Two Centuries of Momentum

SUMMARY

- A momentum-based investing approach can be confusing to investors who are often told that “chasing performance” is a massive mistake and “timing the market” is impossible.
- Yet as a systematized strategy, momentum sits upon nearly a quarter century of positive academic evidence and a century of successful empirical results.
- Our firm, Newfound Research, was founded in August 2008 to offer research derived from our volatility-adjusted momentum models. Today, we provide tactically risk-managed investment portfolios using those same models.
- Momentum, and particularly time-series momentum, has been in our DNA since day one.
- In this Foundational Series piece, we want to explore momentum’s rich history and the academic evidence demonstrating its robustness across asset classes, geographies, and market cycles.

NEWFOUND RESEARCH

About Newfound Research

Founded in August 2008 Newfound Research is a quantitative asset management firm based in Boston, MA.

Investing at the intersection of quantitative and behavioral finance, Newfound Research is dedicated to helping investors achieve their long-term goals with research-driven, quantitatively-managed portfolios, while simultaneously acknowledging that the quality of the journey is just as important as the destination.

We work exclusively with financial advisors and institutions to help them manage the wealth of their clients through our suite of investment portfolios and mutual funds.

Portfolios Focused on Risk Management

Our strategies reflect our view that investing is not easy. Emotional decisions can derail even the best laid plan. Therefore, we believe that the optimal investment plan is, first and foremost, one that investors can stick with. Research shows that investors feel the pain of losses more than they feel the joy of gains. This is reflected in a deep desire to protect the capital that they have worked hard to accumulate. Accordingly, we seek to improve risk-adjusted returns and investor experience by prioritizing downside risk management and seeking to avoid large losses.

Our portfolios are available as separately managed accounts, through model manager platforms, and as mutual funds[1].

Multi-Manager Model Allocations

For investors looking to outsource their asset allocation and manager selection decisions, we offer our QuBe ("Quantitative Behavioral") portfolio series, a suite of strategically managed, behavior aware, hybrid active/passive portfolios offered with zero overlay fee[2].

Newfound was awarded 2016 ETF Strategist of the Year by ETF.com[3].

[1] See http://www.thinknewfoundfunds.com
[2] See http://www.thinknewfound.com/qube-managed-portfolios
[3] An ETF Strategist is a firm that builds portfolios primarily using exchange-traded funds.

NEWFOUND RESEARCH

1. What is Momentum?

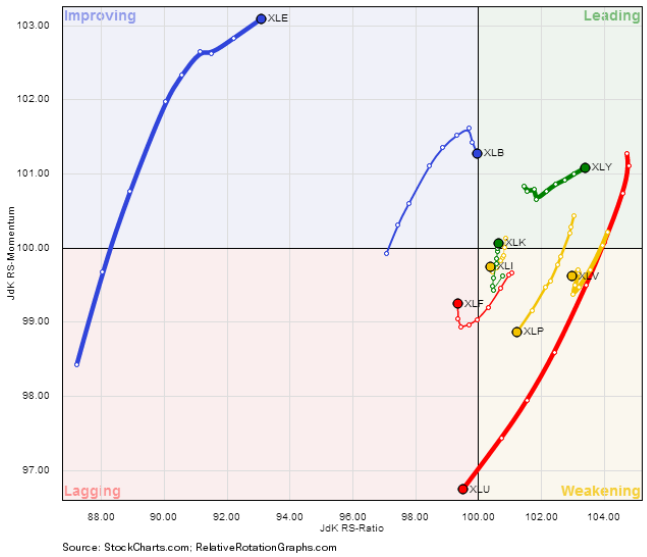
Momentum is a system of investing that buys and sells based upon recent returns. Momentum investors buy outperforming securities and avoid – or sell short – underperforming ones.

The notion is closely tied to physics. In physics, momentum is the product of the mass and velocity of an object. For example, a heavy truck moving at a high speed has large momentum. To stop the truck, we must apply either a large or a prolonged force against it.

Momentum investors apply a similar notion. They assume outperforming securities will continue to outperform in absence of significant headwinds.

2. The Two Faces & Many Names of Momentum

2.1. Relative Momentum



The phenomenon of relative momentum is also called cross-sectional momentum and relative strength.

Relative momentum investors compare securities against each other's performance. They favor buying outperforming securities and avoiding – or short-selling – underperforming securities.

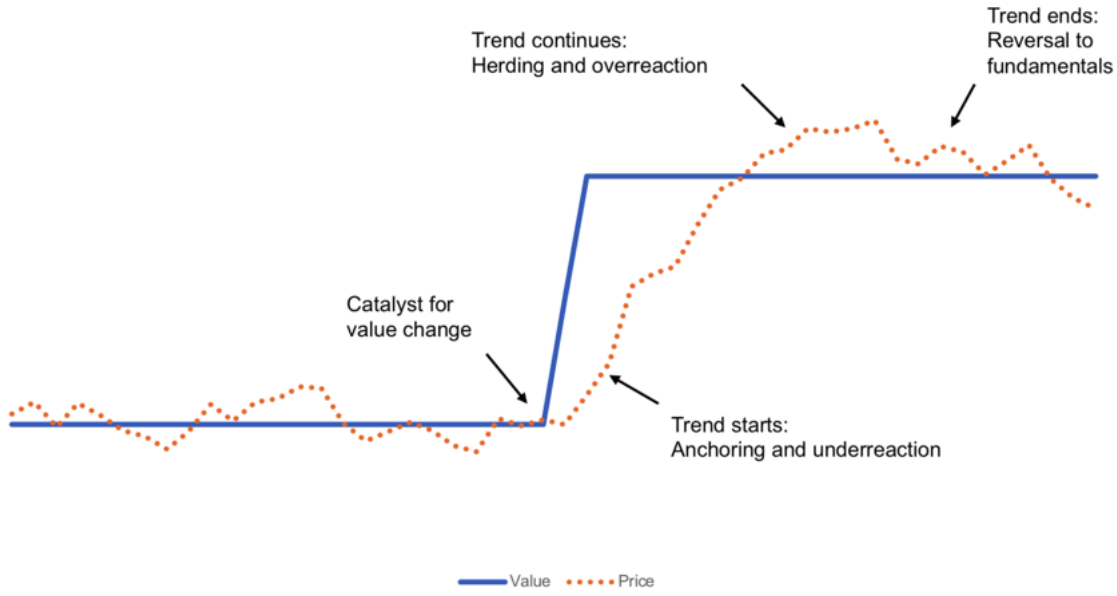
Long-only relative momentum investors rotate between a subset of holdings within their investable universe. For example, a simple long-only relative strength system example is "best N of." At rebalance, this system sells its current holdings and buys the top N performing securities of a basket. In doing so, the strategy seeks to align the portfolio with the best performing securities in hopes they continue to outperform.

2.2. Absolute Momentum

Absolute momentum is also referred to as time-series momentum or trend following.

Absolute momentum investors compare a security against its own historical performance. The system buys positive returning securities and avoids, or sells short, negative returning securities.

The primary difference is that relative momentum makes no distinction about return direction. If all securities are losing value, relative momentum will seek to invest in those assets that are going down least. Absolute momentum will seek to avoid negative returning assets.



3. A Brief History of Momentum

3.1. Early Practitioners

Momentum is one of Wall Street's oldest investment strategies.

In 1838, James Grant published The Great Metroplis, Volume 2. Within, he spoke of David Ricardo, an English political economist who was active in the London markets in the late 1700s and early 1800s. Ricardo amassed a large fortune trading both bonds and stocks.

According to Grant, Ricardo's success was attributed to three golden rules:

"As I have mentioned the name of Mr. Ricardo, I may observe that he amassed his immense fortune by a scrupulous attention to what he called his own three golden rules, the observance of which he used to press on his private friends. These were, "Never refuse an option when you can get it,"—"Cut short your losses,"—"Let your profits run on." By cutting short one's losses, Mr. Ricardo meant that when a member had made a purchase of stock, and prices were falling, he ought to resell immediately. And by letting one's profits run on he meant, that when a member possessed stock, and prices were raising, he ought not to sell until prices had reached their highest, and were beginning again to fall. These are, indeed,*

golden rules, and may be applied with advantage to innumerable other transactions than those connected with the Stock Exchange."

The rules "cut short your losses" and "let your profits run on" are foundational philosophies of momentum.

Following in Ricardo's footsteps are some of Wall Street's greatest legends who implemented momentum and trend-following techniques.

Charles H. Dow (1851 – 1902) was the founder and first editor of the Wall Street Journal as well as the co-founder of Dow Jones and Company. In his Wall Street Journal column, he published his market trend analysis, which eventually developed into a body of research called Dow theory. Dow theory primarily focuses on the identification of trends as being the key signal for investing.

Jesse Livermore (1877 – 1940) was a stock market speculator in the early 1900s who famously made – and subsequently lost – two massive fortunes during the market panic of 1907 and crash of 1929. He is attributed (by Edwin Lefèvre, in Reminiscences of a Stock Operator) to saying,

"[T]he big money was not in the individual fluctuations but in the main movements … sizing up the entire market and its trend."

Livermore claimed that his lack of adherence to his own rules was the main reason he lost his wealth.

In the same era of Livermore, Richard Wyckoff (1873 – 1934) noted that stocks tended to trend together. Thus he focused on entering long positions only when the broad market was trending up. When the market was in decline, he focused on shorting. He also emphasized the placement of stop-losses to help control risk.

He was personally so successful with his techniques, he eventually owned nine and a half acres in the Hamptons.

Starting in the 1930s, George Chestnutt successfully ran the American Investors Fund for nearly 30 years using relative strength techniques. He also published market letters with stock and industry group rankings based on his methods. He wrote,

"[I]t is better to buy the leaders and leave the laggards alone. In the market, as in many other phases of life, 'the strong get stronger, and the weak get weaker.'"

In the late 1940s and early 1950s, Richard Donchian developed a rules based technical system that became the foundation for his firm Futures, Inc. Futures, Inc. was one of the first publicly held commodity funds. The investment philosophy was based upon Donchian's belief that commodity prices moved in long, sweeping bull and bear markets. Using moving averages, Donchian built one of the first systematic trend-following methods, earning him the title of the father of trend-following.

In the late 1950s, Nicholas Darvas (1920 – 1977), trained economist and touring dancer, invented "BOX theory." He modeled stock prices as a series of boxes. If a stock price remained in a box, he waited. As a stock price broke out of a box to new highs, he bought and placed a tight stop loss. He is quoted as saying,

"I keep out in a bear market and leave such exceptional stocks to those who don't mind risking their money against the market trend."

Also during the 1950s and 1960s was Jack Dreyfus, who Barron's named the second most significant money manager of the last century. From 1953 to 1964, his Dreyfus Fund returned 604% compared to 346% for the Dow index. Studies performed by William O'Neil showed that Dreyfus tended to buy stocks making new 52-week highs. It wouldn't be until 2004 that academic studies would confirm this method of investing.

Richard Driehaus took the momentum torch during the 1980s. In his interview in Jack Schwager's The New Market Wizards, he said he believed that money was made buying high and selling higher.

"That means buying stocks that have already had good moves and have high relative strength – that is, stocks in demand by other investors. I would much rather invest in a stock that's increasing in price and take the risk that it may begin to decline than invest in a stock that's already in a decline and try to guess when it will turn around."

3.1 Earliest Academic Studies

In 1933, Alfred Cowles III and Herbert Jones released a research paper titled Some A Posteriori Probabilities in Stock Market Action. Within it they specifically focused on "inertia" at the "microscopic" – or stock – level.

They focused on counting the ratio of sequences – times when positive returns were followed by positive returns, or negative returns were followed by negative returns – to reversals – times when positive returns were followed by negative returns, and vice versa.

Their results:

"It was found that, for every series with intervals between observations of from 20 minutes up to and including 3 years, the sequences out-numbered the reversals. For example, in the case of the monthly series from 1835 to 1935, a total of 1200 observations, there were 748 sequences and 450 reversals. That is, the probability appeared to be .625 that, if the market had risen in a given month, it would rise in the succeeding month, or, if it had fallen, that it would continue to decline for another month. The standard deviation for such a long series constructed by random penny tossing would be 17.3; therefore the deviation of 149 from the expected value of 599 is in excess of eight times the standard deviation. The probability of obtaining such a result in a penny-tossing series is infinitesimal."

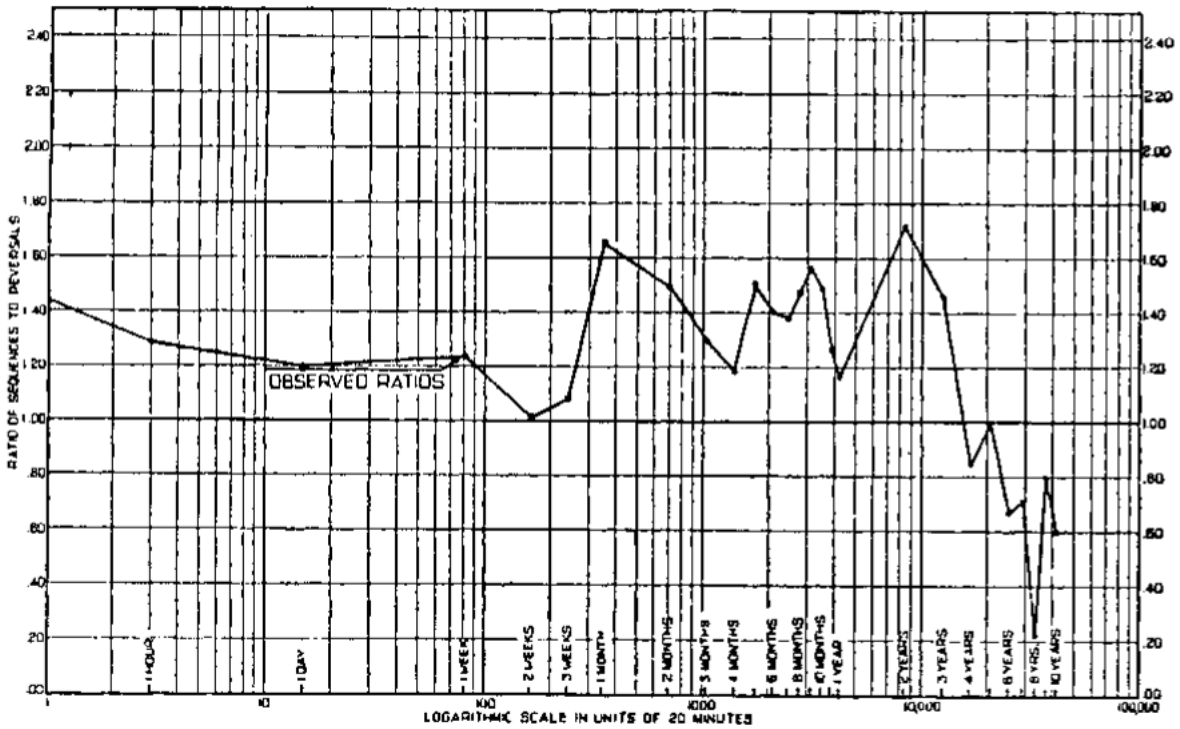


FIGURE 1.—Ratio of sequences to reversals in direction of stock price indexes for various time intervals.

Despite the success of their research on the statistical significance of sequences, the next academic study on momentum was not released for 30 years.

In 1967, Robert Levy published Relative Strength as a Criterion for Investment Selection. Levy found that there was "good correlation between past performance groups and future … performance groups" over 26-week periods. He states:

"[…] the [26-week] average ranks and ratios clearly support the concept of continuation of relative strength. The stocks which historically were among the 10 per cent strongest (lowest ranked) appreciated in price by an average of 9.6 per cent over a 26-week future period. On the other hand, the stocks which historically were among the 10 per cent weakest (highest ranked) appreciated in price an average of only 2.9 per cent over a 26-week future period."

Unfortunately, the scope of the study was limited. The period used in the analysis was only from 1960 to 1965. Thus, of the 26-week periods tested, only 8 were independent. In Levy's words, "the results were extensively intercorrelated; and the use of standard statistical measures becomes suspect." Therefore, Levy omitted these statistics.

Despite its promise, momentum research went dark for the next 25 years.

4. The Dark Days of Momentum Research

Despite the success of practitioners and promising results of early studies, momentum would go largely ignored by academics until the 1990s.

Exactly why is unknown, but we have a theory: fundamental investing, modern portfolio theory, and the efficient market hypothesis.

4.1 The Rise of Fundamental Investing

In 1934, Benjamin Graham and David Dodd published Security Analysis. Later, in 1949, they published The Intelligent Investor. In these tomes, they outline their methods for successful investing.

For Graham and Dodd, a purchase of stock was a purchase of partial ownership of a business. Therefore, it was important that investors evaluate the financial state of the underlying business they were buying.

They also defined a strong delineation between investing and speculating. To quote,

"An investment operation is one which, upon thorough analysis, promises safety of principal and an adequate return. Operations not meeting these requirements are speculative."

Speculative was a pejorative term. Even the title of The Intelligent Investor implied that any investors not performing security analysis were not intelligent.

The intelligent investor began her process by computing a firm's intrinsic value. In other words, "what is the business truly worth?" This value was either objectively right or wrong based on the investor's analysis. Whether the market agreed or not was irrelevant.

Once an intrinsic value was determined, Graham and Dodd advocated investors buy with a margin of safety. This meant waiting for the market to offer stock prices at a deep discount to intrinsic value.

These methods of analysis became the foundation of value investing.

To disciples of Graham and Dodd, momentum is speculative nonsense. To quote Warren Buffett in The Superinvestors of Graham-and-Doddsville:

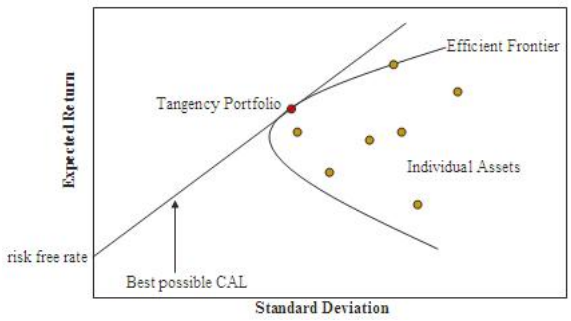
"I always find it extraordinary that so many studies are made of price and volume behavior, the stuff of chartists. Can you imagine buying an entire business simply because the price of the business had been marked up substantially last week and the week before?"

4.2 Modern Portfolio Theory and the Efficient Market Hypothesis

In his 1952 article "Portfolio Selection," Harry Markowitz outlined the foundations of Modern Portfolio Theory (MPT). The biggest breakthrough of MPT was that it provided a mathematical formulation for diversification.

While the concept of diversification has existed since pre-Biblical eras, it had never before been quantified. With MPT, practitioners could now derive portfolios that optimally balanced risk and reward. For example, by combining assets together, Markowitz created the efficient frontier: those combinations for which there is the lowest risk for a given level of expected return.

By introducing a risk-free asset, the expected return of any portfolio constructed can be linearly changed by varying the allocation to the risk-free asset. In a graph like the one on the left, this can be visualized by constructing a line that passes through the risk-free asset and the risky portfolio (called a Capital Allocation Line or CAL). The CAL that is tangent to the efficient frontier is called the capital market line (CML). The point of tangency along the efficient frontier is the portfolio with the highest Sharpe ratio (excess expected return divided by volatility).



According to MPT, in which all investors seek to maximize their Sharpe ratio, an investor should only hold a mixture of this portfolio and the risk free asset. Increasing the allocation to the risk-free asset decreases risk while introducing leverage increases risk.

The fact that any investor should only hold one portfolio has a very important implication: given all the assets available in the market, all investors should hold, in equal relative proportion, the same portfolio of global asset classes. Additionally, if all investors are holding the same mix of assets, in market equilibrium, the prices of asset classes – and therefore their expected returns – must adjust such that the allocation ratios of the assets in the tangency portfolio will match the ratio in which risky assets are supplied to the market.

Holding anything but a combination of the tangency portfolio and the risk-free asset is considered sub-optimal.

From this foundation, concepts for the Capital Asset Pricing Model (CAPM) are derived. CAPM was introduced independently by Jack Treynor, William Sharpe, John Lintner, and Jan Mossin from 1961-1966.

CAPM defines a "single-factor model" for pricing securities. The expected return of a security is defined in relation to a risk-free rate, the security's "systematic" risk (sensitivity to the tangency portfolio), and the expected market return. All other potentially influencing factors are considered to be superfluous.

While its origins trace back to the 1800s, the efficient market hypothesis (EMH) was officially developed by Eugene Fama in his 1962 Ph.D. thesis.

EMH states that stock prices reflect all known and relevant information and always trade at fair value. If stocks could not trade above or below fair value, investors would never be able to buy them at discounts or sell them at premiums. Therefore, "beating the market" on a risk-adjusted basis is impossible.

Technically, MPT and EMH are independent theories. MPT tells us we want to behave optimally, and gives us a framework to do so. EMH tells us that even optimal behavior will not generate any return in excess of returns predicted by asset pricing models like CAPM.

Markowitz, Fama, and Sharpe all went on to win Nobel prizes for their work.

4.3 Growing Skepticism Towards Technical Analysis

Technical analysis is a category of investing methods that use past market data – primarily price and volume – to make forward forecasts.

As a category, technical analysis is quite broad. Some technicians look for defined patterns in price charts. Others look for lines of support or resistance. A variety of indicators may be calculated and used. Some technicians follow specific techniques – like Dow theory or Elliot Wave theory.

Unfortunately, the broad nature of technical analysis makes it difficult to evaluate academically. Methods vary widely and different technical analysts can make contradictory predictions using the same data.

Thus, during the rise of EMH through the 1960s and 1970s, technical analysis was largely dismissed by academics.

Since momentum relies only on past prices, and many practitioners used tools like moving averages to identify trends, it was categorized as a form of technical analysis. As academics dismissed the field, momentum went overlooked.

4.4 But Value Research Went On

Despite CAPM, EMH, and growing skepticism towards technical analysis, academic research for fundamental investing continued. Focus was especially strong on value investing.

For example, in 1977, S. Basu authored a comprehensive study on value investing, titled Investment Performance of Common Stocks in Relation to their Price-Earnings Ratios: A Test of the Efficient Market Hypothesis. Within, Basu finds that the return relationship strictly increases for stocks sorted on their price-earnings ratio. Put more simply, cheap stocks outperform expensive ones.

Unfortunately, in many of these studies, the opposite of value was labeled growth or glamor. This became synonymous with high flying, over-priced stocks. Of course, not value is not the same as growth. And not value is certainly not the same as momentum. It is entirely possible that a stock can be in the middle of a positive trend, yet still be undervalued. Nevertheless, it is easy to see how relatively outperforming and over-priced may be conflated.

It is possible that the success of value research in demonstrating the success of buying cheap stocks dampened the enthusiasm for momentum research.

5. The Return of Momentum

Fortunately, decades of value-based evidence against market efficiency finally piled up.

In February 1993, Eugene Fama and Kenneth French released Common Risk Factors in the Returns on Stocks and Bonds. Fama and French extended the single-factor model of CAPM into a three-factor model. Beyond the "market factor," factors for "value" and "size" were added, acknowledging these distinct drivers of return.

Momentum was still nowhere to be found.

But a mere month later, Narasimhan Jegadeesh and Sheridan Titman published their seminal work on momentum, titled Returns to Buying Winners and Selling Losers: Implication for Stock Market Efficiency. Within they demonstrated:

"Strategies which buy stocks that have performed well in the past and sell stocks that have performed poorly in the past generate significant positive returns over 3- to 12-month holding periods."

The results of the paper could not be explained by systematic risk or delayed reactions to other common factors, echoing the results of Cowles and Jones some 60 years prior.

In 1996, Fama and French authored Multifactor Explanations of Asset Pricing Anomalies. Armed with their new three-factor model, they explored whether recently discovered market phenomena – including Jegadeesh and Titman's momentum – could be rationally explained away.

While most anomalies disappeared under scrutiny, the momentum results remained robust. In fact, in the paper Fama and French admitted that,

"[momentum is the] main embarrassment of the three-factor model."

6. The Overwhelming Evidence for Momentum

With its rediscovery and robustness against prevailing rational pricing models, momentum research exploded over the next two decades. It was applied across asset classes, geographies, and time periods. In chronological order:

Asness, Liew, and Stevens (1997) shows that momentum investing is a profitable strategy for **country indices**.

Carhart (1997) finds that portfolios of **mutual funds**, constructed by sorting on trailing one-year returns, decrease in monthly excess return nearly monotonically, inline with momentum expectations.

Rouwenhorst (1998) demonstrates that stocks in **international equity markets** exhibit medium-term return continuations. The study covered stocks from Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.

LeBaron (1999) finds that a simple momentum model creates unusually large profits **in foreign exchange series**.

Moskowitz and Grinblatt (1999) finds evidence for a strong and **persistent industry momentum** effect.

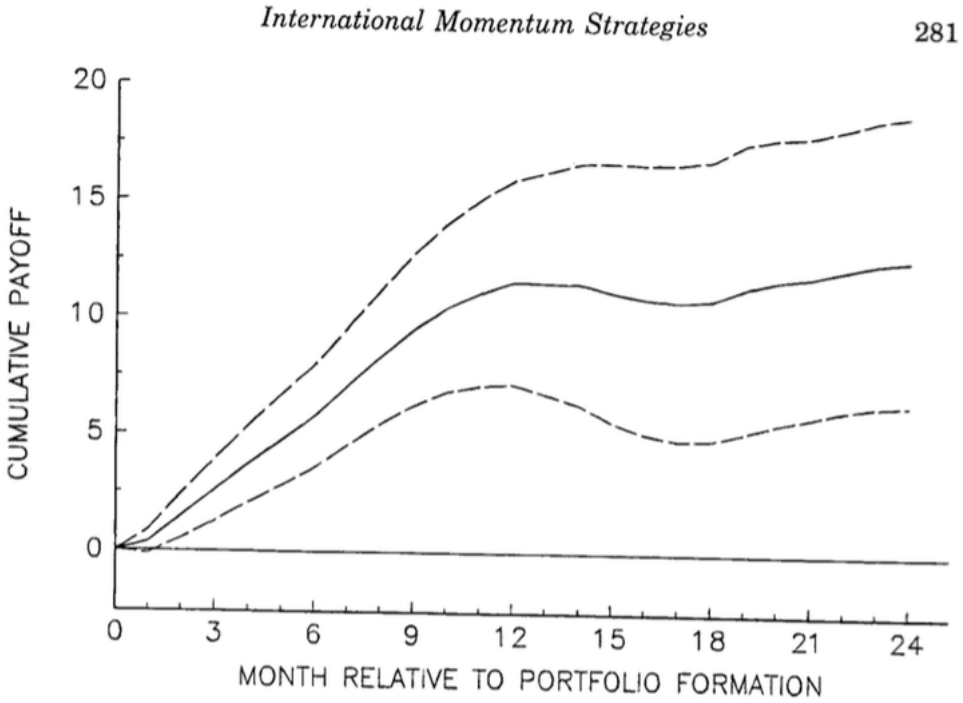


Figure 1. Cumulative payoff to momentum strategies in event time. The solid line gives the average cumulative payoff to a buy-and-hold strategy that invest a deutsche mark (DM) in a portfolio of Winners financed by a unit DM portfolio of Losers, in the kth month after portfolio formation. The payoff is measured in pfennigs (equals 0.01 DM). At the time of formation, the Winners and Losers are equally weighted portfolios constructed to be both size- and country-neutral. They contain from each of the 36 size-country groups the top and bottom decile of stocks ranked in ascending order based on past six-month return. The dashed lines give the 95 percent confidence interval of the average payoff, computed using autocorrelation consistent standard errors.

Rouwenhorst (1999), in a study of 1700 firms across 20 countries, demonstrates that **emerging market stocks** exhibit momentum.

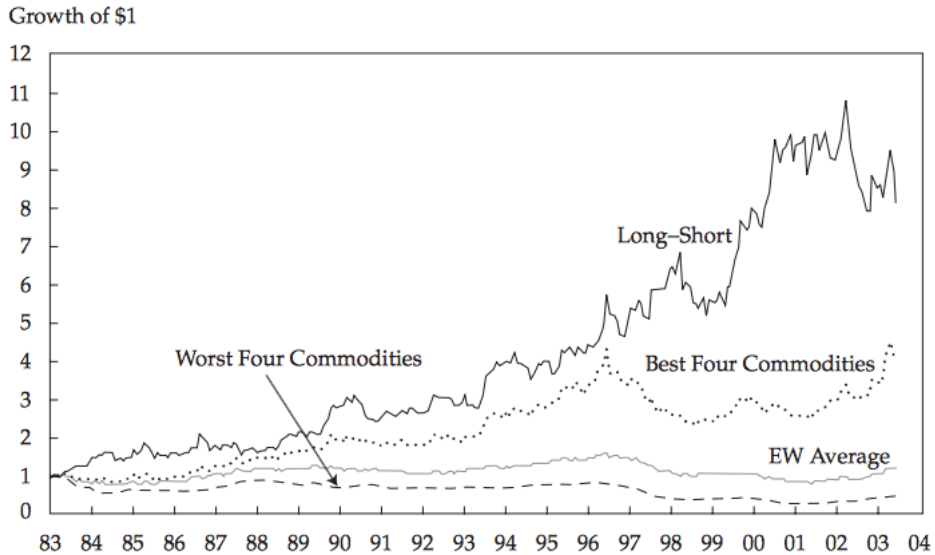
Liew and Vassalou (2000) shows that momentum returns are significantly positive in **foreign developed countries** but there is little evidence to explain them by economic developments.

Griffin, Ji, and Martin (2003) demonstrates momentum's robustness, finding it to be large and **statistically reliable in periods of both negative and positive economic growt**h. The study finds no evidence for macroeconomic or risk-based explanations to momentum returns.

Erb and Harvey (2006) shows evidence of success for momentum investing in **commodity futures**.

Gorton, Hayashi, and Rouwenhorst (2008) extends momentum research on **commodities**, confirming its existence in futures but also identifying its existence in spot prices.

Figure 8. Momentum Portfolios, December 1982–May 2004



Jostova, Niklova Philopov, and Stahel (2012) shows that momentum profits are significant for **non-investment grade corporate bonds**.

Luu and Yu (2012) identifies that **for liquid fixed-income assets**, such as government bonds, momentum strategies may provide a good risk-return trade-off and a hedge for credit exposure.

7. Academic Explanations for Momentum

While academia has accepted momentum as a distinct driver of return premia in many asset classes around the world, the root cause is still debated.

So far, the theory for rational markets has failed to account for momentum's significant and robust returns. It is not correlated with macroeconomic variables and does not seem to reflect exposure to other known risk factors.

But there are several hypotheses that might explain how irrational behavior may lead to momentum.

7.1 Behavioral Thesis

The most commonly accepted argument for why momentum exists and persists comes from behavioral finance. Behavioral finance is a field that seeks to link psychological theory with economics and finance to explain irrational decisions.

Some of the popular behavioral finance explanations for momentum include:

- Herding: Also known as the "bandwagon effect," herding is the tendency for individuals to mimic the actions of a larger group.
- Anchoring Bias: The tendency to rely too heavily on the first piece of information received.
- Confirmation Bias: The tendency to ignore information contradictory to prior beliefs.
- Disposition Effect: Investors tend to sell winners too early and hold on to losers too long. This occurs because investors like to realize their gains but not their losses, hoping to "make back" what has been lost.

Together, these biases cause investors to either under- or over-react to information, causing pricing inefficiencies and irrational behavior.

7.1.1 Cumulative Advantage & Momentum Beyond Markets

There is strong evidence for momentum being a behavioral and social phenomenon beyond stock markets.

Matthew Salganik, Peter Dodds, and Duncan Watts ran a 14,000 participant, web-based study designed to establish independence of taste and preference in music.

Participants were asked to explore, listen to, and rate music. One group of participants would be able to see how many times a song was downloaded and how other participants rated it; the other group would not be able to see downloads or ratings. The group that could see the number of downloads ("social influence") was then sub-divided into 8 distinct, random groups where members of each sub-group could only see the download and ratings statistics of their sub-group peers.

The hypothesis of the study was that "good music" should garner the same amount of market share regardless of the existence of social influence: hits should be hits. Secondly, the same hits should be hits across all independent social influence groups.

What the study found was dramatically different. Each social-influence group had its own hit songs, and those songs commanded a much larger market share of downloads than songs did in the socially-independent group.

Introducing social-influence did two things: it made hits bigger and it made hits more unpredictable. The authors called this effect "cumulative advantage." The consequences are profound. To quote an article in the New York Times by Watts,

"It's a simple result to state, but it has a surprisingly deep consequence. Because the long-run success of a song depends so sensitively on the decisions of a few early-arriving individuals, whose choices are subsequently amplified and eventually locked in by the cumulative-advantage process, and because the particular individuals who play this important role are chosen randomly and may make different decisions from one moment to the next, the resulting unpredictability is inherent to the nature of the market. It cannot be eliminated either by accumulating more information — about people or songs — or by developing fancier prediction algorithms, any more than you can repeatedly roll sixes no matter how carefully you try to throw the die."

7.2 Behavioral Thesis

EMH assumes that any mis-pricing in public markets will be immediately arbitraged away by rational market participants. The limits to arbitrage theory recognizes that there are often restrictions – both regulatory and capital based – that may limit rational traders from fully arbitraging away these price inefficiencies.

In support of this thesis is Chabot, Ghysels, and Jagannathan (2009), which finds that when arbitrage capital is in short supply, momentum cycles last longer.

Similarly, those investors bringing good news to the market may lack the capital to take full advantage of that information. So if there has been good news in the past, there may be good news not yet incorporated into the price.

7.3 The Rational Inattention Thesis

Source: In Search of Crisis Alpha: A Short Guide to Investing in Managed Futures by Kathryn M. Kaminski, Ph.D., Senior Investment Analyst, RPM Risk & Portfolio Management

Humans possess a finite capacity to process the large amounts of information they are confronted with. Time is a scarce resource for decision makers.

The rational inattention theory argues that some information may be evaluated less carefully, or even outright ignored. Or, alternatively, it may be optimal for investors to obtain news with limited frequency or limited accuracy. This can cause investors to over- or under-invest and could cause the persistence of trends.

Chen and Yu (2014) found that portfolios constructed from stocks "more likely to grab attention" based on visual patterns induces investor over-reaction. They provide evidence that momentum continuation is induced by visually-based psychological biases.

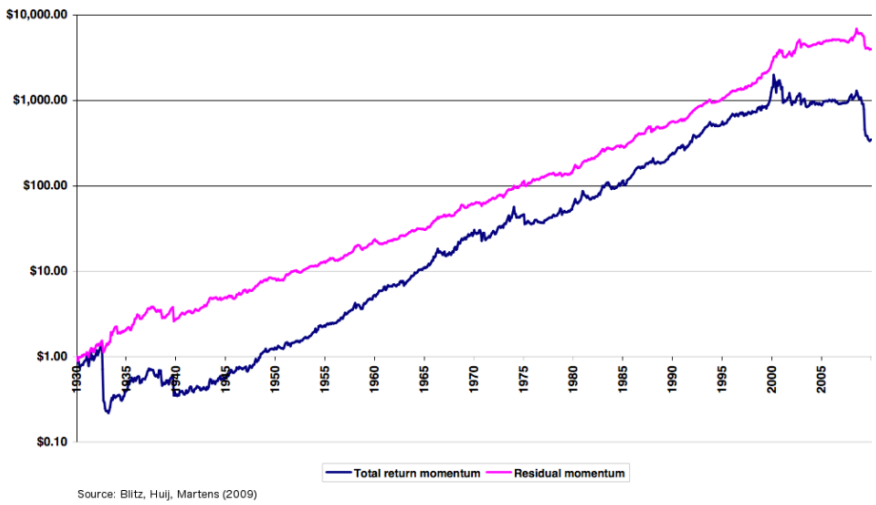
8. Advances in Cross-Sectional Research

Much like there are many ways to identify value, there are many ways to identify momentum. Recent research has identified methods that may improve upon traditional total return momentum.

52-Week Highs: Hwang and George (2004) shows that nearness to a 52-week high price dominates and improves upon the forecasting power of past returns (i.e. momentum). Perhaps most interestingly, future returns forecast using a 52-week high do not mean-revert in the long run, like traditional momentum.

Liu, Liu, and Ma (2010) tests the 52-week high strategy in 20 international markets and finds that it is profitable in 18 and significant in 10.

FIGURE 1. Total return momentum versus residual momentum over time (CONTINUED).



Source: Blitz, Huij, Martens (2009)

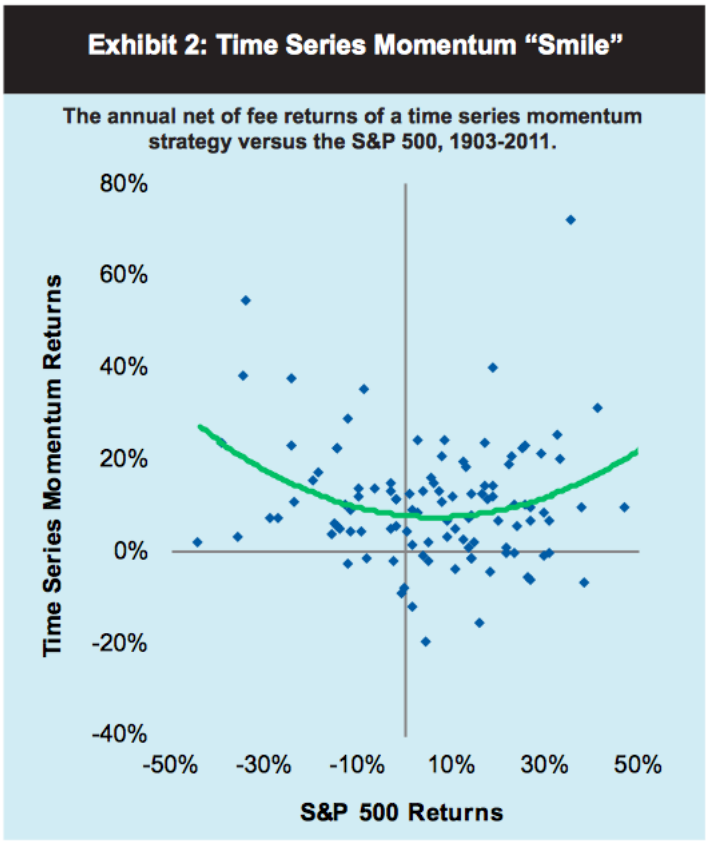
Residual Momentum: Using a universe of domestic equities, covering the period of January 1926 to December 2009, Blitz, Huij, and Martens (2009) decomposes stock returns using the Fama-French three-factor model. Returns unexplained by the market, value, and size factors are considered to be residual. The study finds that momentum strategies built from residual returns exhibit risk-adjusted profits that are twice as large as those associated with total return momentum.

Idiosyncratic Momentum: Similar to Blitz, Huij, and Martens, Chaves (2012) uses the CAPM model to correct stocks for market returns and identify idiosyncratic returns. Idiosyncratic momentum is found to work better than momentum in a sample of 21 developed

countries. Perhaps most importantly, idiosyncratic momentum is successful in Japan, where most traditional momentum strategies have failed.

9. Using Momentum to Manage Risk

While most research in the late 1990s and early 2000s focused on relative momentum, research after 2008 has been heavily focused on time-series momentum for its risk-mitigating and diversification properties.



Source: AQR. Time Series performance is hypothetical as described above. Please read important disclosures at the end relating to hypothetical performance.

Some of the earliest, most popular research was done by Faber (2006), in which a simple price-minus-moving-average approach was used to drive a portfolio of U.S. equities, foreign developed equities, commodities, U.S. REITs, and U.S. government bonds. The resulting portfolio demonstrates **"equity-like returns with bond-like volatility."**

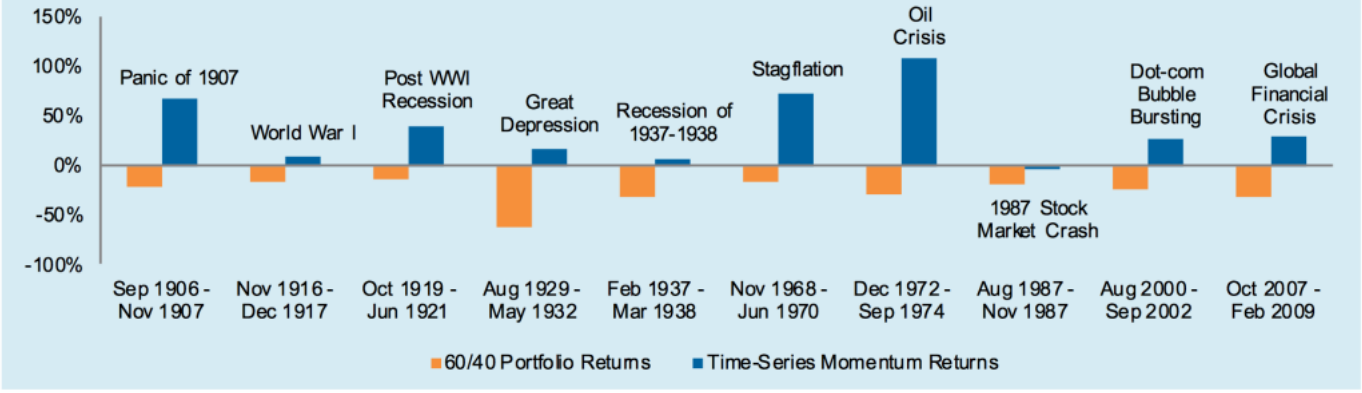
Hurst, Ooi, and Pedersen (2010) identifies that trend-following, or time-series momentum, is a significant component of returns for managed futures strategies. In doing so, the research demonstrates the **consistency of trend-following approaches in generating returns in both bull and bear markets.**

Going beyond managed futures specifically, Moskowitz, Ooi, Hua, and Pedersen (2011) documents significant time-series momentum in **equity index, currency, commodity, and bond futures** covering 58 liquid instruments over a 25-year period.

Perhaps some of the most conclusive evidence comes from Hurst, Ooi, Pedersen (2012), which explores **time-series momentum going back to 1903 and through 2011.**

The study constructs a portfolio of an equal-weight combination of 1-month, 3-month, and 12-month time-series momentum strategies for 59 markets across 4 major asset classes, including commodities, equity indices, and currency pairs. The approach is consistently profitable across decades. The research also shows that incorporating a time-series momentum approach into a traditional 60/40 stock/bond portfolio increases returns, reduces volatility, and reduces maximum drawdown.

Exhibit 3: Total Returns of U.S. 60/40 Portfolio and Time Series Momentum in the Ten Worst Drawdowns for 60/40 between 1903 and 2012



Source: AQR. Time Series performance is hypothetical as described above.

Strategy performance after simulated transaction costs both gross and net of hypothetical 2-and-20 fees.

Time Period	Gross of Fee Returns (Annualized)	Net of 2/20 Fee Returns (Annualized)	Realized Volatility (Annualized)	Sharpe Ratio, Net of Fees	Correlation to S&P 500 Returns	Correlation to US 10-year Bond Returns
Full Sample:						
Jan 1903 - June 2012	20.0%	14.3%	9.9%	1.00	-0.05	-0.05
By Decade:						
Jan 1903 - Dec 1912	18.8%	13.4%	10.1%	0.84	-0.30	-0.59
Jan 1913 - Dec 1922	17.1%	11.9%	10.4%	0.70	-0.12	-0.11
Jan 1923 - Dec 1932	17.1%	11.9%	9.7%	0.92	-0.07	0.10
Jan 1933 - Dec 1942	9.7%	6.0%	9.2%	0.66	0.00	0.55
Jan 1943 - Dec 1952	19.4%	13.7%	11.7%	1.08	0.21	0.22
Jan 1953 - Dec 1962	24.8%	18.4%	10.0%	1.51	0.21	-0.18
Jan 1963 - Dec 1972	26.9%	19.6%	9.2%	1.42	-0.14	-0.35
Jan 1973 - Dec 1982	40.3%	30.3%	9.2%	1.89	-0.19	-0.40
Jan 1983 - Dec 1992	17.8%	12.5%	9.4%	0.53	0.15	0.13
Jan 1993 - Dec 2002	19.3%	13.6%	8.4%	1.04	-0.21	0.32
Jan 2003 - June 2012	11.4%	7.5%	9.7%	0.61	-0.22	0.20

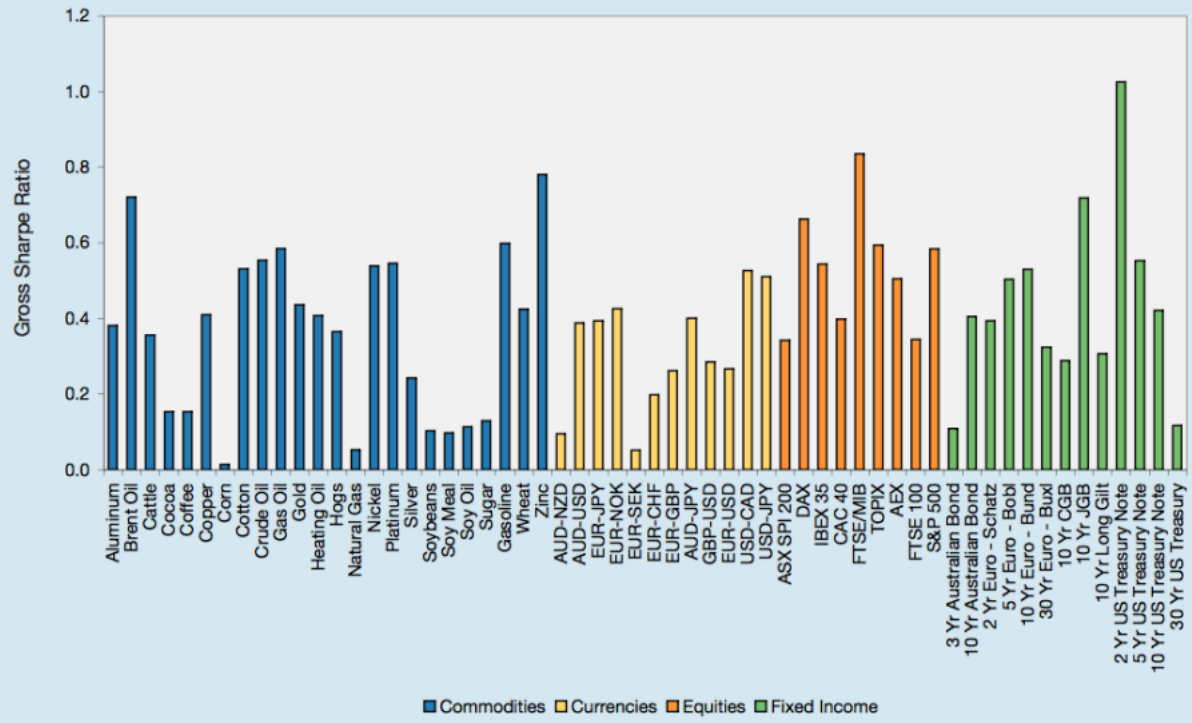
Source: AQR. Please read important disclosures at the end relating to hypothetical performance and risks.

Finally, Lempérière, Deremble, Seager, Potters, and Bouchard (2014) extends the tests even further, using **both futures and spot prices to go back to 1800 for commodity and stock indices**. It finds that excess returns driven by trend-following is both significant and stable across time and asset classes.

10. Evidence & Advances in Time-Series Momentum

While the evidence for time-series momentum was significantly advanced by the papers and teams cited above, there were other, more focused contributions throughout the years that helped establish it in more specific asset classes.

Exhibit 3: Performance of the hypothetical Simple Managed Futures Strategy for each individual asset.



Source: AQR. For illustrative purposes only and not the performance of an actual account. Please read important disclosures relating to hypothetical performance at the end of this paper.

Wilcox and Crittenden (2005) demonstrates that buying stocks when they make new 52-week highs and selling after a prescribed stop-loss is broken materially outperforms the S&P 500 even after accounting for trading slippage.

ap Gwilym, Clare, Seaton, and Thomas (2009) explores whether **trend-following can be used as an allocation tool for international equity markets**. Similar to Faber (2006), it utilizes a 10-month price-minus-moving-average model. Such an approach delivers a similar compound annual growth rate to buy and hold, but with significantly lower volatility, increasing the Sharpe ratio from 0.41 to 0.75.

Szakmary, Shen, and Sharma (2010) explores **trend-following strategies on commodity futures markets covering 48 years and 28 markets**. After deducting reasonable transaction costs, it finds that both a dual moving-average-double-crossover strategy and a channel strategy yield significant profit over the full sample period.

Antonacci (2012) explores a global tactical asset allocation approach utilizing both relative and absolute momentum techniques in an approach called "dual momentum." Dual momentum **increases annualized return, reduces volatility, and reduces maximum drawdown for equities, high yield & credit bonds, equity & mortgage REITs, and gold & treasury bonds.**

Dudler, Gmuer, and Malamud (2015) demonstrates that risk-adjusted time series momentum – returns normalized by volatility – outperforms time series momentum on a universe of 64 liquid futures contracts for almost all combinations of holdings and look-back periods.

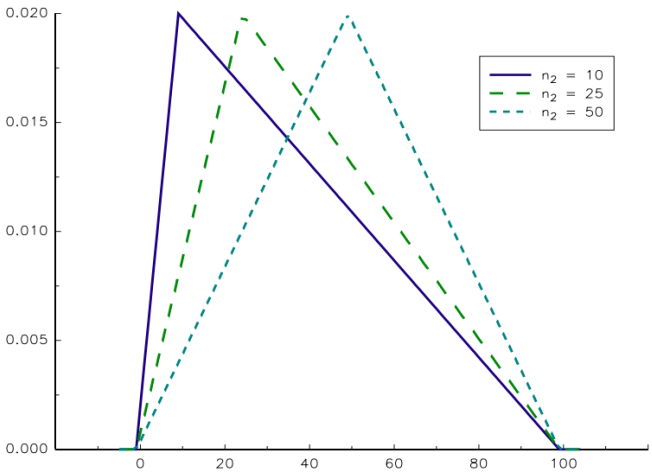
Levine and Pedersen (2015) uses smoothed past prices and smoothed current prices in their calculation of time-series momentum to reduce random noise in data that might occur from focusing on a single past or current price.

Clare, Seaton, Smith and Thomas (2014) finds that trend following "is observed to be a very effective strategy over the study period **delivering superior risk-adjusted returns** across a range of size categories in both **developed and emerging markets.**"

11. Unifying Momentum & Technical Analysis

Despite their similarities, trend-following moving average rules are often still considered to be technical trading rules versus the quantitative approach of time-series momentum. Perhaps the biggest difference is that the trend-following camp tended to focus on prices while the momentum camp focused on returns.

Figure 1: Window function $\mathcal{L}_i$ of moving average crossovers ($n_1 = 100$)



However, research over the last half-decade actually shows that they are highly related strategies.

Bruder, Dao, Richard, and Roncalli (2011) unites moving-average-double-crossover strategies and time-series momentum by showing that cross-overs were really just an alternative weighting scheme for returns in time-series momentum. To quote,

"The weighting of each return … forms a triangle, and the biggest weighting is given at the horizon of the smallest moving average. Therefore, depending on the horizon n2 of the shortest moving average, the indicator can be focused toward the current trend (if n2 is small) or toward past trends (if n2 is as large as n1/2 for instance)."

We can see, above, this effect in play. When n2 << n1 (e.g. n2=10, n1=100), returns are heavily back-weighted in the calculation. As n2 approaches half of n1, we can see that returns are most heavily weighted at the middle point.

Marshall, Nguyen and Visaltanachoti (2012) proves that time-series momentum is related to moving-average-change-in-direction. In fact, time-series momentum signals will not occur until the moving average changes direction. Therefore,

signals from a price-minus-moving-average strategy are likely to occur before a change in signal from time-series momentum.

Levine and Pedersen (2015) shows that time-series momentum and moving average cross-overs are highly related. It also find that time-series momentum and moving-average cross-over strategies perform similarly across 58 liquid futures and forward contracts.

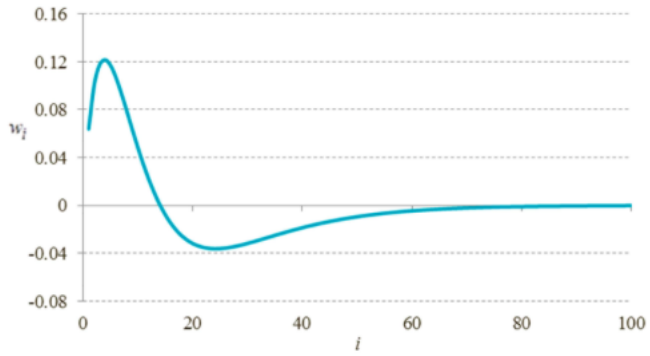


Exhibit 5: The weighting scheme of the MACD rule, with standard 26, 12, and 9-day parameters, i.e. $\lambda_s = 25/27 \approx 0.926$, $\lambda_f = 11/13 \approx 0.846$, and $\lambda = 8/10$ (see Appel [2005]). The sum of positive weights is equal to the sum of negative weights, so that the MACD rule is just as much a mean reversion rule as it is a trend rule (see Appendix).

Beekhuizen and Hallerbach (2015) also links moving averages with returns, but further explores trend rules with skip periods and the popular MACD rule. Using the implied link of moving averages and returns, it shows that the MACD is as much trend following as it is mean-reversion.

Zakamulin (2015) explores price-minus-moving-average, moving-average-double-crossover, and moving-average-change-of-direction technical trading rules and finds that they can be interpreted as the computation of a weighted moving average of momentum rules with different lookback periods.

These studies are important because they help validate the approach of price-based systems. Being mathematically linked, technical approaches like moving averages can now be tied to the same theoretical basis as the growing body of work in time-series momentum.

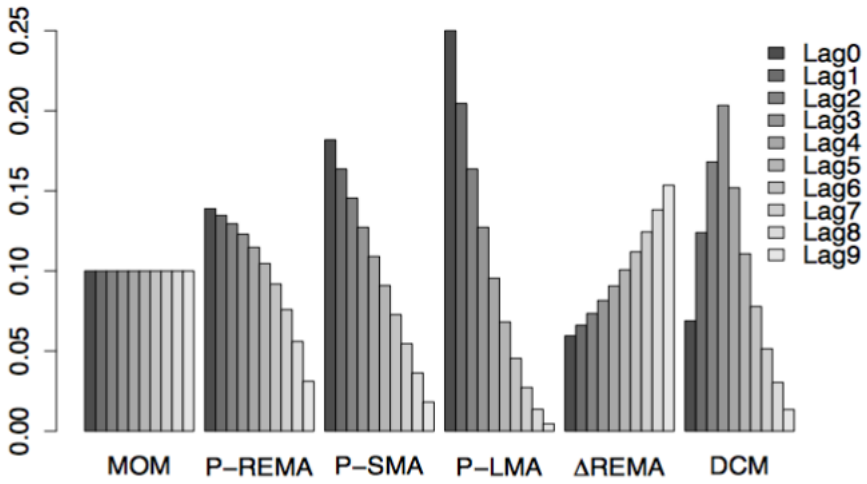


Figure 1: Weights of monthly price changes used for the computations of the technical trading indicators with $k = 10$. **MOM** denotes the Momentum rule. **P-REMA** denotes the Price-Minus-Reverse-Exponential-Moving-Average rule (with $\lambda = 0.8$). **P-SMA** denotes the Price-Minus-Simple-Moving-Average rule. **P-LMA** denotes the Price-Minus-Linear-Moving-Average rule. **ΔREMA** denotes the Reverse-Exponential-Moving-Average-Change-of-Direction rule (with $\lambda = 0.9$). **DCM** denotes the Double Crossover Method (based on using two exponential moving averages with $\lambda = 0.8$ and $s = 3$). **Lag**$(i-1)$ denotes the weight of the lag ΔP_{t-i}, where Lag0 denotes the most recent price change ΔP_{t-1} and Lag9 denotes the most oldest price change ΔP_{t-10}.

12. Conclusion

As an investment strategy, momentum has a deep and rich history.

Its foundational principles can be traced back nearly two centuries and the 1900s were filled with its successful practitioners.

But momentum went long misunderstood and ignored by academics.

In 1993, Jegadeesh and Titman published "Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency." Prevailing academic theories were unable to account for cross-sectional momentum in rational pricing models and the premier market anomaly was born.

While momentum's philosophy of "buy high, sell higher" may seem counterintuitive, prevailing explanations identify its systemized process as taking advantage of the irrational behavior exhibited by investors.

Over the two decades following momentum's (re)introduction, academics and practitioners identified the phenomenon as being robust in different asset classes and geographies around the globe.

After the financial crisis of 2008, a focus on using time-series momentum emerged as a means to manage risk. Much like cross-sectional momentum, time-series momentum was found to be robust, offering significant risk-management opportunities.

While new studies on momentum are consistently published, the current evidence is clear: momentum is the premier market anomaly.

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