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ABSTRACT

Conventional financial theory considers ex-ante that risk, generally measured by the volatility, has to be appropriately rewarded by expected returns. In modern financial markets, there are countless quantitative and systematic strategies which may test and eventually lead to excess returns when quantified by these conventional stochastic measures. One of them is the momentum effect which denotes an ongoing movement of the prices of financial assets in a certain direction, for a determined time horizon. Colloquially, assets that have performed better in the past tend to do so in the future. The objective of this paper is to test the existence of excess returns from momentum strategies. To do the aforementioned, we test different selection criteria with diverse weighting schemes. Finally, we analyze how is the behavior of equity options on those underlying assets in order to establish a two-way strategy; first performing pure equity option strategies and then blending equity options with index options.

JEL *Classification*: C1, C3, N2, G11

Keywords: Momentum, four-factor model, asset pricing, option pricing, implied volatility, index options.

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* We deeply appreciate comments made at the 2017 World Finance Conference and at the UCEMA Finance seminars. The author's views are on their own and do not necessarily represent those of the Universidad del CEMA.

Introduction

In conventional financial theory, it is still widely accepted that just the expected return and standard deviation are the only measures to characterize the utility function of investors, regardless of the stochastic distribution implied by assets' returns or further preferences derived from investors profiling.

We tested different approaches to tackle the equity momentum puzzle, showing that some of them can achieve excess return, with the caveat that their success could be a reward for bearing higher moments of the returns distribution, akin to new sources of risk. Moreover, we have tested the same base strategies but instead of using equity we used options on the previously selected underlyings, with the goal of not only learning about their behavior but also ascertain potential excess returns. Finally, we combine the proposed strategies with index options. The exploitation of this phenomenon through options is still novel approach since it has not been deeply researched in academic papers, at least from a perspective of generating strategies.

As for the paper, the structure is the following: in Section I we introduce the momentum strategies and briefly review the main contributions of the literature to the topic under analysis; in Section II we describe thoroughly the different approaches of momentum strategies tested; in Section III we test the option momentum strategies. Finally, in Section IV we discuss the main conclusions and future research.

I) Literature

One of the first research papers about momentum strategies was published by De Bondt and Thaler (1985), showing the existence of a contrary phenomenon, i.e., stocks with higher returns in the past have lower returns in the future and vice versa. These findings led the authors to conclude the existence of an overreaction by investors, specifically for longer periods of time, opening the possibility for prediction of price movements and putting at risk the efficient markets hypothesis.

These results are also consistent with the ones by Jegadeesh (1990), with similar conclusions about the behavior of investors and the movements of prices, but unlike De Bondt and Thaler, the empirical results suggested that the phenomenon occurred in a short term rather than on a long-term[1].

[1] Consider long term as a 5-year period and a short term as a maximum period of 3 years. One of the authors' explanations for the effect of overreaction is attributed to a violation of the Bayes rule, since investors tend to overreact to unwanted and unexpected news.

Despite the findings cited above, some years later additional studies proved the opposite. Assets with the best performance in terms of past returns tend to have the best performance in the future for the same term (Jegadeesh and Titman, 1993). This is proven for many asset classes and markets around the world, up to the point that Eugene Fama and Kenneth French (2008) argued that momentum was a first-class anomaly.

These results lead many academics, as well as practitioners, to continue deepening the study on the subject. Significant work was published almost contemporaneously (Assnes, 1994), showing similar results towards the confirmation of this anomaly.

Subsequent studies found that the continuation of the path of returns in the medium term could be explained by investors underreacting to the arrival of new information flows (Chan, Jegadeesh, and Lakonishok, 1996).

It is also worth noting that the effect under study has been tested for many countries and regions. One paper finds positive evidence for 12 European countries (Rouwenhorst, 1998), the same was found for Asian countries (Hameed and Kusnadi, 2002).

Such was the enthusiasm (and still is) for studying this phenomenon that in recent years research was extended not only to geographical issues, but also to different kinds of financial assets such as indexes, currencies, bonds, and futures (Assnes, Moskowitz and Pedersen, 2013).

However, despite all the desired attributes that momentum strategies have, empirical evidence showed that under certain market conditions they lose these qualities, potentially leading to devastating results for an investment portfolio. This was specially observed afterwards the sub-prime crisis, with momentum strategies yielding a significant underperformance.

One of the crises in which most studies focused was the Great Depression of 1929, obtaining roughly the same conclusions discussed above. In times of financial distress, where sharp falls in market prices are followed by sharp recoveries, the use of momentum strategies as a portfolio management technique can be devastating, leading to widely known events called "momentum crashes."

Some authors state that the cause behind these events is the high portfolio exposure to systematic risk factors (Blitz, Huij and Martens, 2011). To deal with it, they propose an alternative strategy called *"residual momentum,"* differing from the conventional approach in the criteria used to classify assets. The objective is to neutralize the exposure of the strategies to these common factors and consequently avoid large losses during certain markets states.

Apart from that, some authors claimed that the momentum crashes do not respond to systematic risk factors, but specific factors associated with each asset (Barroso and Santa Clara, 2012). Having said this, they showed that returns from conventional momentum strategies have a deep negative skewness, indicating that distribution of returns is heavily tilted to the left with wider tails than a normal distribution (this could explain the reason for big losses during certain events in the markets). With that insight, and considering that the risk of the strategy can be predicted, they proposed scaling weights in the portfolios based on historical volatility.

Another important study (Daniel and Moskowitz, 2013) proposed an explanation about momentum crashes similar to Blitz et al. suggesting that these strategies show infrequent but significant losses due to the high exposure to the variation of market betas over time, mainly during markets turmoil. Therefore, if markets start to recover suddenly, as has occurred repeatedly throughout history, momentum strategies will suffer severe losses, due to their high negative beta exposure. In order to work this around, they propose dynamic weights based on estimated returns and volatility of the portfolio momentum under study.

At the same time, some authors have proposed a different approach called absolute momentum, also known as time-series momentum (Moskowitz, Ooi and Pedersen, 2012). It differs from the cross sectional strategy in the sense that assets are not classified and chosen in a relative way, but using their own past performance as an indicator.

Regarding momentum strategies on equity options, we were not able to find academic papers that study this topic. However, diverse authors have been studying the relationship between momentum stocks as underlying assets and their options (Zhuo Chen and Andrea Lu, 2014). Results suggested that winners (losers) stocks, in terms of momentum, with the highest growth (drop) in call options implied volatility outperform others in the same sample period. This is consistent with the theory that options implied volatility could be an indicator of the information diffusion stage for stocks, showing that momentum profits concentrate in stocks with the lowest information diffusion.

Beyond the different approaches and findings made regarding the causes or factors that lead to momentum, none of them has been able to fully explain the abnormal returns derived from such strategies, leaving the debate open to further research.

II) Equity momentum strategies

A) Data and methodology

This paper focuses on the US Equity Markets, given the depth, liquidity and widespread availability of equities and derivatives to execute momentum strategies. In order to avoid liquidity issues, and taking into account survivorship biases, we decided to use the components of the Standard & Poor's 500 Index.

The sample period spans from January 1996 to August 2013. Throughout this period two bear markets were experienced, capitalizing on the insights produced on the performance of the strategies under these unusual market conditions.

The main descriptive statistics of the assets analyzed are detailed below. Conclusions about excess returns are drawn when comparing the strategies against passive investment (buying and holding the S&P 500).

[Insert table 1 here]

The methodology used to conduct this study is similar to the previously mentioned for Jegadeesh and Titman. Finally, we conducted different momentum strategies using two selection criteria and diverse weighting schemes.

In general terms, strategies consist of two instances: first, assets are classified and sorted according to their past returns (or other selection criteria), known as the formation period; after which long and short positions are taken (immediately or by skipping one month). Under the premise of building a "self-financed" portfolio, the amount invested in each leg is identical, keeping the portfolio unchanged for a period of time until it is rebalanced. This last stage is known as the holding period. Thus, all strategies were analyzed for different combinations of formation/skip/holding periods (J/S/K).

It is worth mentioning that, in order to test different approaches, we have used both past mean of returns and volatility-adjusted mean of returns.

Likewise, the portfolios are formed under different weighting schemes. First, equally-weighted portfolios constitute our naïve approach. Then we compare this base case with different alternatives: volatility-, momentum-, and momentum-concentration-based weighting.

Initially, under the naïve-weighting method, each asset is weighted based on the number of stocks selected:

$$W_i = \frac{1}{N}$$

For the second approach, the volatility-weighted scheme, the first step is to calculate the realized volatility of each asset during the formation period:

$$\sigma_{t,i} = \sqrt{\frac{1}{N-1}\sum_{i}^{N}|r_i - \mu|^2}$$

Being μ the average of the returns:

$$\mu = \frac{1}{N}\sum_{i}^{N} r_i$$

Subsequently, a reference coefficient is calculated:

$$K_t = 1/\sum_{i}^{N}\sigma_{t,i}^{-1}$$

Where $\sigma_{t,i}^{-1}$ is the inverse of the volatility calculated for the asset i at time t. So the coefficient is made as the inverse of the sum of the inverse volatility of all assets. Finally, each asset´s weighting, at each point in time, is computed as follows:

$$WV_{t,i} = K_t/\sigma_{t,i}$$

Under the third method, the momentum-weighted, two methodologies were studied. The first consists of calculating a coefficient using a Gaussian transformation of the "z-score" for each asset:

$$G_{i,l} = \theta\left(\frac{m_{i,l} - m_l}{\sigma_{m,l}}\right)$$

Being θ the cumulative distribution of probabilities, each *"z-score"* becomes a percentile value between 0 and 1. Finally, the weighting for each asset is obtained as a result of the ratio between the values previously obtained for the asset i, and the sum of these.

$$W_{t,i} = \left(\frac{G_i}{\sum_i^k G}\right)$$

For the second one, we initially calculate a coefficient,

$$K_t = 1/\sum_{i}^{N} M_{t,i}$$

where $M_{t,i}$ is the momentum of asset i at time t, calculated according to the criterion used to classify the momentum in each approach. For example,

$$M_{t,i} = \frac{1}{N}\sum_{m}^{m+J} r_{t,i}$$

being $M_{t,i}$ the momentum for each asset according to the average return during the formation period (from *m* to *m* + *J*).

Finally, each asset weight at each moment of time is computed as follows:

$$WM_{t,i} = K_t * \sigma_{t,i}$$

In addition, we tested under this last method the performance decay given different concentration degrees. For example, a percentile of 50 assets (for each leg) is taken in total, allocating 25% of the total money available in the 5 highest momentum stocks (interpreted as 5 degrees of concentration). The rest of the assets are weighted according to their momentum following the calculation presented above up to 100% of the spare capital. We vary the degree of concentration, being 1 asset and 15 assets the extremes, investing 5% and 75% of the total amount in the highest momentum assets and the rest being allocated according to the momentum scheme.

B) Equity momentum strategies results

Both for the mean of returns and the volatility-adjusted mean of returns selection criteria, the best performance in terms of Sharpe ratio and maximum drawdown was achieved under the momentum-weighting approach and a 12/0/2 months framework. The annualized average returns achieved was 7.21% and 9.25% with a volatility of 21.36% and 19.06%, leading Sharpe ratios of 0.33 and 0.47, respectively. The maximum drawdowns were 32.44% and 29.43%, for both selection criteria. Anyway, the performance did not differ much between the volatility-, and momentum-weighting schemes.

[Insert table 2, 3 and 4 and figures 1, 2 and 3 here]

It is worth mentioning that, by applying the second momentum-weighted approach, we were able to appreciate an almost linear pattern, where the risk adjusted returns improved until a 12-level concentration (or 60% of the total amount invested in the 12 highest momentum stocks), obtaining for both selection criteria (and 12/0/2 months) average annualized returns of 8.97% and 12.40% with a volatility of 27.16% and 25.00%, leading Sharpe ratios of 0.32 and 0.49, respectively. However, the maximum drawdowns were 45.05% and 40.89% for both selection criteria.

[Insert table 5 here]

Up to this point, it is important to emphasize that momentum strategies, although originally designed to run with long/short self-financed portfolios, can generate good results by only taking positions on the long side. Since not all investors have access to short positions, nor is it possible in all markets, the finding further increases these strategies attractiveness. These points can be observed in a more detailed view at the annex.

C) Robustness regarding different combination of J/K periods

The combination of different formation and holding periods (J/K) is one of the determining factors when executing the strategies. For this reason, a sensitivity analysis was performed by changing the mentioned parameters, finding a very clear pattern for both selection criteria and all the weighting approaches proposed.

Given the *J*, to the extent that *K* increases, the strategies tend to decrease in performance abruptly, highlighting that returns from momentum tend to persist only in the short term.

[Insert tables 6, 7, and 8 here]

D) Risks: Beyond volatility

We complete our analysis by extending the research to other risk metrics, such as kurtosis, skewness and systematic risk. Almost all strategies showed high level of excess of kurtosis, indicating that returns are strongly concentrated around the mean. In addition, we observed in most cases a negative skewness coefficient, although not very relevant. The latter finding differs from other studies in the area, which suggest a strong negative skewness, being this a probable explanation of momentum crashes.

We also analyzed the strategy exposure to systematic risk factors, applying Carhart four-factor model. In line with others studies, the strategies tested did not show significant exposure to the outlined factors, at least in statistical terms. However, when analyzed over time, we noticed that returns had high time-varying exposures to the systematic risk factors, mainly to the market excess return.

Additionally, we analyzed the alphas obtained by the strategies, achieving for some cases positive and significant alphas (statistic *t* greater than 2). The model used was the following:

$$R_{i,t} = \alpha_i + \beta_{MKT,i} R_{MARKET,t} + \beta_{SMB,i} R_{SMB,t} + \beta_{HML,i} R_{HML,t} + \beta_{MOM,i} R_{MOM,t} + \epsilon_{i,t}$$

where $R_{i,t}$ are the excess returns on stock i at time t, R_{MARKET} are the excess returns of a portfolio mimicking the market, $R_{SMB,t}$ are the excess returns of small companies regarding larger ones, $R_{HML,t}$ are the excess returns of value companies, and finally $R_{MOM,t}$ are the excess returns of winners companies regarding losers in term of the past returns.

[Insert table 9 here]

The above results provide evidence that the returns from the strategies under study are not explained by specific risks to each asset, at least measured as volatility and skewness. This is less clear when kurtosis is evaluated, being very high in most cases. Regarding the systematic risk, it will be discussed in the following subsection.

E) Momentum Crashes

In spite of the good results obtained so far, it should be noted that, in the wake of some unusual events -or more precisely after their occurrence-, the strategies under study can perform poorly. One way to observe it is through the calculation of the Drawdown (DD)[2] over the equity curve.

We noticed that the market betas of the strategy were unstable, being negative and statistically significant both after the dot-com crash and the subprime crisis, although with less magnitude in the latter.

[Insert table 10 and figure 4 here]

These results make us conclude that one of the main causes of momentum crashes could be the exposure of the strategies to a high time-varying systematic market factor. Other factors analyzed showed more stable paths.

III) Option momentum strategies

One finding in tune with previous showings is that equity momentum strategies could potentially lead to excess returns. The purpose of this section is to explore the behavior of equity options whose underlying assets are momentum stocks and establish option-based strategies to see if it is possible to mitigate momentum crashes. This constitutes an innovation in terms of risk management, since we have not found available research on the subject.

[2] A drawdown is usually measured as the percentage between the previously peak and the subsequent through.

In order to establish the strategies, we first choose the assets based on the methodology proposed above, using the two selection criteria and limiting ourselves to test strategies with a formation period of 12-months and a holding period of 2-months under an equally-weighted scheme.

We restricted our analysis to closest to at-the-money options (defining them as those with a degree of moneyness between 0.95 and 1.05). The time-to-maturity chosen was two months, matching them with the selected holding period of the equity momentum strategies.

Our initial hypothesis was that the use of options could pose an improvement for the strategies, mitigating momentum crashes due to the specific payoff function embedded in this kind of derivatives, compared to their underlying counterparty, which is exposed to unlimited losses.

First, we used a naïve method, taking long positions in call (put) options for the winner (loser) stocks, keeping them unaltered during the established holding period. We allocated accordingly, without leveraging, and the rest of the available money[3] was invested into one-month Treasury Bills.

As a second step, the whole sample was divided into subsamples based on the stock returns of the ten prior days to the established holding period. We explored whether there were differences in the options performance of these subgroups.

The first results showed an impressive performance in terms of volatility adjusted returns, obtaining annualized average returns of 5.06% and 4.72% with a volatility of 5.91%, and 5.25% leading to a Sharpe ratios of 0.82 and 0.85 for the mean of returns and the volatility-adjusted mean of returns selection criteria, respectively.

The drawdowns were reduced, when compared with equity-based momentum strategies, being approximately two times lower. However, when risk is measured with others moments of the probability distribution, such as kurtosis and skewness, they do not differ significantly.

At this point, we consider worth mentioning that in almost all studied cases, call positions strongly outperformed put positions, with higher Sharpe and Calmar ratios. This is in line with others studies, where the authors argue that put options are systematically overvalued as observed by a marked asymmetry between their implied volatilities, probably generated by an excess of demand generated by the investors who want to hedge their portfolios.

[3] We assume one million dollars available to invest in each leg (winners and losers).

Next, we tested the performance of the top and the bottom option percentiles, not being able to outperform the strategy stated above. For the top percentile, we obtained annualized returns of 3.88% and 3.78% with a volatility of 6.86% and 5.88%, and Sharpe ratios of 0.49 and 0.60, for both selection criteria, respectively. The bottom percentile strategy outperformed the top, obtaining annualized returns of 4.40% and 5.23% with a volatility of 7.04% and 6.28%, achieving Sharpe ratios of 0.60 and 0.80. These results reinforce the idea that options on high-momentum stocks could be overvalued relative to low-momentum stocks, perhaps due to the popularity among investors of this kind of strategies.

Another relevant issue is that put options leg in the bottom percentile strongly outperformed the ones in the top percentile. For the call options leg this pattern does not appear, with ambiguous results.

[Insert table 11 and figure 5, 6, 7, 8 and 9 here]

In addition, we analyze the four-factor alphas obtained by these strategies. In almost cases, the best performance was obtained by strategies based on the volatility-adjusted mean of returns as a selection criterion, although in no single case the t-stat was higher than 2. In line with the findings presented above, all the strategies based on the top percentile got the lowest alphas.

[Insert table 12 here]

We have shown so far that momentum strategies can lead to excess returns. Besides, in a paper published by Dapena and Siri (2016), the authors showed that passive options investment strategies applied on the US equity market can also give rise to excess returns. The literature reports that option buyers tend to earn less return than predicted by standard risk-return models, which in turn means that option sellers earn more (excess returns) than predicted.

In order to exploit the findings regarding equity options on momentum stocks and index options presented up to this point, we tested a mixed strategy based on both. To do that we followed the previously mentioned methodology, in which every two months (being the holding period) we take long positions in equity options and short positions in index options. To define the quantity of index options we used the following equation:

$$Q_{i,t} = \left(\frac{V_{i,t}^{EO}}{V_{i,t}^{IO}}\right)$$

where $Q_{i,t}$ is quantity of index options i (call or put) to short at time t, $V_{i,t}^{EO}$ is the notional value of each equity options portfolio i (calls or puts portfolio) at time t and finally, $V_{i,t}^{IO}$ is the notional value of one index option contract i (call or put) at time t.

This strategy outperformed the previous one based solely on equity options. The returns obtained were 6.56% and 6.33% with a volatility of 6.12%, and 5.28%, and Sharpe ratios of 1.03 and 1.16, both for the mean of returns and the volatility-adjusted mean of returns selection criteria, respectively. The maximum drawdowns were significantly lower, mainly for the second selection criterion which was stood at 6.76%.

The risks measures when contemplating higher moments of the probability distribution, like kurtosis and skewness, do not differ much to the previous strategies. However, the call options leg presented a very high kurtosis, being 17.03 and 14.32 for the mean of returns and the volatility-adjusted mean of returns selection criteria.

Regarding the differences between extreme percentiles, the patterns found were similar to the ones in the pure equity options strategy. One important point worth highlighting is that the call options leg for the bottom percentile presented a very high kurtosis.

[Insert table 13 and figure 10, 11 and 12 here]

As a final test, we analyzed returns against the four-factor model and the produced alpha. Opposite to the strategy tested in the last subsection, here all strategies posted economically and statistically significant alphas. The highest alphas were achieved using all available options and the bottom percentile options, presenting the highest t-stats.

[Insert table 14 here]

IV) CONCLUSIONS

The main purpose of the study was twofold. On the one hand, it tested whether there is evidence in the financial market about the momentum effect. The results obtained allowed us to conclude that this phenomenon does exist and that it can be exploited.

The variables that had the greatest impact on the performance of the strategies was the combination of periods (J / K) and the selection criterion chosen. The results achieved meet expectations. However, it is important to note that during certain events the strategies under study may suffer huge losses.

On the other hand, we have exploited the momentum effect from a different perspective, using derivatives. We found out several findings. First, following a naïve approach better performance was achieved, in terms of returns, volatility, and drawdowns, although is not generating alpha. Second, we divided the whole sample into subsamples to analyze the differences in the performance between the extremes percentiles, finding that although none of the percentiles studied outperformed the main strategy, there was a big difference in terms of risk-adjusted returns between the top and the bottom percentile, the latter outperforming in all cases. Finally, we mixed the pure equity-options momentum strategies with index-options selling strategies, achieving impressive results, with Sharpe ratios approximately 1.5 and 3 times higher than the pure equity-options momentum strategies and equity momentum strategies. The four-factor alphas were higher and also strongly economically and statistically significant.

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TABLES

Table 1. Descriptive statistics of the S&P 500 Index returns

Table 1 shows the main descriptive statistics for the Standard & Poor's 500 Index, from 1996 to 2013.

Standard & Poor's 500					
Mean	Volatility	Sharpe	Kurtosis	Skewness	MaxDD
7.77%	16.36%	0.46	0.81	-0.66	67.12%

Table 2. Statistics of momentum strategies with an equally-weighted scheme

Table 2 shows the descriptive statistics and ratios on annual basis of the momentum strategies using the two proposed selection criteria with an equally-weighted scheme.

		Mean of returns			Volatility-adjusted mean of returns		
		P10	P1	P10-P1	P10	P1	P10-P1
K = 2	Mean	6.81%	-3.74%	7.33%	7.24%	-3.78%	8.63%
	Std	16.04%	25.96%	22.00%	12.87%	22.12%	19.54%
	Sharpe Ratio	0.41	-0.15	0.32	0.55	-0.18	0.43
	Kurtosis	1.45	4.80	7.66	1.77	3.69	8.27
	Skewness	-0.04	0.16	-0.27	0.05	-0.04	-0.29
	MaxDD	42.28%	123.34%	37.42%	41.07%	114.47%	33.55%
	Calmar Ratio	0.16	-0.03	0.20	0.18	-0.03	0.26
K = 6	Mean	5.75%	2.82%	-3.43%	8.01%	1.43%	2.46%
	Std	18.68%	29.43%	25.73%	15.12%	25.16%	21.54%
	Sharpe Ratio	0.30	0.09	-0.14	0.52	0.05	0.10
	Kurtosis	1.34	3.85	6.35	1.72	3.38	5.36
	Skewness	-0.35	0.55	-1.24	-0.32	0.20	-0.74
	MaxDD	57.79%	135.19%	80.26%	54.38%	121.38%	47.07%
	Calmar Ratio	0.10	0.02	-0.04	0.15	0.01	0.05
K = 9	Mean	1.82%	-0.42%	-6.46%	2.40%	-0.84%	-1.66%
	Std	20.91%	25.77%	25.95%	15.99%	22.75%	20.53%
	Sharpe Ratio	0.08	-0.02	-0.26	0.14	-0.05	-0.09
	Kurtosis	0.99	3.75	11.03	1.38	3.33	7.72
	Skewness	-0.16	0.38	-1.80	-0.33	0.10	-0.98
	MaxDD	87.70%	157.56%	148.28%	64.83%	144.47%	91.85%
	Calmar Ratio	0.02	0.00	-0.04	0.04	-0.01	-0.02

Table 3. Statistics of momentum strategies with a volatility-weighted scheme

Table 3 shows the descriptive statistics and ratios on annual basis of the momentum strategies using the two proposed selection criteria with a volatility-weighted scheme.

		Mean of returns			Volatility-adjusted mean of returns		
		P10	P1	P10-P1	P10	P1	P10-P1
K = 2	Mean	7.05%	-3.15%	7.45%	6.21%	-2.21%	6.69%
	Std	14.89%	23.98%	21.48%	11.41%	18.81%	16.55%
	Sharpe Ratio	0.46	-0.14	0.34	0.53	-0.13	0.39
	Kurtosis	1.41	4.91	7.89	1.42	2.82	6.56
	Skewness	0.05	-0.02	-0.12	0.07	-0.25	-0.17
	MaxDD	39.22%	114.67%	36.55%	37.49%	92.99%	26.08%
	Calmar Ratio	0.18	-0.03	0.20	0.17	-0.02	0.26
K = 6	Mean	6.85%	3.33%	-2.10%	6.99%	2.74%	1.11%
	Std	17.42%	27.67%	25.56%	13.40%	21.73%	18.89%
	Sharpe Ratio	0.38	0.11	-0.09	0.51	0.12	0.05
	Kurtosis	1.28	4.73	7.42	1.50	3.13	5.23
	Skewness	-0.29	0.59	-1.16	-0.32	-0.02	-0.72
	MaxDD	56.20%	128.17%	75.15%	50.15%	105.80%	45.02%
	Calmar Ratio	0.12	0.03	-0.03	0.14	0.03	0.02
K = 9	Mean	2.59%	-0.50%	-3.74%	2.54%	-0.51%	0.12%
	Std	19.20%	24.11%	23.71%	14.43%	20.17%	17.15%
	Sharpe Ratio	0.12	-0.03	-0.17	0.16	-0.04	0.00
	Kurtosis	0.98	4.39	8.06	1.18	3.67	5.56
	Skewness	-0.17	0.30	-1.10	-0.30	-0.04	-0.48
	MaxDD	78.49%	159.69%	120.53%	59.38%	133.60%	70.15%
	Calmar Ratio	0.03	0.00	-0.03	0.04	0.00	0.00

Table 4. Statistics of momentum strategies with a momentum-weighted scheme

Table 4 shows the descriptive statistics and ratios on annual basis of the momentum strategies using the two proposed selection criteria with a momentum-weighted scheme.

		Mean of returns			Volatility-adjusted mean of returns		
		P10	P1	P10-P1	P10	P1	P10-P1
K = 2	Mean	6.91%	-2.61%	7.21%	8.48%	-2.16%	9.25%
	Std	18.22%	23.13%	21.36%	15.85%	18.26%	19.06%
	Sharpe Ratio	0.37	-0.12	0.33	0.52	-0.13	0.47
	Kurtosis	2.07	4.96	6.66	2.69	2.88	7.48
	Skewness	0.07	0.01	0.27	0.19	-0.25	0.69
	MaxDD	50.22%	103.77%	32.44%	49.47%	83.17%	29.43%
	Calmar Ratio	0.14	-0.03	0.22	0.17	-0.03	0.31
K = 60	Mean	4.48%	3.33%	-3.46%	8.53%	2.28%	3.24%
	Std	21.14%	26.47%	26.09%	18.66%	21.15%	21.95%
	Sharpe Ratio	0.20	0.12	-0.14	0.45	0.10	0.14
	Kurtosis	1.26	4.48	5.92	2.01	3.44	5.32
	Skewness	-0.17	0.62	-0.91	-0.17	0.00	-0.34
	MaxDD	64.70%	116.48%	80.73%	59.60%	100.81%	62.35%
	Calmar Ratio	0.07	0.03	-0.04	0.14	0.02	0.05
K = 9	Mean	-0.75%	0.78%	-7.65%	1.38%	0.11%	-1.47%
	Std	23.20%	23.80%	24.26%	19.24%	20.06%	19.71%
	Sharpe Ratio	-0.04	0.02	-0.32	0.06	0.00	-0.08
	Kurtosis	0.79	3.87	4.75	1.55	4.23	5.66
	Skewness	-0.17	0.42	-1.02	-0.36	0.05	-0.16
	MaxDD	114.66%	150.13%	159.39%	79.69%	131.75%	82.20%
	Calmar Ratio	-0.01	0.01	-0.05	0.02	0.00	-0.02

Table 5. Performance of momentum strategies with a momentum-weighted scheme under different degrees of concentration

Table 5 shows the descriptive statistics and ratios on annual basis of the two selection criteria under the second momentum-weighted scheme proposed. The degrees of concentration range from 1 to 15. For example, 5 degrees of concentration means that 25% of the total amount invested is allocated to the first 5 stocks, i.e., to the highest 5 momentum stocks. The remainder is allocated to the other selected stocks following the methodology explained above.

Mean of returns							
	1	3	5	8	10	12	15
Mean	-0.05%	6.10%	6.80%	7.76%	8.21%	8.97%	7.81%
Std	29.24%	28.02%	25.00%	25.85%	26.05%	27.16%	28.92%
Sharpe Ratio	-0.01	0.21	0.26	0.29	0.31	0.32	0.26
Kurtosis	17.94	8.98	6.22	6.77	6.67	7.65	7.30
Skewness	-2.21	0.47	-0.19	-0.16	-0.15	-0.15	-0.13
MaxDD	107.47%	63.93%	42.16%	41.69%	41.86%	45.05%	46.46%
Calmar Ratio	0.00	0.10	0.16	0.19	0.20	0.20	0.17

Volatility adjusted mean of returns							
	1	3	5	8	10	12	15
Mean	9.48%	11.85%	10.74%	11.15%	11.60%	12.40%	8.09%
Std	24.78%	32.94%	24.22%	24.30%	24.37%	25.00%	25.52%
Sharpe Ratio	0.37	0.35	0.44	0.45	0.47	0.49	0.31
Kurtosis	8.57	34.94	8.03	8.27	8.46	7.34	8.34
Skewness	-0.32	3.43	-0.15	-0.22	-0.33	-0.15	-0.39
MaxDD	42.64%	55.14%	40.58%	41.05%	41.80%	40.98%	43.71%
Calmar Ratio	0.22	0.21	0.26	0.27	0.28	0.30	0.19

Table 6.Sensitivity analysis of momentum strategies to different formation/holding periods
Table 6 shows the descriptive statistics and ratios on annual basis of the momentum strategies using the two selection criteria with an equally-weighted scheme. Here we ran a sensitivity analysis to test how the performance varies to different combinations of *J/K* periods.

		Mean of returns			Volatility-adjusted mean of returns		
		J = 6	J = 9	J = 12	J = 6	J = 9	J = 12
	Mean	5.16%	4.97%	7.33%	3.53%	3.88%	8.63%
	Std	20.39%	22.00%	22.00%	17.35%	18.67%	19.54%
K = 2	Sharpe Ratio	0.24	0.22	0.32	0.19	0.20	0.43
	Kurtosis	8.64	8.60	7.66	5.78	7.00	8.27
	Skewness	-0.25	-0.25	-0.27	0.71	0.17	-0.29
	MaxDD	34.54%	43.95%	37.42%	37.72%	48.65%	33.55%
	Calmar Ratio	0.15	0.11	0.20	0.09	0.08	0.26
	Mean	-3.92%	1.74%	-3.43%	1.55%	5.08%	2.46%
	Std	24.47%	23.63%	25.73%	19.94%	19.55%	21.54%
K = 6	Sharpe Ratio	-0.17	0.07	-0.14	0.07	0.25	0.10
	Kurtosis	9.22	6.96	6.35	6.10	5.63	5.36
	Skewness	-1.08	-0.64	-1.24	-0.16	-0.73	-0.74
	MaxDD	64.10%	77.94%	80.26%	38.37%	36.40%	47.07%
	Calmar Ratio	-0.06	0.02	-0.04	0.04	0.14	0.05

Table 7. Sensitivity analysis of momentum strategies to different formation/holding periods

Table 7 shows the descriptive statistics and ratios on annual basis of the momentum strategies using the two selection criteria with a volatility-weighted scheme. Here we ran a sensitivity analysis to test how the performance varies to different combinations of *J/K* periods.

		Mean of returns			Volatility-adjusted mean of returns		
		J = 6	J = 9	J = 12	J = 6	J = 9	J = 12
K = 2	Mean	4.47%	5.03%	7.45%	-0.45%	0.71%	6.69%
	Std	20.30%	21.75%	21.48%	16.50%	16.61%	16.55%
	Sharpe Ratio	0.21	0.22	0.34	-0.04	0.03	0.39
	Kurtosis	9.16	9.84	7.89	7.72	8.38	6.56
	Skewness	-0.14	-0.20	-0.12	-0.16	-0.24	-0.17
	MaxDD	34.97%	41.91%	36.55%	43.63%	47.15%	26.08%
	Calmar Ratio	0.13	0.12	0.20	-0.01	0.02	0.26
K = 6	Mean	-2.41%	2.67%	-2.10%	-0.04%	2.03%	1.11%
	Std	23.81%	22.93%	25.56%	17.82%	17.97%	18.89%
	Sharpe Ratio	-0.11	0.11	-0.09	-0.01	0.10	0.05
	Kurtosis	9.24	8.14	7.42	6.26	6.71	5.23
	Skewness	-0.85	-0.58	-1.16	-0.34	-1.11	-0.72
	MaxDD	62.42%	74.12%	75.15%	34.74%	48.13%	45.02%
	Calmar Ratio	-0.04	0.04	-0.03	0.00	0.04	0.02

Table 8. Sensitivity analysis of momentum strategies to different formation/holding periods

Table 8 shows the descriptive statistics and ratios on annual basis of the momentum strategies using the two selection criteria under a momentum-weighted scheme. Here we ran a sensitivity analysis to test how the performance varies under different combinations of *J/K* periods.

		Mean of returns			Volatility-adjusted mean of returns		
		J = 6	J = 9	J = 12	J = 6	J = 9	J = 12
K = 2	Mean	5.03%	4.57%	7.21%	4.01%	4.85%	9.25%
	Std	20.43%	21.20%	21.36%	16.82%	18.51%	19.06%
	Sharpe Ratio	0.24	0.21	0.33	0.23	0.25	0.47
	Kurtosis	8.98	8.59	6.66	12.22	13.02	7.48
	Skewness	0.38	0.40	0.27	2.02	1.63	0.69
	MaxDD	31.08%	40.44%	32.44%	44.36%	47.41%	29.43%
	Calmar Ratio	0.16	0.11	0.22	0.09	0.10	0.31
K = 6	Mean	-5.37%	-0.30%	-3.46%	1.55%	4.62%	3.24%
	Std	23.59%	23.32%	26.09%	19.26%	19.46%	21.95%
	Sharpe Ratio	-0.24	-0.02	-0.14	0.07	0.23	0.14
	Kurtosis	7.50	6.06	5.92	8.43	6.07	5.32
	Skewness	-0.30	-0.65	-0.91	1.12	-0.02	-0.34
	MaxDD	73.00%	86.43%	80.73%	40.11%	44.78%	62.35%
	Calmar Ratio	-0.07	0.00	-0.04	0.04	0.10	0.05

Table 9. Four factors model analysis

Table 9 shows the results of regressing the strategies returns (12/0/2-months) against the four factor-model under the different proposed weighted schemes. In parentheses we report the t-statistics. Bolded t-stats are significant at 95% level.

	Mean of returns						Volatility-adjusted mean of returns					
	Alpha	RMRF	SMB	HML	MOM	Adjusted R2	Alpha	RMRF	SMB	HML	MOM	Adjusted R2
Equally weighted	0.68	-0.16	0.07	0.03	0.08	0.006	0.71	-0.12	0.11	0.06	0.04	0.00
	(1.53)	-(1.58)	(0.56)	(0.23)	(0.93)		(1.77)	-(1.39)	(0.99)	(0.53)	(0.62)	
Volatility weighted	0.69	-0.176	0.084	0.035	0.06	0.007	0.51	-0.09	0.07	0.02	0.06	0.00
	(1.59)	-(1.74)	(0.65)	(0.25)	(0.77)		(1.49)	-(1.20)	(0.77)	(0.24)	(1.01)	
Momentum weighted	0.66	-0.111	-0.02	-0.01	0.09	0.001	0.77	-0.10	0.06	0.01	0.03	0.00
	(1.53)	-(1.10)	-(0.17)	-(0.08)	(1.20)		(1.97)	-(1.17)	(0.59)	(0.14)	(0.49)	
Momentum weighted (10)	0.82	-0.131	0.126	0.015	0.058	0.007	1.08	-0.20	0.20	0.04	-0.01	0.00
	(1.54)	-(1.06)	(0.80)	(0.09)	(0.58)		**(2.17)**	-(1.81)	(1.41)	(0.28)	-(0.14)	
Momentum weighted (12)	0.91	-0.137	0.134	-0.003	0.064	0.006	1.23	-0.28	0.15	-0.07	-0.00	0.01
	(1.64)	-(1.07)	(0.82)	-(0.02)	(0.61)		**(2.43)**	**-(2.45)**	(1.02)	-(0.44)	-(0.04)	

Table 10. Performance of strategies under different market states

Table 10 shows the returns of the strategies under study and the S&P 500 index to different financial distress events occurred during the period under review. The selection criterion is the mean of returns.

Event	MOM	S&P 500
Dot-com crash	9.81%	-37.61%
Post Dot-com crash	-29.33%	14.84%
Subprime Crisis	67.12%	-49.69%
Post Subprime crisis	-32.17%	43.03%

Table 11. Performance of pure option momentum strategies

Table 11 shows the performance of pure equity option strategies on the previously momentum selected stocks. First is showed the naïve strategy in which all selected stocks were used. Next, the results of the strategies based on the top and the bottom quintile are exposed. The two proposed selection criteria were used.

All available options						
	Mean of returns			Volatility-adjusted mean of returns		
	Long Calls	Long Puts	Aggregated	Long Calls	Long Puts	Aggregated
Mean	5.14%	4.95%	5.06%	5.26%	4.06%	4.72%
Std	8.08%	11.74%	5.91%	7.10%	10.72%	5.25%
Sharpe Ratio	0.61	0.40	0.82	0.71	0.36	0.85
Kurtosis	3.81	6.34	4.19	4.05	5.29	5.36
Skewness	1.14	1.70	0.85	1.09	1.56	1.06
MaxDD	15.01%	31.77%	14.69%	16.69%	27.52%	11.16%
Calmar Ratio	0.34	0.16	0.34	0.31	0.15	0.42

10 highest momentum stock options						
	Mean of returns			Volatility-adjusted mean of returns		
	Long Calls	Long Puts	Aggregated	Long Calls	Long Puts	Aggregated
Mean	4.77%	2.77%	3.88%	4.69%	2.74%	3.78%
Std	8.45%	12.75%	6.86%	8.04%	11.71%	5.88%
Sharpe Ratio	0.54	0.20	0.49	0.56	0.22	0.60
Kurtosis	5.73	7.39	3.64	6.83	6.04	3.83
Skewness	1.21	1.62	0.59	1.50	1.56	0.76
MaxDD	22.49%	36.80%	20.89%	21.24%	33.63%	15.91%
Calmar Ratio	0.21	0.08	0.19	0.22	0.08	0.24

10 lowest momentum stock options						
	Mean of returns			Volatility-adjusted mean of returns		
	Long Calls	Long Puts	Aggregated	Long Calls	Long Puts	Aggregated
Mean	3.61%	5.11%	4.40%	5.08%	5.38%	5.23%
Std	10.15%	13.26%	7.04%	8.59%	11.64%	6.28%
Sharpe Ratio	0.33	0.37	0.60	0.57	0.45	0.80
Kurtosis	5.37	8.53	3.79	6.47	7.00	6.94
Skewness	1.18	2.13	0.88	1.49	1.90	1.34
MaxDD	30.32%	33.89%	15.58%	17.44%	28.71%	8.71%
Calmar Ratio	0.12	0.15	0.28	0.29	0.19	0.60

Table 12. Four factors model analysis

Table 12 shows the results of regressing the monthly strategies returns against the four factor-model. In parentheses, we report the t-statistics. Bolded t-stats are significant at 95% level.

All available option	Alpha	RMRF	SMB	HML	MOM	Adjusted R2
Mean of returns	0.19	0.00	0.07	-0.05	0.02	0.04
	(1.62)	(0.13)	**(2.10)**	-(1.21)	(1.03)	
Volatility-adjusted mean of returns	0.16	0.03	-0.06	0.03	0.01	0.01
	(1.61)	(1.04)	-(1.91)	(0.77)	(0.37)	

10 highest momentum stock options	Alpha	RMRF	SMB	HML	MOM	Adjusted R2
Mean of returns	0.08	0.03	0.08	-0.03	0.02	0.03
	(0.63)	(0.85)	**(2.05)**	-(0.68)	(0.72)	
Volatility-adjusted mean of returns	0.08	0.04	-0.06	0.05	0.01	0.02
	(0.70)	(1.48)	-(1.68)	(1.45)	(0.44)	

10 lowest momentum stock options	Alpha	RMRF	SMB	HML	MOM	Adjusted R2
Mean of returns	0.15	-0.03	0.12	-0.05	0.03	0.04
	(0.99)	-(0.79)	**(2.65)**	-(1.03)	(0.88)	
Volatility-adjusted mean of returns	0.21	-0.01	0.09	-0.07	0.03	0.06
	(1.73)	-(0.26)	**(2.51)**	-(1.80)	(1.18)	

Table 13. Performance of the equity option momentum strategies mixed with index options.

Table 13 shows the performance of pure equity option strategies on the previously momentum selected stocks mixed with index options selling strategies. First, is showed the naïve strategy in which all selected stocks were used. Next, the results of the strategies based on the top and the bottom quintile are exposed. The two proposed selection criteria were used

All available options						
	Mean of returns			Volatility-adjusted mean of returns		
	Long Leg (Calls)	Short Leg (Puts)	Aggregated	Long Leg (Calls)	Short Leg (Puts)	Aggregated
Mean	5.48%	7.52%	6.56%	6.22%	6.55%	6.33%
Std	5.88%	8.56%	6.12%	5.27%	7.05%	5.28%
Sharpe Ratio	0.89	0.85	1.03	1.14	0.90	1.16
Kurtosis	17.03	5.26	3.94	14.32	3.17	4.31
Skewness	2.10	1.56	1.03	1.62	1.28	0.97
MaxDD	12.35%	15.06%	12.46%	7.08%	10.07%	6.76%
Calmar Ratio	0.44	0.50	0.53	0.88	0.65	0.94

10 highest momentum stocks options						
	Mean of returns			Volatility-adjusted mean of returns		
	Long Leg (Calls)	Short Leg (Puts)	Aggregated	Long Leg (Calls)	Short Leg (Puts)	Aggregated
Mean	6.46%	5.15%	5.85%	6.08%	5.24%	6.08%
Std	6.99%	8.90%	6.35%	6.29%	8.06%	6.29%
Sharpe Ratio	0.89	0.55	0.88	0.93	0.62	0.93
Kurtosis	4.36	4.53	1.93	4.82	2.99	4.82
Skewness	1.08	1.43	0.65	0.91	1.16	0.91

MaxDD	15.48%	16.23%	13.43%	9.79%	14.75%	9.79%
Calmar Ratio	0.42	0.32	0.44	0.62	0.36	0.62

10 lowest momentum stocks options

	Mean of returns			Volatility-adjusted mean of returns		
	Long Leg (Calls)	Short Leg (Puts)	Aggregated	Long Leg (Calls)	Short Leg (Puts)	Aggregated
Mean	5.23%	7.64%	6.53%	6.57%	7.91%	7.25%
Std	8.51%	9.83%	7.26%	7.24%	8.42%	6.40%
Sharpe Ratio	0.59	0.75	0.87	0.88	0.91	1.10
Kurtosis	11.78	8.76	4.70	13.96	6.25	6.54
Skewness	1.85	2.11	1.14	2.03	1.94	1.48
MaxDD	18.60%	11.64%	12.37%	7.80%	10.64%	6.28%
Calmar Ratio	0.28	0.66	0.53	0.84	0.74	1.15

Table 14. Four factors model analysis

Table 14 shows the results of regressing equity/index option strategies returns against the four-factor model. In parentheses, we report the t-statistics. Bolded t-stats are significant at 95% level

All available options	Alpha	RMRF	SMB	HML	MOM	Adjusted R2
Mean of returns	0.35	-0.02	-0.01	0.01	-0.01	0.01
	(2.78)	-(0.60)	-(0.37)	(0.28)	-(0.49)	
Volatility-adjusted mean of returns	0.34	-0.01	-0.04	-0.01	-0.01	0.01
	(3.12)	-(0.54)	-(1.25)	-(0.25)	-(0.68)	

10 highest momentum stocks options	Alpha	RMRF	SMB	HML	MOM	Adjusted R2
Mean of returns	0.28	0.01	-0.04	0.02	-0.01	0.01
	(2.15)	(0.40)	-(0.91)	(0.41)	-(0.48)	
Volatility-adjusted mean of returns	0.27	0.00	-0.05	0.01	-0.01	0.00
	(2.34)	(0.15)	-(1.44)	(0.25)	-(0.36)	

10 lowest momentum stocks options	Alpha	RMRF	SMB	HML	MOM	Adjusted R2
Mean of returns	0.40	-0.07	-0.02	-0.03	-0.05	0.01
	(2.76)	**-(2.19)**	-(0.36)	-(0.60)	-(1.62)	
Volatility-adjusted mean of returns	0.44	-0.04	-0.04	-0.03	-0.03	0.00
	(3.40)	-(1.47)	-(0.90)	-(0.71)	-(1.27)	

FIGURES

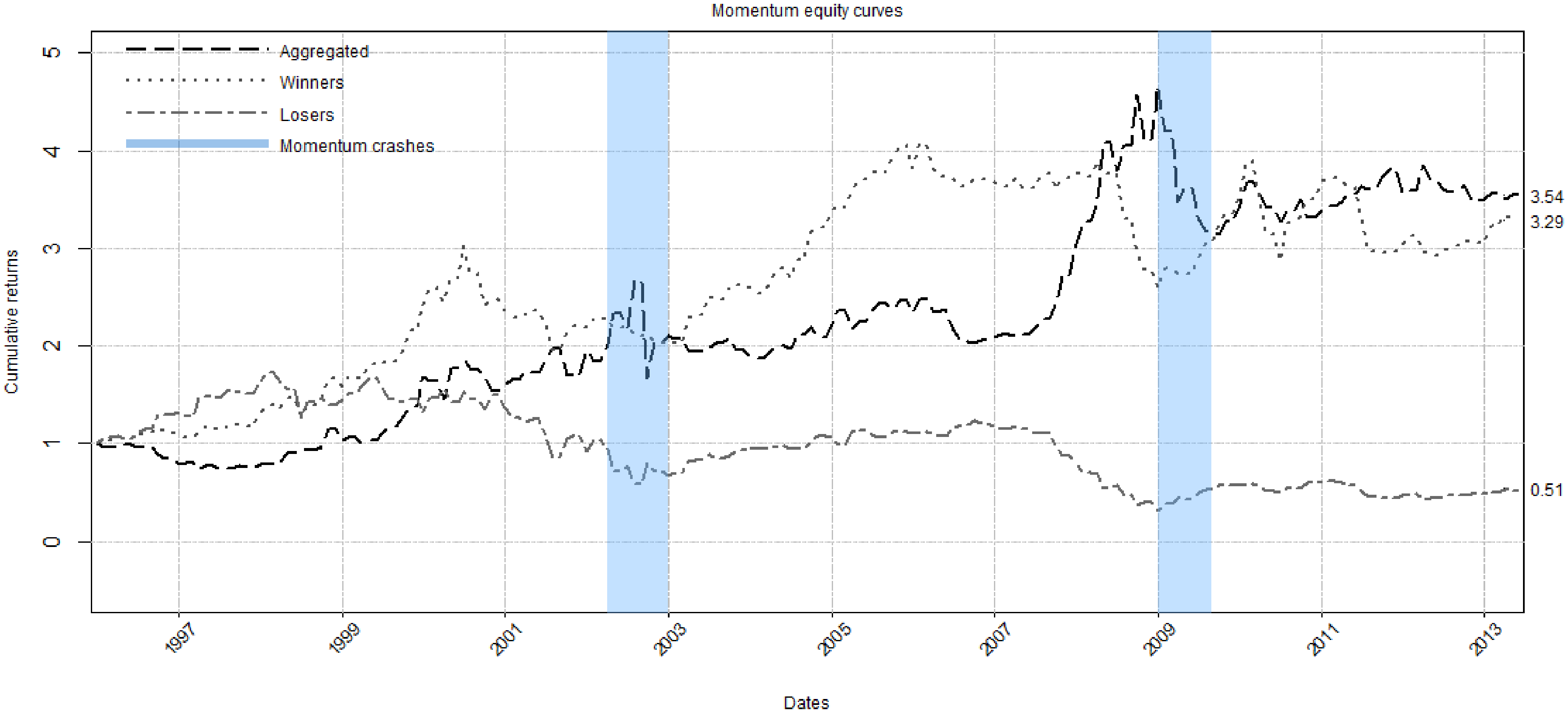

Figure 1. Mean of return selection criterion
This plot shows the equity curves (cumulative monthly returns) to the three momentum portfolios; the aggregated one ("auto-financed" - *long/short* positions), past winners (top decile) and past losers (bottom decile). Momentum crash events were highlighted. The selection criterion used was the mean of returns with an equally-weighted approach.

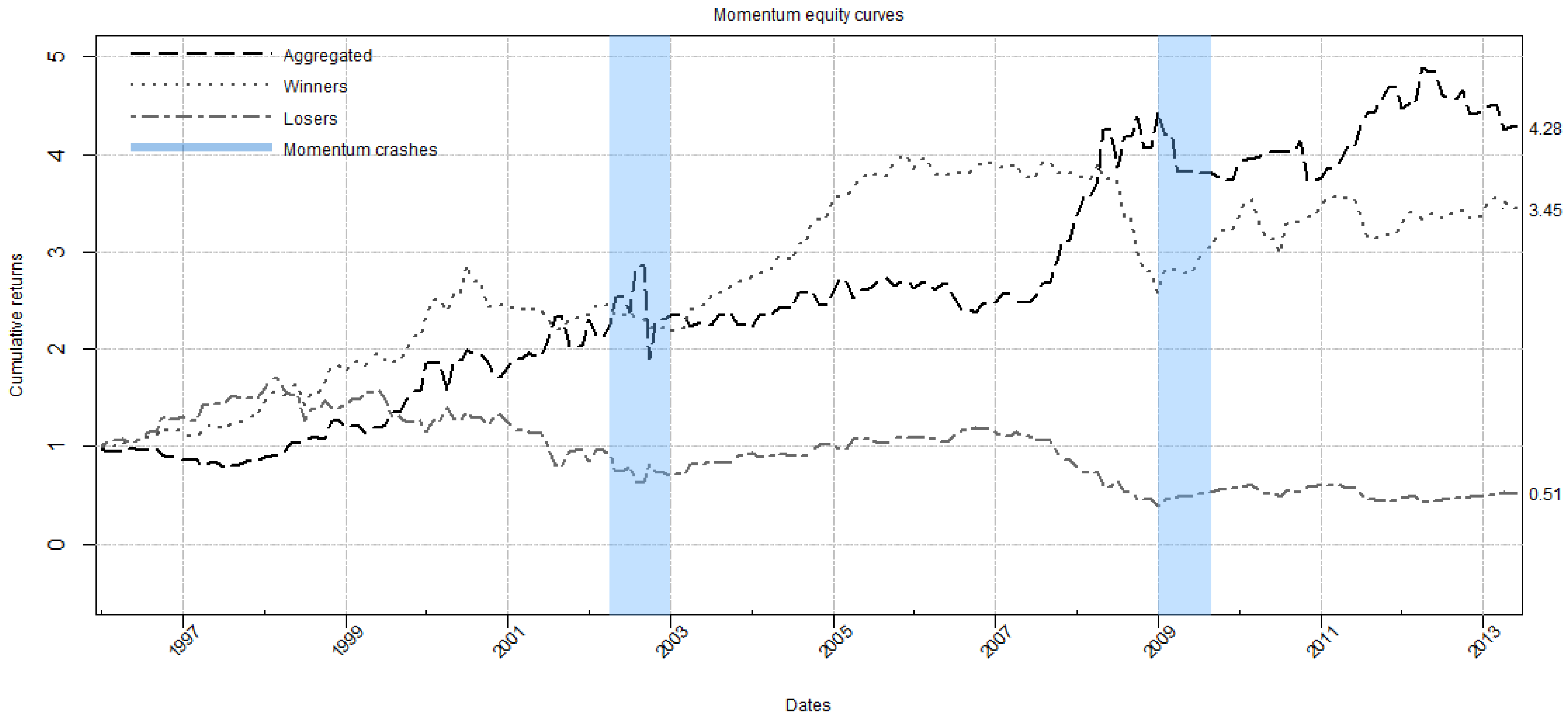

Figure 2. Volatility-adjusted mean of return selection criterion
This plot shows the equity curves (cumulative monthly returns) to the three momentum portfolios; the aggregated one ("auto-financed" - *long*/*short* positions), past winners (top decile) and past losers (bottom decile). Momentum crash events were highlighted. The selection criterion used was the volatility-adjusted mean of returns with an equally-weighted approach.

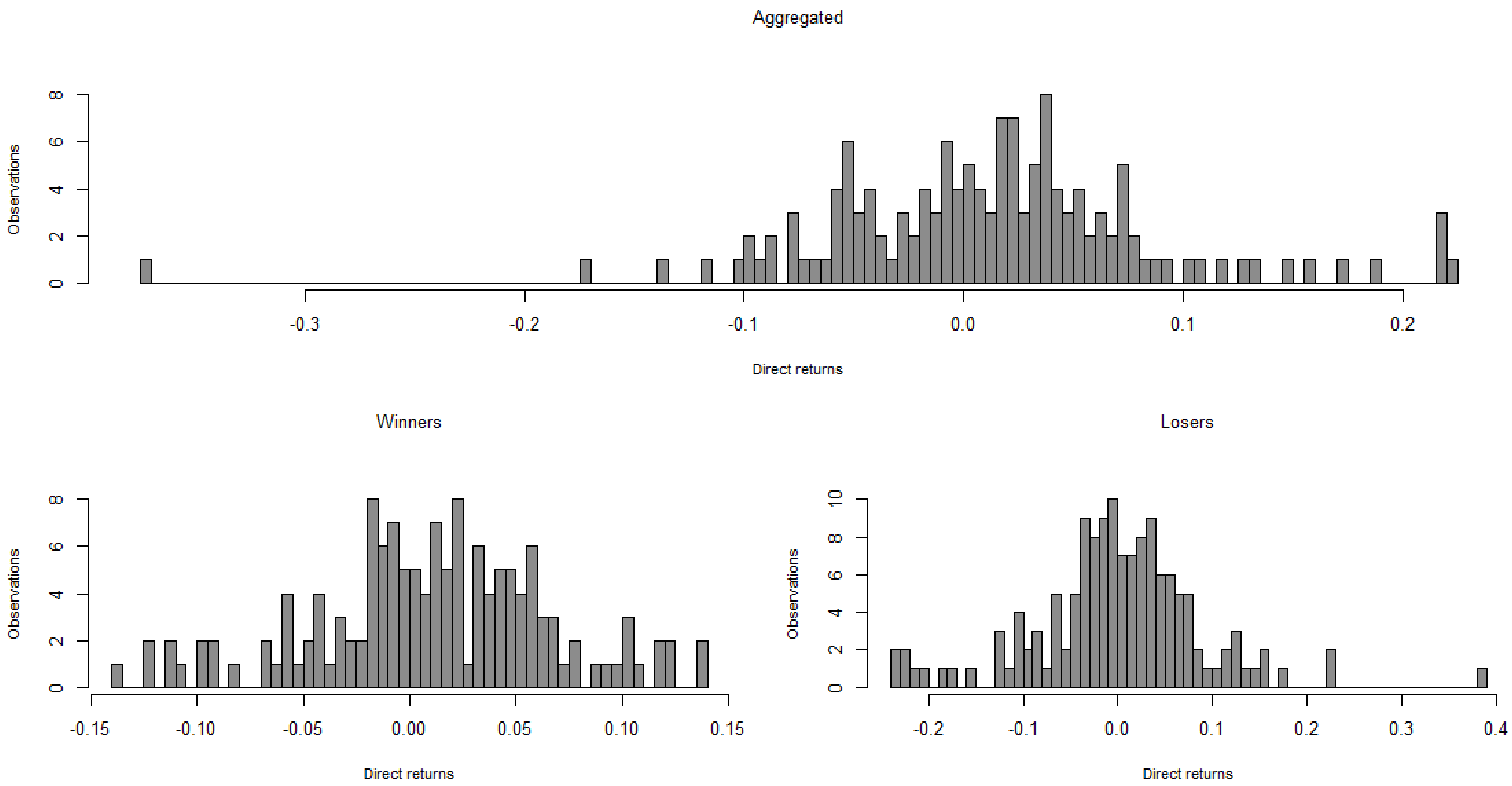

Figure 3. Histogram of returns
This plot shows the histograms (monthly direct returns) to the three momentum portfolios; the aggregated one ("auto-financed" - *long*/*short* positions) at the top, past winners (top decile) at the bottom left and past losers (bottom decile) at the bottom right. The selection criterion used was the mean of returns with an equally-weighted approach.

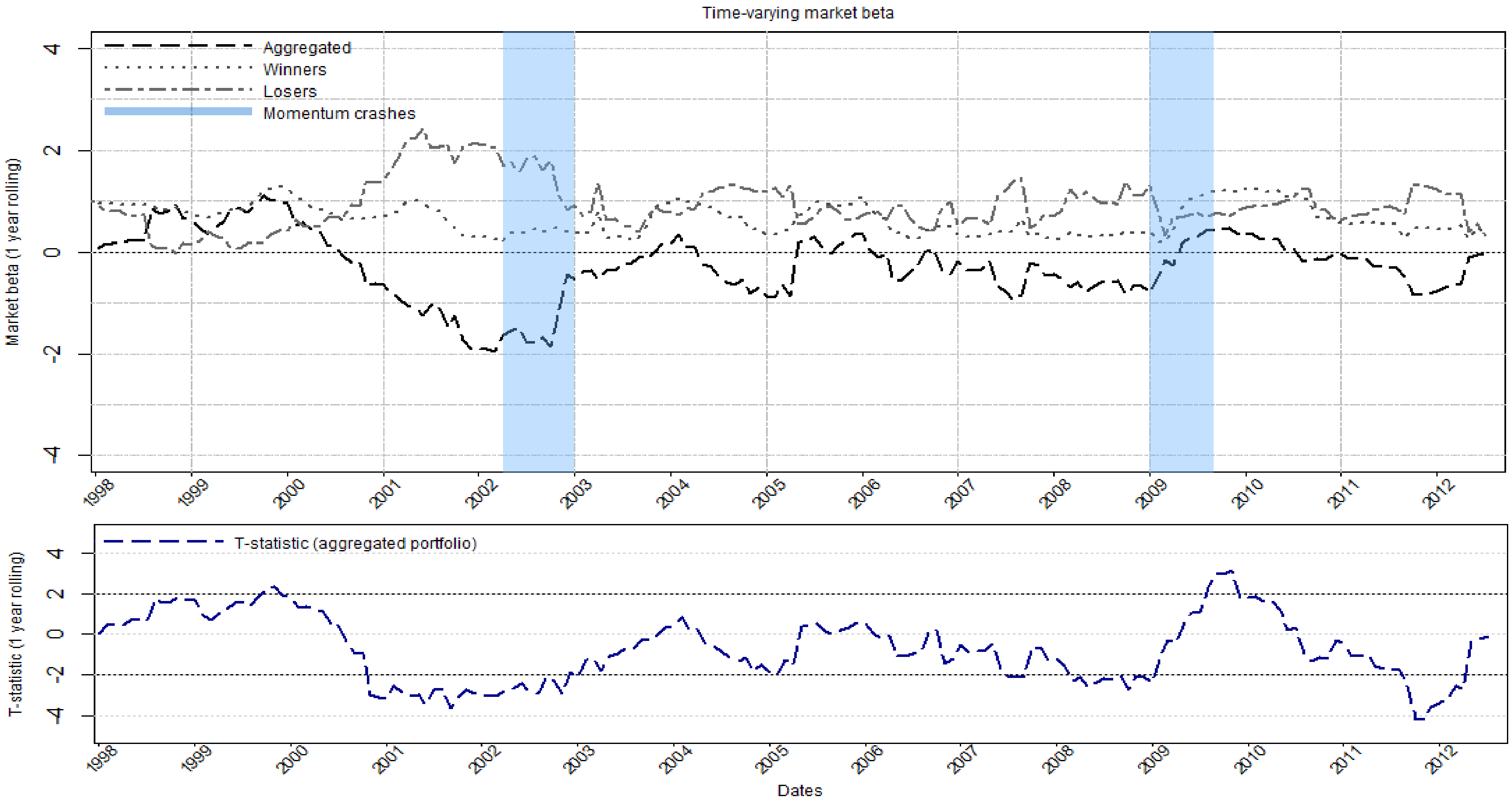

Figure 4. Time-varying market beta

The first plot presents the estimated market betas to the three momentum portfolios; the aggregated one ("auto-financed" - *long*/*short* positions), past winners (top decile) and past losers (bottom decile). The selection criterion used was the mean of returns under an equally-weighted approach. To estimate the market betas was run a 12-months rolling linear regression of the momentum strategies excess returns on the contemporaneous excess market returns. The second plot presents the estimated t-stat to the aggregated market beta at each point in time.

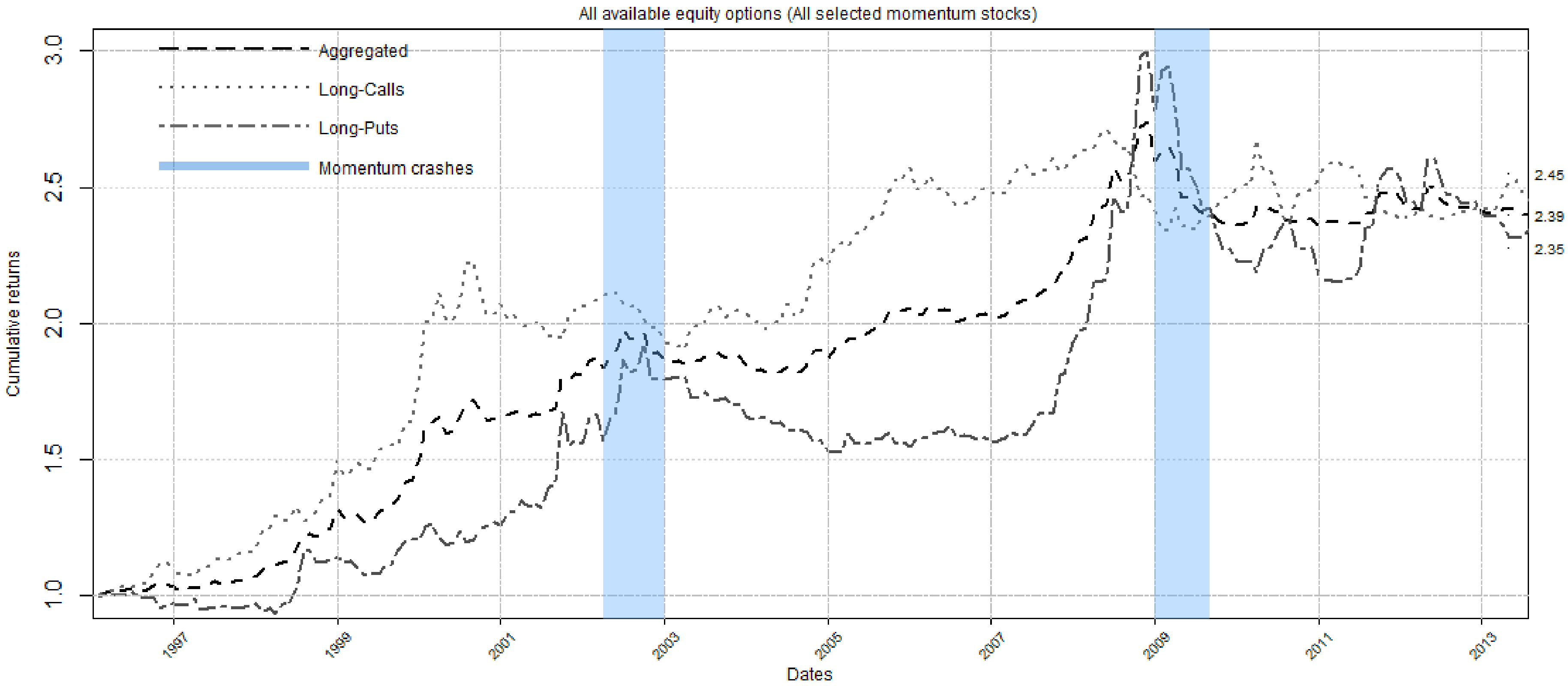

Figure 5. Option momentum strategy with the mean of returns selection criterion
This plot shows the equity curves (cumulative monthly returns) to the three pure equity option momentum portfolios; the aggregated one (*long* positions in calls/puts), long call positions and long put positions. Momentum crash events were highlighted. The selection criterion used was the mean of returns under an equally-weighted approach.

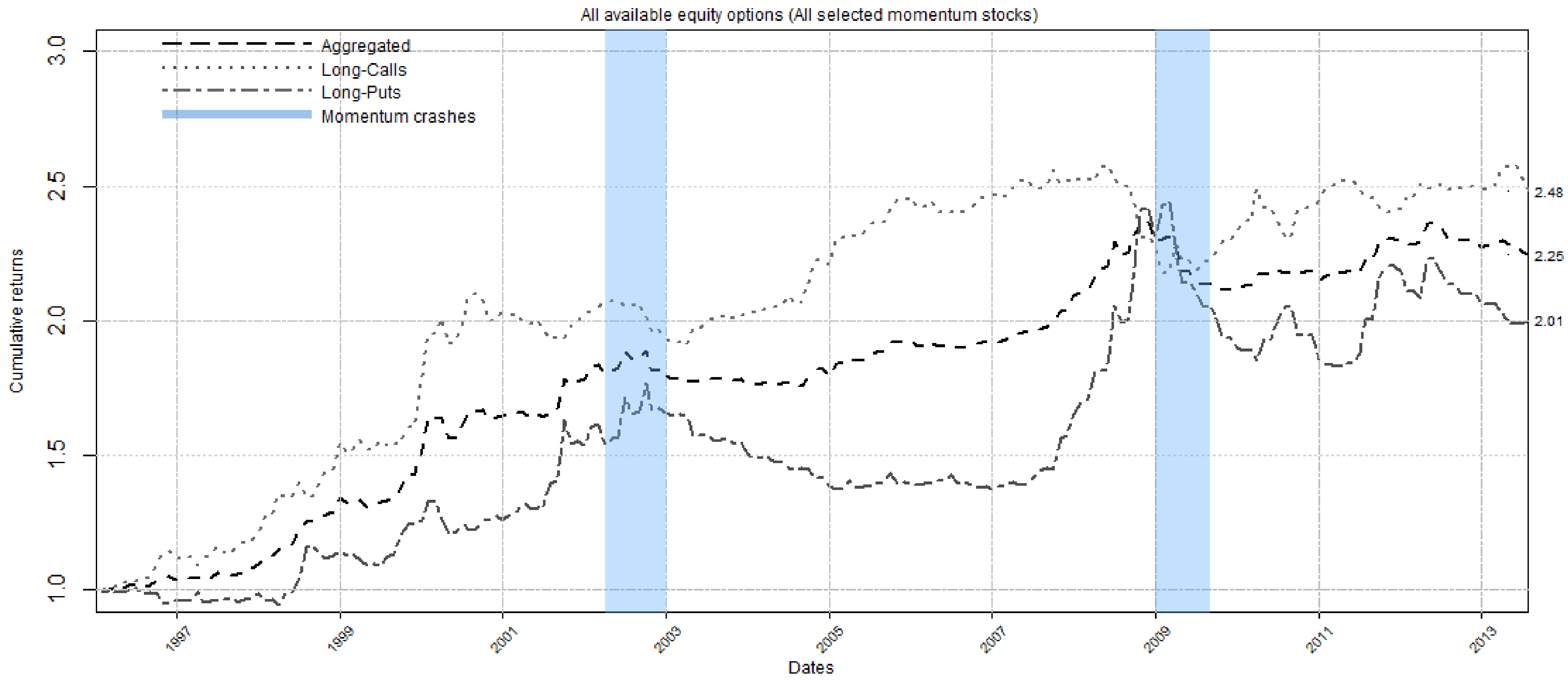

Figure 6. Option momentum strategy with the volatility-adjusted mean of returns selection criterion
This plot shows the equity curves (cumulative monthly returns) to the three pure equity option momentum portfolios; the aggregated one (*long* position in calls/puts), long call positions and long put positions Momentum crash events were highlighted. The selection criterion used was the volatility-adjusted mean of returns under an equally-weighted approach.

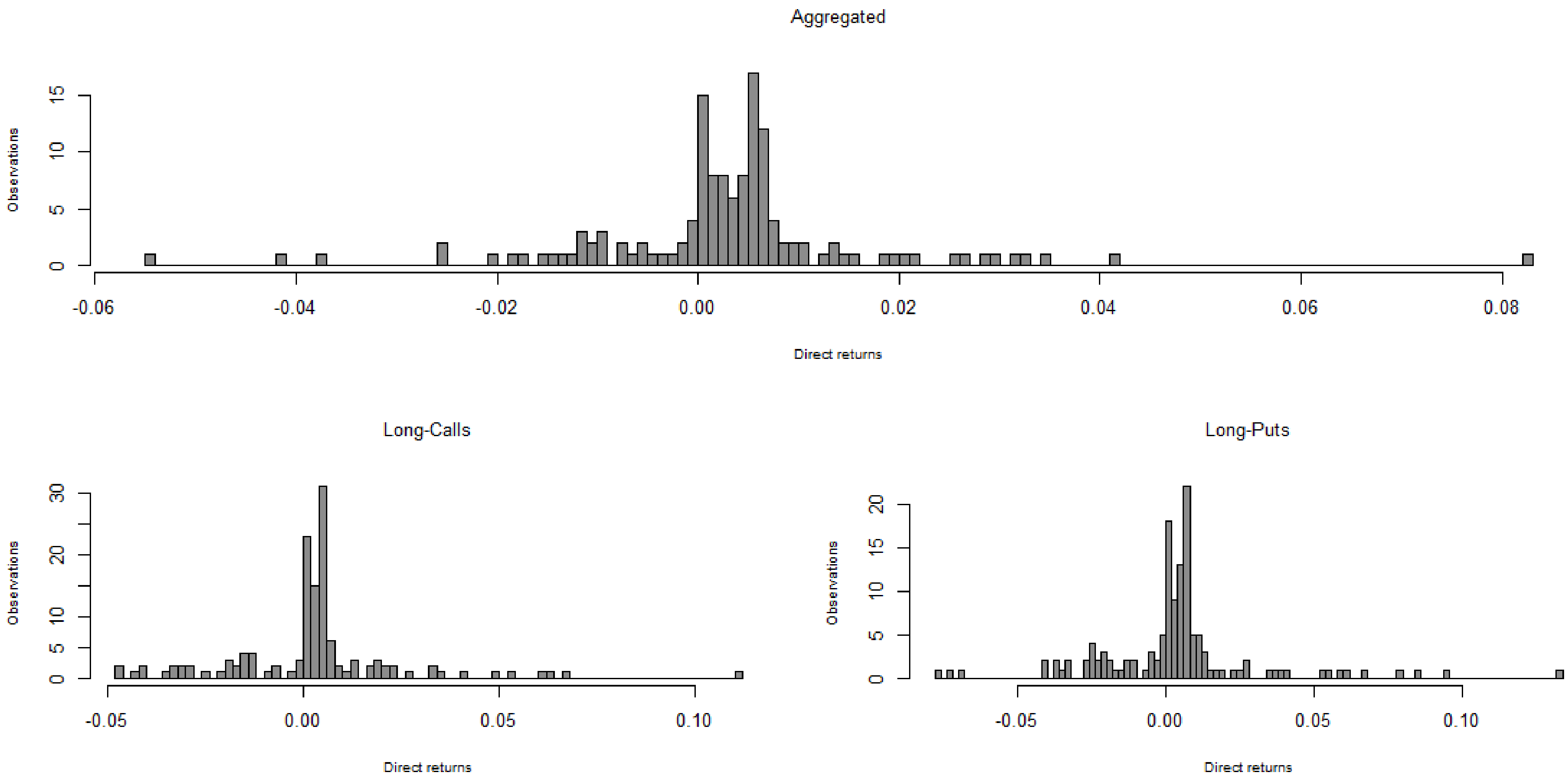

Figure 7. Histogram of returns
This plot shows the histograms (monthly direct returns) to the three pure equity option momentum portfolios; the aggregated one (*long* position in calls/puts), long call positions and long put positions. The selection criterion used was the mean of returns under an equally-weighted approach.

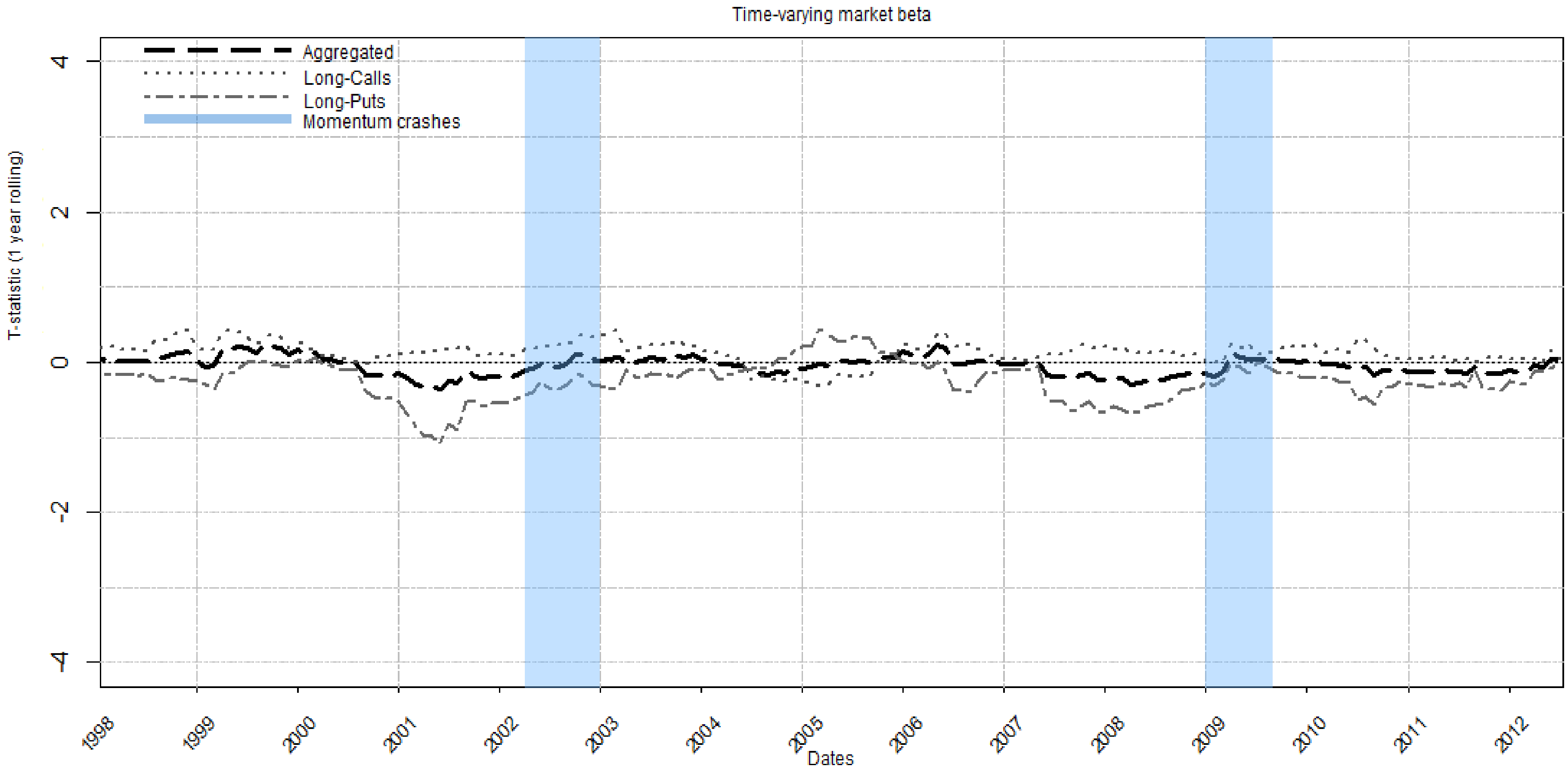

Figure 8. Time-varying of market beta

This plot presents the estimated market betas to the three pure stock option momentum portfolios; the aggregated one (*long* position in calls/puts), long call positions and long put positions. The selection criterion used was the mean of returns under an equally-weighted approach. To estimate the market betas was run a 12 months rolling linear regression of the strategies excess returns on the contemporaneous excess market returns.

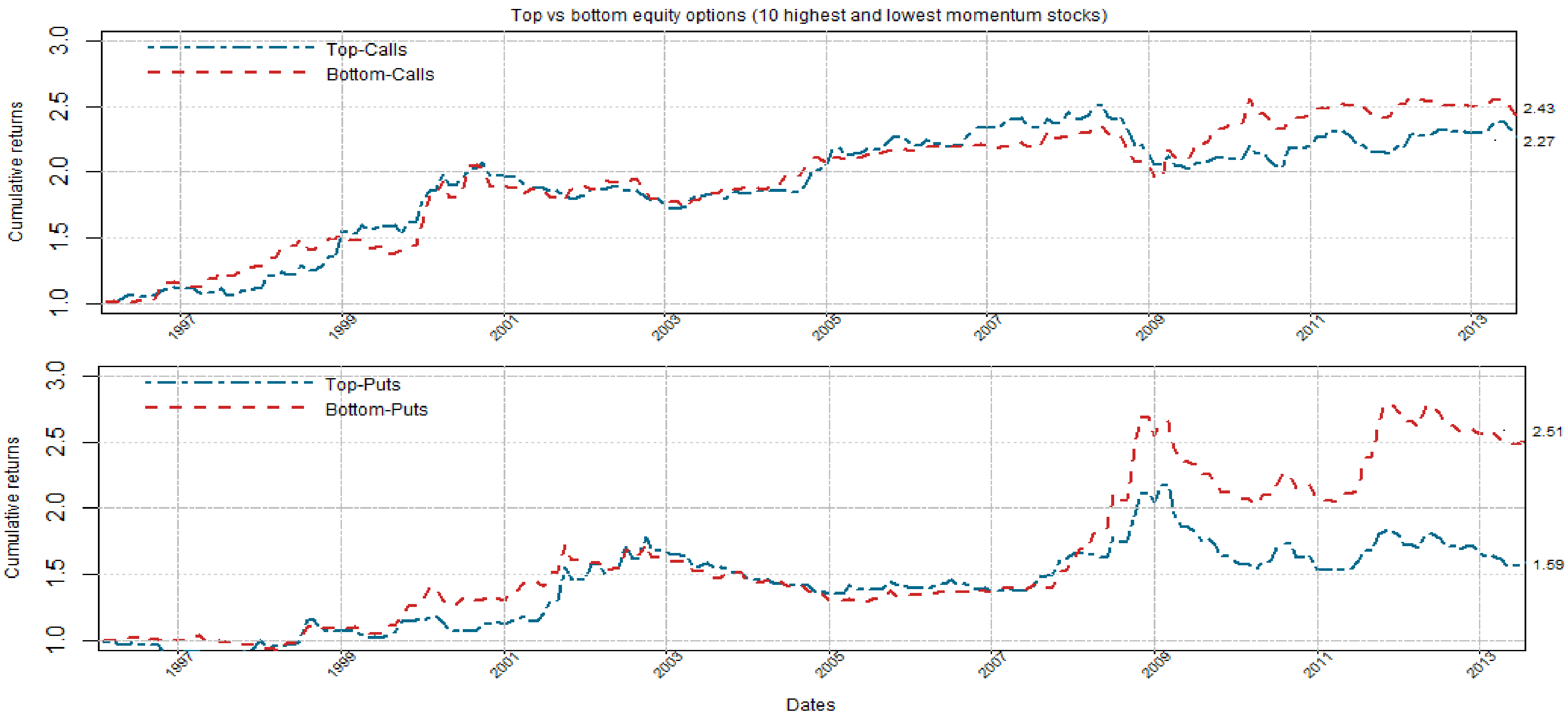

Figure 9. Top and bottom percentiles of put and call positions
This plot shows the top and bottom percentiles for each single position (calls and puts). The selection criterion used was the volatility-adjusted mean of returns under an equally-weighted approach.

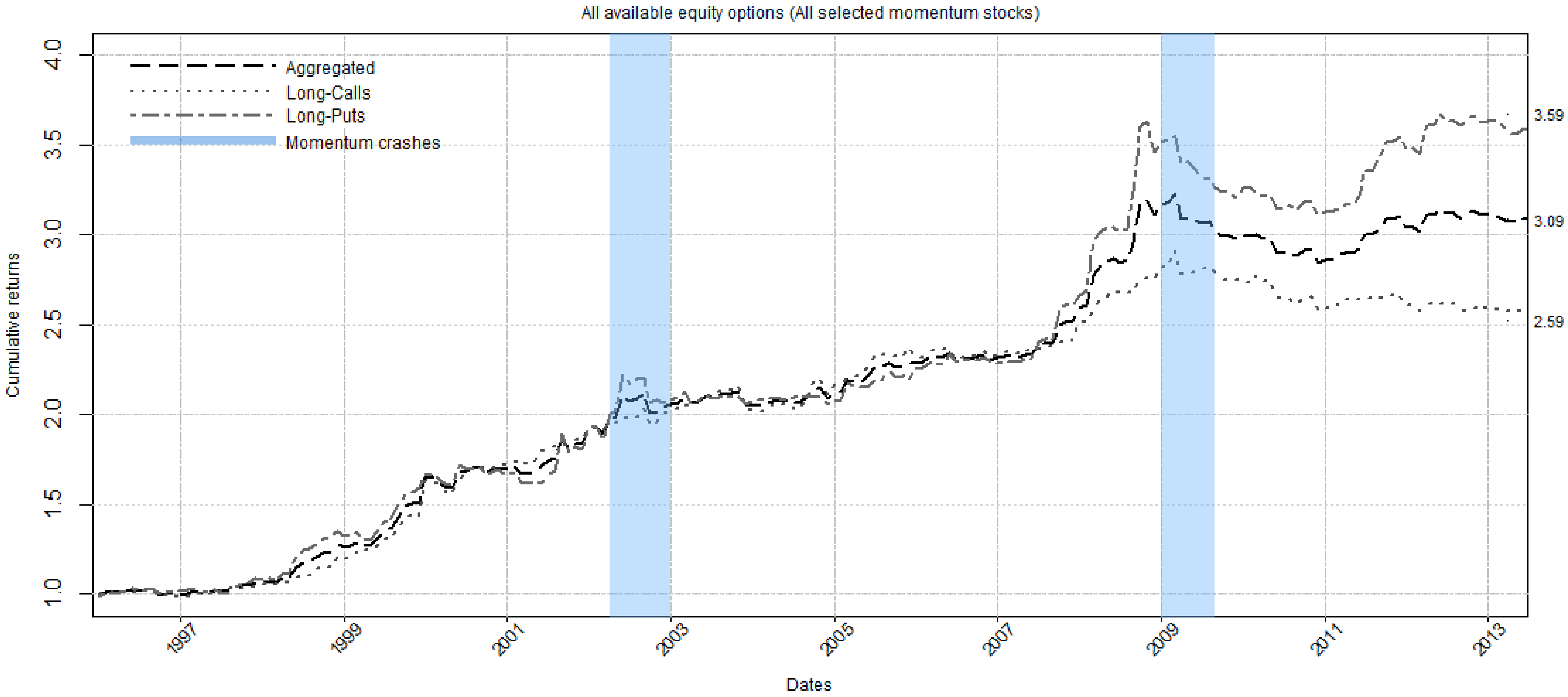

Figure 10. Option momentum strategy with the mean of returns selection criterion

This plot shows the equity curves (cumulative monthly returns) to the three mixed equity/index option portfolios; the aggregated one (*long* position in call/put equity options and short positions in call/put index options), long call equity options/short call index options and long put equity options/short put index options. Momentum crash events were highlighted. The selection criterion used was the mean of returns under an equally-weighted approach. One contract each one-hundred shares was taken.

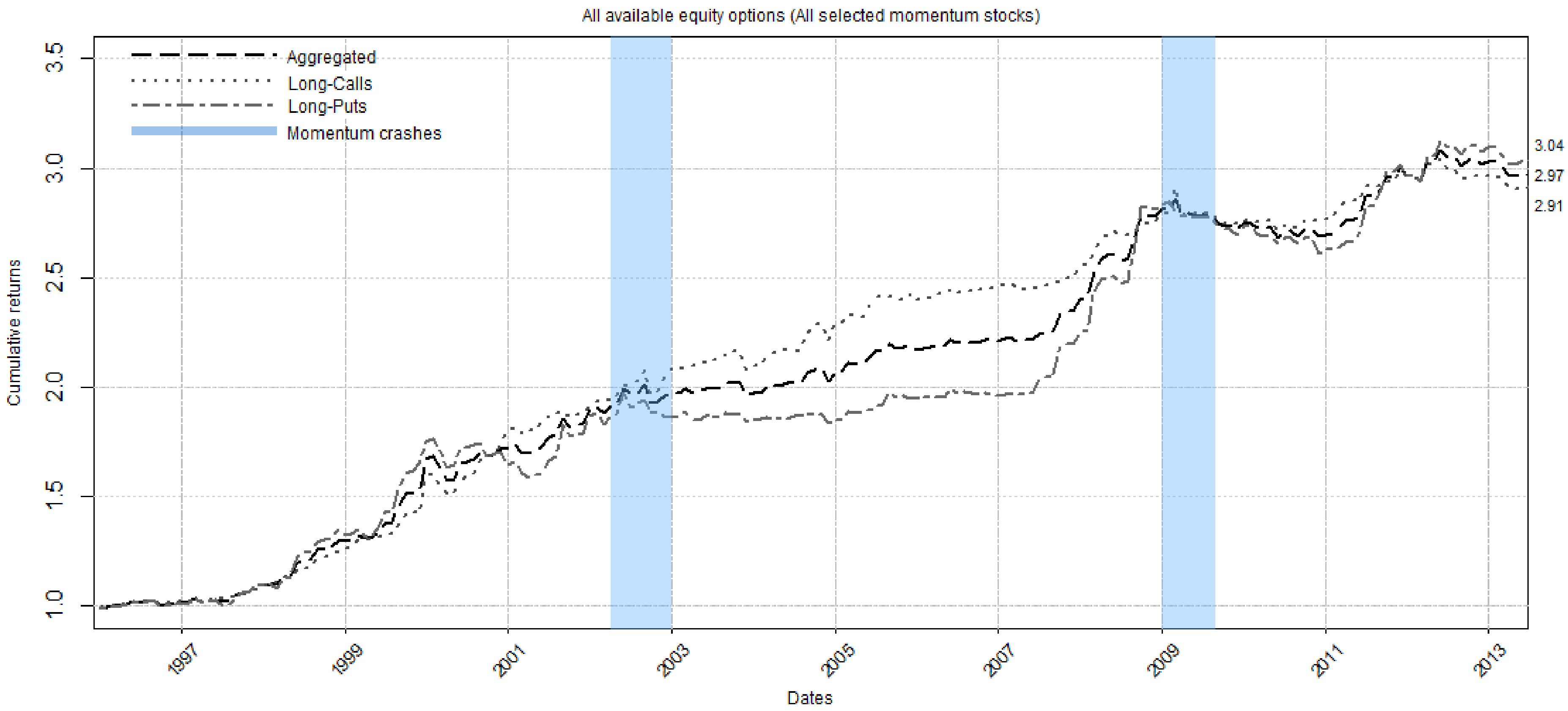

Figure 11. Option momentum strategy with the volatility-adjusted mean of returns selection criterion
This plot shows the equity curves (cumulative monthly returns) to the three momentum mixed equity/index option portfolios; the aggregated one (*long* position in call/put equity options and short positions in call/put index options), long call equity options/short call index options and long put equity options/short put index options. Momentum crash events were highlighted. The selection criterion used was the volatility-adjusted mean of returns under an equally-weighted approach. One contract each one-hundred shares was taken.

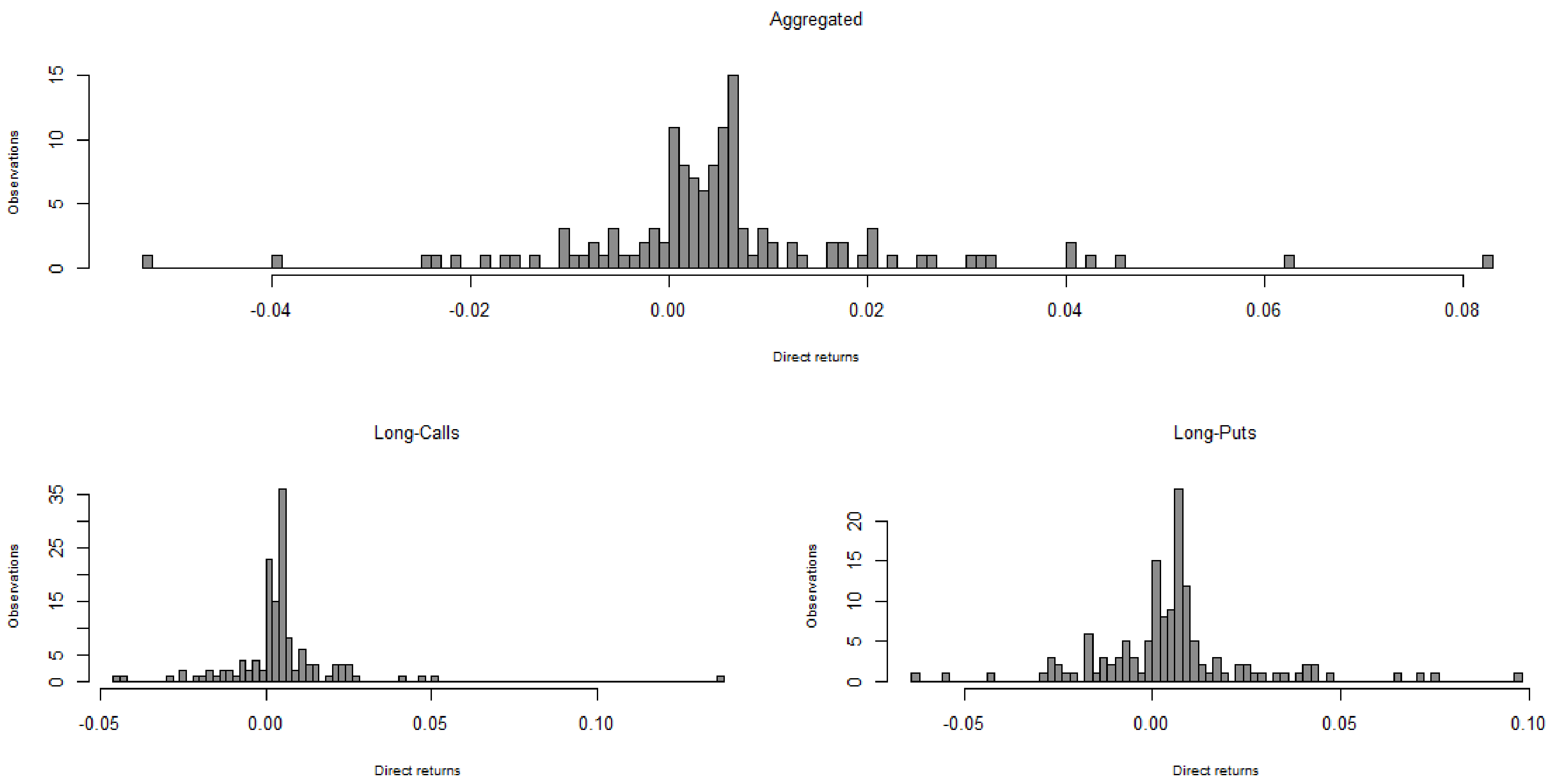

Figure 12. Histogram of returns

This plot shows the histograms (monthly direct returns) to the three mixed equity/index option momentum portfolios; the aggregated one (*long* position in call/put equity options and short positions in call/put index options), long call equity options/short call index options and long put equity options/short put index options. The selection criterion used was the mean of returns under an equally-weighted approach.