The results can be connected to the conclusions that were drawn in the main paper, in particular returns of the strategy invert in the long run. In this sample there are periods of very high *COBAR* that make the abnormal returns to be always negative (as shown in the previous section) regardless of the investment horizon, so although the coefficient becomes less negative, it doesn't reach the point of inverting. When all control variables are included, *COBAR* loses its predictive power and *Mkt Vol 12* and the *Ted Spread* become significant. If the 6 factors model is considered, *COBAR* remains significant as well as *Sentiment* and the *Ted Spread*.

	6 months			3 years		
	(1)	(2)	(3)	(4)	(5)	(6)
COBAR	**-0,0386**	**-0,0351**	**-0,0444**	**-0,0209**	-0,0189**	-0,0185
	-2,28	-1,87	-1,92	-1,67	-1,24	-1,01
Inflation		0,0742	-0,0811		-0,0266	0,0322
		0,77	-0,23		-0,38	0,19
Sentiment		0,0858	0,1728		-0,0421	-0,1334
		0,47	0,47		-0,45	-0,79
Value Spread		-0,0016	0,0002		-0,0022	-0,0011
		-0,43	0,04		-0,80	-0,35
Mkt Vol 12		0,4093	0,2682		-0,2342	-0,4201***
		0,81	0,45		-0,84	-1,53
Ted Spread			-0,0151			**0,0542**
			-0,25			1,88
Nº Obs	502	502	322	502	502	322

Table IV.A - Forecasting 4 factors Carhart, Fama & French abnormal returns

4.3 Beta Expansion

It could be expected that when the stocks included in the strategy are relatively more leveraged, from the mechanism described by Modigliani & Miller (1958), the impact on prices of the positive-feedback trading (signals transmitted to investors to trade stocks) is larger. In fact, if the price of a security rises because many investors decided to invest in those securities, and in the particular case when stocks are leveraged, the MM Proposition II proposes that the price of these stocks will increase even more in comparison to stocks with lower Debt to Equity ratios (inverse mechanisms in the opposite direction of prices). This increase/ decrease in prices will affect the beta of these stocks, increasing the intensity of the signals transmitted to the arbitrageurs and thus, investors can reinforce their strategy with stocks that are already away from their fundamental prices. This mechanism was tested as presented in Table V.

In regressions (1) and (2), the dependent variable is the spread in betas of the value-weighted portfolio of stocks included in the strategy in the formation year after one year of holding those stocks. The independent variables are *COBAR* in the portfolio formation year, *Beta Spread* of the stocks of the strategy in the portfolio formation year, the average book leverage quintile of the portfolio computed in each formation period, and an interaction between *Leverage* and *COBAR*. Contrary to the main paper, the results of regressions (1) and (2) are not statistically significant and therefore become erroneous to draw conclusions.

In regressions (3) and (4), the dependent variable is the fraction of stocks in the low-beta decile, computed in year t and that remain in the low-beta decile in year t+1. It needs to be noted that there is no overlapping in the two periods of *Beta Spread* and *Fraction* as betas were estimated using 52 weeks stocks data. Regression (3) shows that when *COBAR* is high, the fraction of stocks remaining in the low beta decile is statistically significantly higher. When *Leverage* and the interaction between *COBAR* and *Leverage* are included, the impact of *COBAR* is no longer significant and *Leverage* has a negative statistically significant impact, though very close to zero.

	Beta Spread t+1		**Fraction t+1**	
	(1)	**(2)**	**(3)**	**(4)**
Beta Spread t	0,0701**	0,0681**		
	1,21	1,15		
COBAR	-0,3885	0,2145	0,0343***	0,0261
	-0,43	0,15	1,44	0,61
Leverage		0,1314		-0,0060***
		0,73		-1,54
*COBAR*Leverage*		-0,2182		0,0038
		-0,48		0,32
Nº Obs	527	527	527	527

Table V – Beta Expansion, Time Series Analysis

5. Conclusion

The thesis studies the relations between arbitrage activity and the abnormal returns of the beta strategy. Using the novel measure *COBAR* as a proxy for the level of arbitrage activity, it was verified that for very high level of arbitrage activity the abnormal returns of the beta strategy are always negative, independently of the holding period considered by the investor. This conclusion is not equal to the one shown in the main paper, which is explained for the extended sample used in this thesis. Additionally, the leverage of stocks as a fact that can widen the beta spread in the portfolio in periods with high *COBAR* could not be concluded. Besides that, it was proved significant that these periods of high *COBAR* have a positive relation with the stocks that remain in the low beta decile from one year to the other.

The main weaknesses of this thesis are related to the access to data and the complexity of methodology. On the one hand, the variable Assets under Management, Institutional Ownership, and Disagreement were not possible to be computed due to missing public access to data or computations with a complexity that goes beyond the scope of this thesis. On the other hand, the methodology could have been done differently which certainly could result in different results. For example, a one-year ranking period consideration, sample with only stocks from the NYSE, average formula of returns considered, the number of trading days static for each year (260), month (22) and week (5). Moreover, the transaction costs of performing the strategy are not being taken into account, which can also be considered a limitation of this thesis.

Besides its limitations, this thesis continues the work of Lou, Polk, & Huang (2016) and can have an impact on how investors, who intend to pursue the beta strategy, decide to invest. In fact, if they can calculate the values of *COBAR* and have a historical sample of these values, they can identify which periods are more likely to result in higher returns (periods with low values of *COBAR*) and what is likely to be the best holding period of the strategy (between 1 month and 1 year). These strategies are usually easier to implement by professional investors such as Asset Managers and Hedge Funds due to the decreased transactions costs they can be exposed to.

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