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12-1 long/short momentum strategy

Implementation and enhancements

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Case study

24 January 2023

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What is Momentum?

- In physics, momentum refers to the **quantity of motion** that an object has.

- In finance, momentum describes the **rate of change of returns** of an asset.

- Returns are measured over time to determine the momentum rate over a specific time period.

- Momentum: investing style where an investor buys and sells stocks based on recent price trends. If there is enough force behind a price move, the price will continue to move in the same direction.

- Momentum: opposite of "buy low and sell high", as **momentum trading focuses on riding upward or downward price trends**.

Momentum abnormality

Efficient Market Hypothesis states that **asset prices reflect all available information, and only new information should affect asset prices**. Past performance should not be an indicator of future performance, and the fact that stock prices are increasing should not be a reason for further increases.

Said differently, assuming the efficient market hypothesis holds, momentum should not exist. Therefore, **the presence of momentum is the result of anomalies in the financial markets**. Research attributes the anomaly of momentum to investor irrationality. While the efficient market hypothesis assumes rational behavior, momentum may be attributed to irrational behavior, such as cognitive bias or other behavioral effects.

12-1 Momentum

- **12**: Number of lookback periods on which momentum is calculated.

- **-1**: Most recent observation excluded from momentum calculation window, to remove any short-term reversal effects.

- Strategy is naive - stocks part of the momentum strategy are equally weighted.

12-1 momentum: strategy long stocks with highest momentum (winners) and short stocks with lowest momentum (losers). Highest and lowest momentum derived from past 12 monthly returns, to the exception of the most recent one.

Data and objectives

DATA:

Monthly returns of stocks in the MSCI World index from January 1995 to October 2021. Missing data means that the stock was not included in the MSCI World Index, and can NOT be part of the momentum strategy. Dataset includes 322 monthly returns. 4,352 stocks were part of the MSCI World Index during the period.

OBJECTIVES:

- 1. Implement and backtest a 12-1 momentum strategy, long 20% stocks with highest momentum, short 20% stocks with lowest momentum, and with monthly rebalacing assuming one month holding period.

- 2. Propose alternative approaches to improve return-over-risk ratio in comparison with the initial 12-1 long/short momentum strategy.

Implementation

12-1 momentum: 12-month cumulative return, excluding the most recent monthly return to remove short-term reversal effects.

$$12 - 1\, momentum_t = \frac{\prod_{i=1}^{12}(1 + r_{t-i+1})}{(1 + r_t)} - 1$$

Month 12	Month 11	Month 10	Month 9	Month 8	Month 7	Month 6	Month 5	Month 4	Month 3	Month 2	Month 1
30/11/2020	31/12/2020	31/01/2021	28/02/2021	31/03/2021	30/04/2021	31/05/2021	30/06/2021	31/07/2021	31/08/2021	30/09/2021	31/10/2021
t-11	t-10	t-9	t-8	t-7	t-6	t-5	t-4	t-3	t-2	t-1	t
monthly returns included in momentum calculation											October monthly return not included in 12-1 momentum

- 1. Derive from monthly returns the 12-1 momentums and the number of stocks part of the MSCI World Index each month.

- 2. Identify and select the 20% top and 20% bottom stocks with highest and lowest 12-1 momentum respectively.

- 3. Initiate long (resp.short) position on 20% top (resp.bottom) momentum stocks, with holding period of one month; Rebalance.

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Stocks available for investment (AFI)

In some instances, top and bottom 20% momentum stocks are no longer part of the MSCI World Index on the following month ⇒ Investment in these stocks no longer possible!

Selected VS AFI stocks
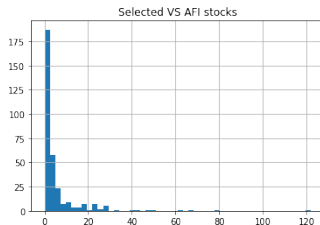
In normal market conditions, selected momentum stocks are mostly AFI on the next month, unlike under stressed market conditions. As an example, in May 2008, 319 long and 257 short positions were AFI in June 2008 out of 349 - 578 stocks AFI on 698.

Measurements

- Monthly long/short 12-1 momentum performance:

$$r_{m,t} = \sum_{i=1,long}^{top_{t-1}} w_{t-1} \cdot r_{i,t} + \sum_{j=1,short}^{bottom_{t-1}} -w_{t-1} \cdot r_{j,t}$$

with $w_{t-1} = \frac{1}{AFI_{t-1}}$

top_{t-1}: number of top AFI stocks to be long at $t-1$

$bottom_{t-1}$: number of bottom AFI stocks to be short at $t-1$

- Cumulative 12-1 momentum performance $r_{c,t} = \prod_{i=1}^{t}(1 + r_{m,i}) - 1$

- Annualized performance $r_A = (1 + r_{C,D})^{\frac{12}{D}} - 1$, with D the total number of months of the momentum strategy

- Annualized volatility $\sigma_A = \sqrt{12} \times \sum_{t=1}^{D} \frac{(r_{m,t} - \bar{r})^2}{D}$, scaling volatility with $\sqrt{12}$ due to monthly returns

Performance chart

12-1 long/short momentum strategy delivers good performance in rising markets, but struggles in bear and stressed markets - where the short strategy particularly suffers. Strategy absolutely crashes during 2008-2009 Global Financial Crisis.

Long/Short 12-1 Momentum strategy performance
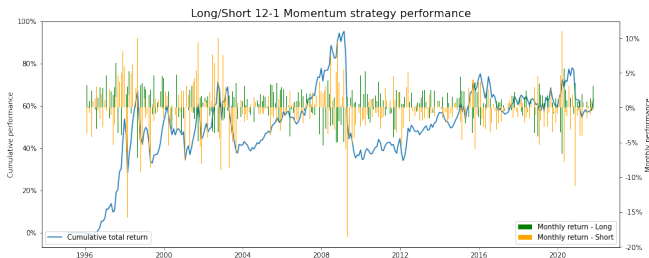
Momentum factor appears to be a performance contributor for long/short portfolios, but a strong performance contributor for long-only portfolios!

Results

- Long and long/short momentum strategy generate a positive return respectively 67% and 59% of the time, whereas short strategy only 45% of the time.

Strategy	Annualized return (in %)	Annualized volatility (in %)	Return-over-Risk ratio
Long	6.18	7.21	0.86
Short	-4.55	11.87	-0.38
Total Long/Short	1.9	9.64	0.2

- Long strategy and long/short strategy profitable. Short strategy is not, and is 64% more volatile than long strategy.

- 12-1 momentum strategy performs better on rising trends than falling ones.

- Return-over-risk ratio for the 12-1 long/short strategy of 0.2, penalized by the short position.

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Half-momentum, half-contrarian

12-1 and 6-1 combination

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Long-only 12-1 momentum strategy

Momentum strategy performance
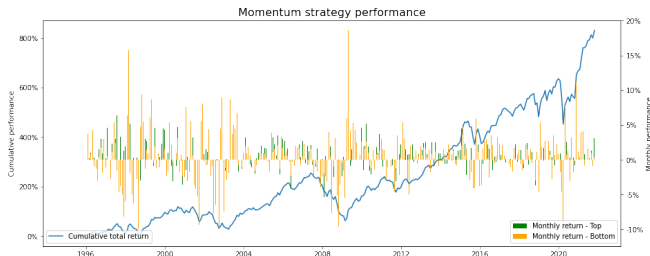
Strategy	Annualized return (in %)	Annualized volatility (in %)	Return over risk ratio
Top	6.18	7.21	0.86
Bottom	3.23	11.87	0.27
Total (Top+Bottom)	9.02	17.11	0.53

- Performance increased significantly, to the detriment of volatility.

- Ratio jumped from 0.2 to 0.5: one unit of risk returns 2.5 times more profit than initial strategy.

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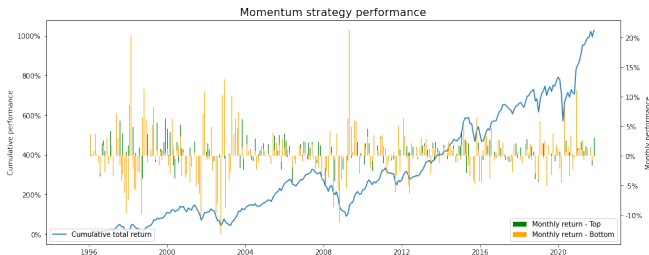Conclusion
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Combination of long/short 12-1 and 6-1 momentums

Select stocks identified in both 12-1 and 6-1 momentum strategies, in an attempt to capture stocks with a solid trend.
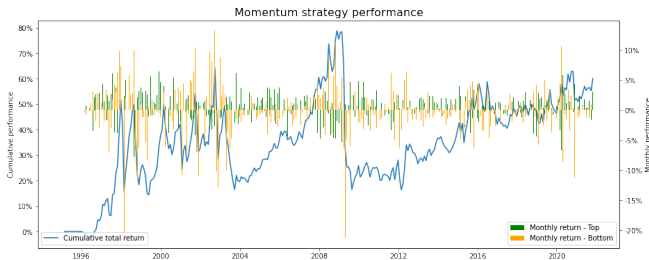
Momentum strategy performance

Strategy	Annualized return (in %)	Annualized volatility (in %)	Return over risk ratio
Top	6.84	7.39	0.92
Bottom	-5.17	13.86	-0.37
Total (Top+Bottom)	1.84	12.3	0.15

Long strategy performs better, while short strategy performs just as bad as the initial strategy.

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Combination of long-only 12-1 and 6-1 momentums

Momentum strategy performance

Strategy	Annualized return (in %)	Annualized volatility (in %)	Return over risk ratio
Top	6.84	7.39	0.92
Bottom	3.35	13.86	0.24
Total (Top+Bottom)	9.84	18.5	0.53

- Long top strategy performs better than initial strategy - ratio from 0.86 to 0.92.

- Long-only approach remains more profitable than long/short.

- Long-only 12-1 and long-only '12-1 and 6-1' momentum strategies share aligned risk-returns profiles and ratio of 0.53.

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Long-only 12-1 momentum from risk-adjusted returns

Risk-adjusted return is a critical element to successful long-term investing, as return potential of any investment should be viewed in the context of the risks it takes to achieve that return.

Long-only 12-1 momentum strategy, with top and bottom momentums derived from risk-adjusted returns ra_t, defined as $ra_t = \frac{r_t}{\frac{\sum_{i=1}^{12}(r_{t-i+1} - \bar{r})^2}{12}}$ - in line with 12-1 momentum calculation window.

Momentum strategy performance

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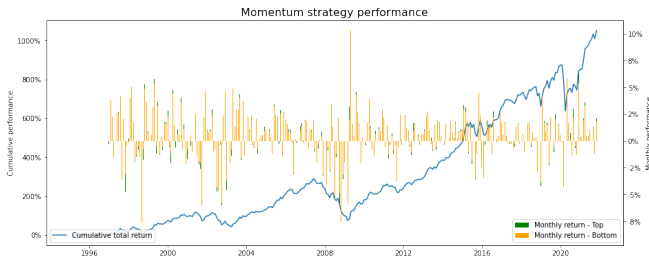
Long-only 12-1 momentum from risk-adjusted returns

Strategy	Annualized return (in %)	Annualized volatility (in %)	Return over risk ratio
Top	4.99	7.57	0.66
Bottom	5.73	7.62	0.75
Total (Top+Bottom)	10.31	15.13	0.68

- Long top strategy performs less than all other strategies - ratio of 0.66 instead of 0.86.

- Long bottom strategy performs significantly well! - ratio of 0.75 instead of -0.38 (resp. 0.27) for long/short (resp. long-only) 12-1 momentum strategy.

- Long-only 12-1 momentum strategy with risk-adjusted returns generated the highest return over risk ratio so far, jumping from 0.2 to 0.68.

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Trend validation with Relative Strength Index (RSI)

IDEA: Be more specific on momentum stocks we decide to buy or short-sell.

The Relative Strength Index is a known contrarian indicator, which measures the speed and change of price movements, in order to detect overbought (RSI $>$ 70) or oversold (RSI $<$ 30) stocks.

$$RSI = 100 - \frac{100}{1 + RS}, \text{ with } RS = \frac{ewma\,(positive\ returns)}{ewma\,(negative\ returns)}$$

STRATEGY:

- Buy top stocks with highest momentum if RSI $<$ 70, otherwise sell - too much bullish momentum, possible downward correction to come.

- Sell bottom stocks with lowest momentum if RSI $>$ 30, otherwise buy - too much bearish momentum, possible upward correction to come.

Trend validation with Relative Strength Index (RSI)

Momentum strategy performance
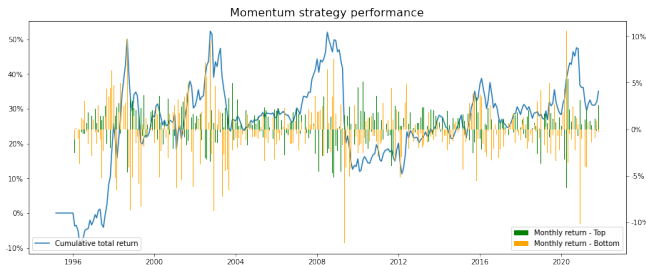
Model performs less than initial strategy!

Strategy	Annualized return (in %)	Annualized volatility (in %)	Return over risk ratio
Top	4.56	5.91	0.77
Bottom	-3.63	10.05	-0.36
Total (Top+Bottom)	1.17	7.86	0.15

Hurst exponent: statistical measure to quantify long-term memory or persistence, and identify if time series exhibits mean-reverting ($H < 0.5$) or trending behavior ($H > 0.5$). No stocks identified with clear trend behavior.

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Drawbacks of Mean-Variance Optimization

- MVO framework assumes asset returns are normally distributed. However, long, short and long/short strategy returns are skewed and not normally distributed.


Performance of the Long/Short momentum strategy
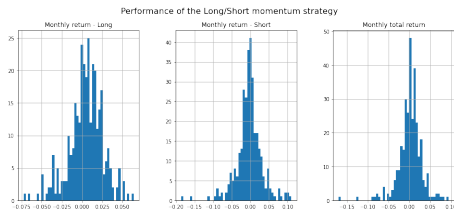
- MVO framework requires a positive semi-definite covariance matrix - guarantees a unique global minimum in a quadratic optimization problem.

- MVO framework highly sensitive to estimation errors. As number of assets and/or correlations increase, portfolio returns and volatility tend to be respectively over and under-estimated, and quadratic optimisers tend to produce unreliable and unstable solutions.

Hierarchical Risk Parity

Recent portfolio optimization technique, developed by Marcos Lopez de Prado (2016).

HRP fundamental idea: **Complex systems such as financial markets show a hierarchical structure such that assets can be grouped into clusters with similar behaviour and risk profile**.

- Form a distance matrix based on the correlation of the portfolio assets.

- Cluster the assets into a tree via hierarchical clustering to form a dendrogram based on distance matrix.

- Within each branch of the tree, form the minimum variance portfolio between two assets.

- Iterate over each level, optimally combining the mini-portfolios at each node.
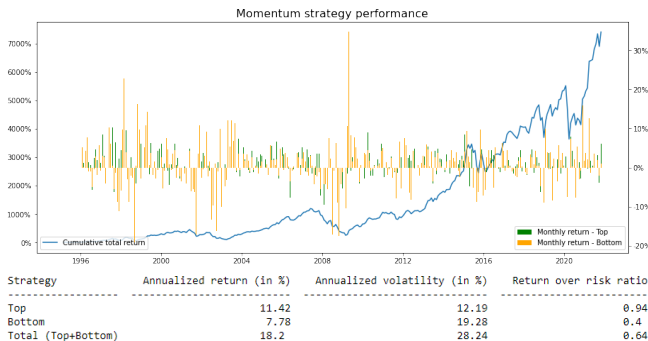
Hierarchical Risk Parity
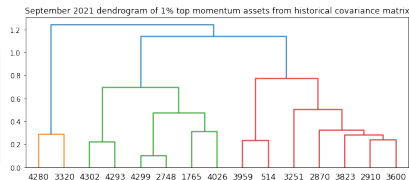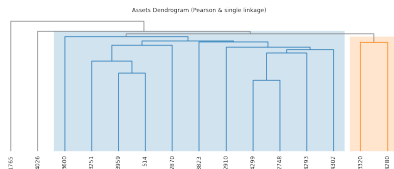
The advantages of the HRP approach makes it quite appropriate to our case:

- It does not require the inversion of the covariance matrix.

- It produces diverse portfolios that perform well out of sample.

- It is stable for a large number of assets.

- It avoids high risk concentration due to the hierarchical clustering which groups highly correlated assets together. Low correlated assets are arranged far away.

HRP long-only momentum performance

Weight allocation derived from HRP portfolio optimization on a 12-1 long-only momentum strategy.

Momentum strategy performance

Strategy	Annualized return (in %)	Annualized volatility (in %)	Return over risk ratio
Top	11.42	12.19	0.94
Bottom	7.78	19.28	0.4
Total (Top+Bottom)	18.2	28.24	0.64

HRP weight allocation strategy twice more profitable than naive strategy (18.2% against 9.0%), although more volatile (28.2% instead of 17.1%).

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Ideas the spirit of all the above

- Change percentage of top and bottom stocks to be part of the momentum strategy: use 1%, 10% threshold rather than 20%.

- Stop to remove short-term reversal effect in momentum calculation.

- Allocate more weight to half largest values among top and bottom stocks (in absolute terms) - or, if contrarian, to the half smallest.

- Complement momentum stock selection with volatility criteria: Only buy (resp. short) stocks with highest volatility among top (resp. bottom) returns.

- HRP portfolio optimization on a long-only 12-1 momentum strategy based on risk-adjusted returns.

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Factor investing with Principal Component Analysis (PCA)

12-1 momentum strategy implementation with a PCA factor model. **If there is momentum in return data, PCA factor returns also have momentum**.

- 1. Pull return history with a lookback period of 12 months, adjust return data by substracting the mean.

- 2. Calculate covariance matrix of mean-adjusted returns, and the eigenvectors and eigenvalues of the covariance matrix.

- 3. Choose a number of significant factors (most important PCA components) that explain most ($>$ 95%) of the return data.

- 4. **Variant**: Hierarchical PCA, group stocks into clusters that are believed to share common features (sector, country, statistical measure, etc).

12-1 momentum strategy implementation: long (short) the winning (losing) stocks which have the highest (lowest) expected returns according to PCA factors.

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How could Machine Learning help?

Machine learning is good at identifying hidden patterns, which would support more active stock selection!

- **Unsupervised learning** - **KMC, SOM**, to identify clusters in momentum or risk-return data. Buy stocks with highest momentum and short stocks with lowest momentum among each cluster.
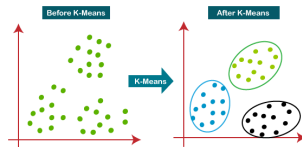
- **Random forests (classification)** to predict whether each stock will pursue its trend further on the upside or downside on the next month. In practise, features would be 12-1 momentum-based, and target variable could be whether the 12-1 momentum exceeds a given threshold (in absolute terms).

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What does ChatGPT say?

ChatGPT code poor and limited (yet, impressive!)

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Momentum strategy	Annual return	Annual volatility	Ratio
12-1 long/short	1.90	9.64	0.2
12-1 long-only	9.02	17.11	0.53
Combination 12-1 and 6-1 long/short	1.84	12.3	0.15
Combination 12-1 and 6-1 long-only	9.84	18.5	0.53
12-1 long-only from risk-adjusted returns	**10.31**	**15.13**	**0.68**
12-1 RSI trend confirmation	1.17	7.86	0.15
12-1 long-only HRP weight allocation	**18.2**	**28.24**	**0.64**

Conclusion

- There is momentum in financial markets, particularly on rising stocks. Falling stocks tend to rebound on the 13th month, hence the underperformance of the short strategy on bottom momentum stocks.

- Long-only portfolios generate more returns and higher return-over-risk ratios than traditional long-short approach, to the detriment of more volatility.

- **Best strategy for risk-adverse investors**: 12-1 long-only momentum derived from risk-adjusted returns. Highest return-over-risk ratio among all strategies, with lowest volatility among all long-only strategies.

- **Best strategy for investors looking for performance**: 12-1 long-only HRP weight allocation. High performance, high volatility, and aligned return-over-risk ratio than 12-1 long-only momentum strategy derived from risk-adjusted returns.