Quantitative Trading Strategies & Algorithmic Trading

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Session 4

- Commonly Used Longer Term Trading Strategies
  - Refresher: previously covered material
  - Momentum
  - Value
  - Profitability

Refresher: Capital Asset Pricing Model (CAPM)

- If the asumptions of the CAPM hold, each asset's expected return $E(R_i)$ can be expressed as follows

$E(R_i) = \beta_{i,M}E(R_M)$

where $E(R_i)$ = expected asset excess return above the risk-free rate

$\beta_{i,M} = cov(R_i,R_M)/var(r_M)$ (an asset's sensitivity to market return / risk)

$E(R_M)$ = expected market excess return above the risk-free rate

- In terms of realised rather than expected returns, we would have

$R_i = \beta_{i,M}R_M + \varepsilon_i$

where ε_i is the **specific return** of company i

Refresher: Capital Asset Pricing Model (CAPM)

- Each asset's return can be decomposed into a **systematic component** and a **company-specific** component

- Investors are only compensated for taking systematic risk (i.e. market or non-diversifiable risk)

- As company-specific risk can be diversified away, investors are not compensated for it

- Investors optimally invest into a combination of the market portfolio of risky assets and a risk-free asset → **capital market line (CML)**

- Linear relation between asset betas and expected returns → **security market line (SML)**

Refresher: Fama-French-Carhart Four-Factor Model

- The Fama-French-Carhart (FFC) model is based on Fama & French (1992) and Carhart (1997).

- It is based on the empirical findings that in addition to the market there seem to be an additional three factors that are related to an asset's systematic (and therefore expected) return / risk

- The FFC model states the following

$$E(R_i) = \beta_{i,M}E(R_M) + \beta_{i,SMB}SMB + \beta_{i,HML}HML + \beta_{i,WML}WML$$

where SMB = "small-minus-big", the **size** factor

HML = "high-minus-low", the **book-to-market** factor

WML = "winner-minus-loser", the **momentum** factor

$\beta_{i,SMB}$, $\beta_{i,HML}$, $\beta_{i,WML}$ = an asset's sensitivity to each of the factors

Refresher: Fama-French Five-Factor Model

- The Fama-French Five-Factor (FF5) model is based on Fama & French (2015).

- It is based on the empirical findings that in addition to the market there seem to be an additional four factors that are related to an asset's systematic (and therefore expected) return / risk

- The FFC model states the following

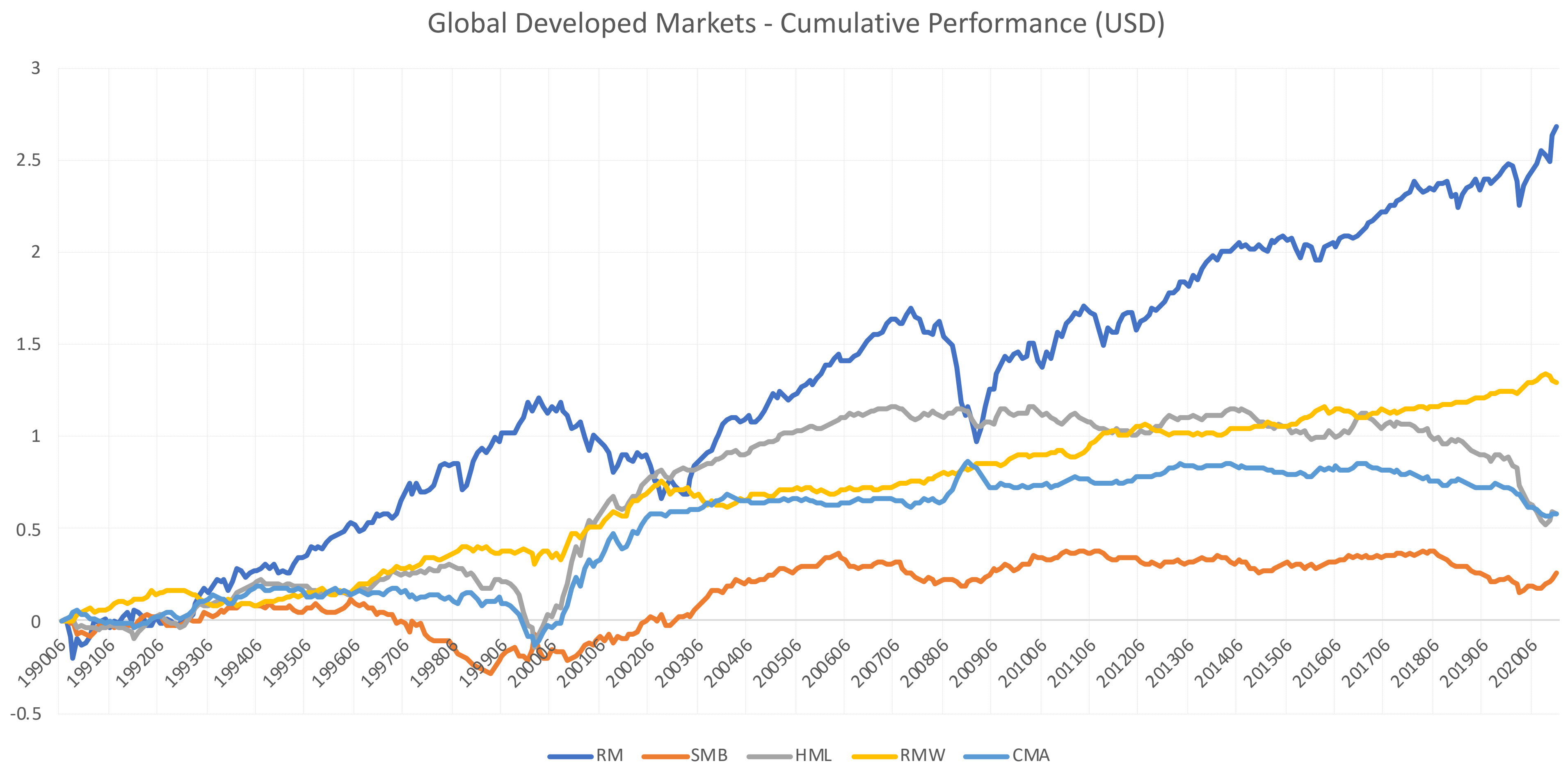
$$E(R_i) = \beta_{i,M}E(R_M) + \beta_{i,SMB}SMB + \beta_{i,HML}HML + \beta_{i,CMA}CMA + \beta_{i,RMW}RMW$$

where CMA = "conservative-minus-aggressive", the **investment** factor

RMW = "robust-minus-weak", the **profitability** factor

$\beta_{i,CMA}$, $\beta_{i,RMW}$ = an asset's sensitivity to each of the factors

Global Cumulative Factor Performance (in USD)



Source: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Refresher: Regression Analysis in Matlab

- The Matlab "**Statistics and Machine Learning Toolbox**" provides a number of different regression routines

- I generally use **REGSTATS** for regression analysis which has the following basic syntax:

stats = regstats(y, X, model, whichstats)

where	y	=	response (dependent) variable
	X	=	independent variable(s); a regression intercept is included by default
	model	=	type of regression model to use, e.g. '**linear**'
	whichstats	=	type of output, e.g. '**beta**' for regression coefs, '**tstat**' for t-statistics and p-values, '**rsquare**' for R^2, '**r**' for regression residuals

Refresher: Regression Analysis in Python

- Different libraries in Python offer regression routines.
- Commonly used routine is among the Numpy linear algebra functions, namely numpy.linalg.lstsq (the Scipy library contains a very similar routine):

stats = numpy.linalg.lstsq(X, y, rcond=None)

where	X	=	independent variable(s); to include an intercept in the regression, add a column of ones to X
	y	=	response (dependent) variable
	stats	=	regression coefficient estimates; regression residuals

Refresher: Time Series Regressions

- In order to test whether certain variables are related to each other over time a time series regression can be used, e.g. are stock returns related to changes in the rate of inflation?

- The following regression can be run

$$Y = \alpha + X\gamma + \varepsilon$$

where Y = Tx1 vector of dependent variable, where T = number of time periods

X = TxK array of independent variable(s), where K = number of variables

γ = Kx1 vector of regression coefficients (to be determined in the regression)

ε = Tx1 vector of regression residuals

- For example, this type of regression is often used to compute assets' CAPM beta coefficients.

Exercise: Compute CAPM Statistics

- Write a **Matlab or Python program** that uses the CAPM methodology to compute the following **statistics** from time series of stock and market excess returns (in excess of the risk-free interest rate) for each stock:
  - beta
  - systematic risk
  - company-specific risk

- **Proceed as follows:**
  - Have an array of stock excess returns and a vector of market excess returns as function inputs.
  - For each company, regress excess stock returns on excess market returns.
  - Specify the appropriate types of outputs that you require from regstats (“whichstats”)
  - Have the three statistics listed above computed for each stock as function outputs

- Use the excess return data in the file “**stockReturns.xlsx**” as inputs in order to check your program.

Refresher: Cross-Sectional Regressions

- In order to test whether certain factor(s) (or company characteristic(s)) forecast(s) subsequent stock returns, we use the following regression

$$R_{t+1} = \alpha_t + X_t \gamma_t + \varepsilon_t$$

where R_{t+1} = vector of stock returns over period t+1 for N stocks

X_t = vector or matrix of company characteristics known as of date t

- As one-period-ahead (t+1) returns are regressed on date t information, the regression is a **predictive regression**

- A statistically significant regression coefficient (or vector of regression coefficients) demonstrates that a predictive relationship exists (positive or negative)

- **HOWEVER**:

  - This analysis is limited to one cross-section at one point in time (date t).
  - Any potential relationship between X and Y may change over time
  - Need to carry out the analysis repeatedly over time

Refresher: Fama-MacBeth Regressions

- The Fama-MacBeth methodology was developed by Nobel laureate Eugene Fama and James MacBeth in 1973*

- It combines cross-sectional regression analysis with a time series dimension

- At each date *t* the cross-sectional regression from above is run

$$R_{t+1} = \alpha_t + X_t \gamma_t + \varepsilon_t$$

- Since this regression is run repeatedly, we obtain a time series of regression coefficients γ (can be vector or matrix depending on whether one or several variables are included in X_t)

- We can perform a t-test on the γ time series in order to check whether they are statistically significantly different from zero (i.e. a predictive relationship exists):

t-statistic = mean(γ) / std error(γ)

* Fama, Eugene F.; MacBeth, James D. (1973). "Risk, Return, and Equilibrium: Empirical Tests". Journal of Political Economy. 81 (3): 607–636.

Exercise: Testing the CAPM using Fama-MacBeth

- Load the file “**uk_data.xslx**” into Matlab or Python which contains estimated beta coefficients (“**beta**”) updated on a monthly basis for a cross-section of UK stocks and also monthly stock returns (“**returns**”).

- Write a Matlab or Python program that performs the **Fama-MacBeth methodology** (outlined above) and which outputs a time series of regression betas as well as the results of the t-test discussed above.

- Evaluate the t-statistic computed and graph the time series of gammas. What can you conclude from this analysis?

Cross-Sectional Momentum

- Focuses on relative performance of securities in the cross-section. **Securities that recently outperformed their peers over the past three to twelve months continue to outperform their peers on average over the next month.***

- In the academic literature, cross-sectional momentum was first mentioned by Jegadeesh and Titman (1993).

- However, relative trends in past asset returns have been used by practitioners to make return forecasts for a long time.

- Researchers have argued that the momentum effect occurs as **information** about the underlying assets is **incorporated into their prices slowly**.

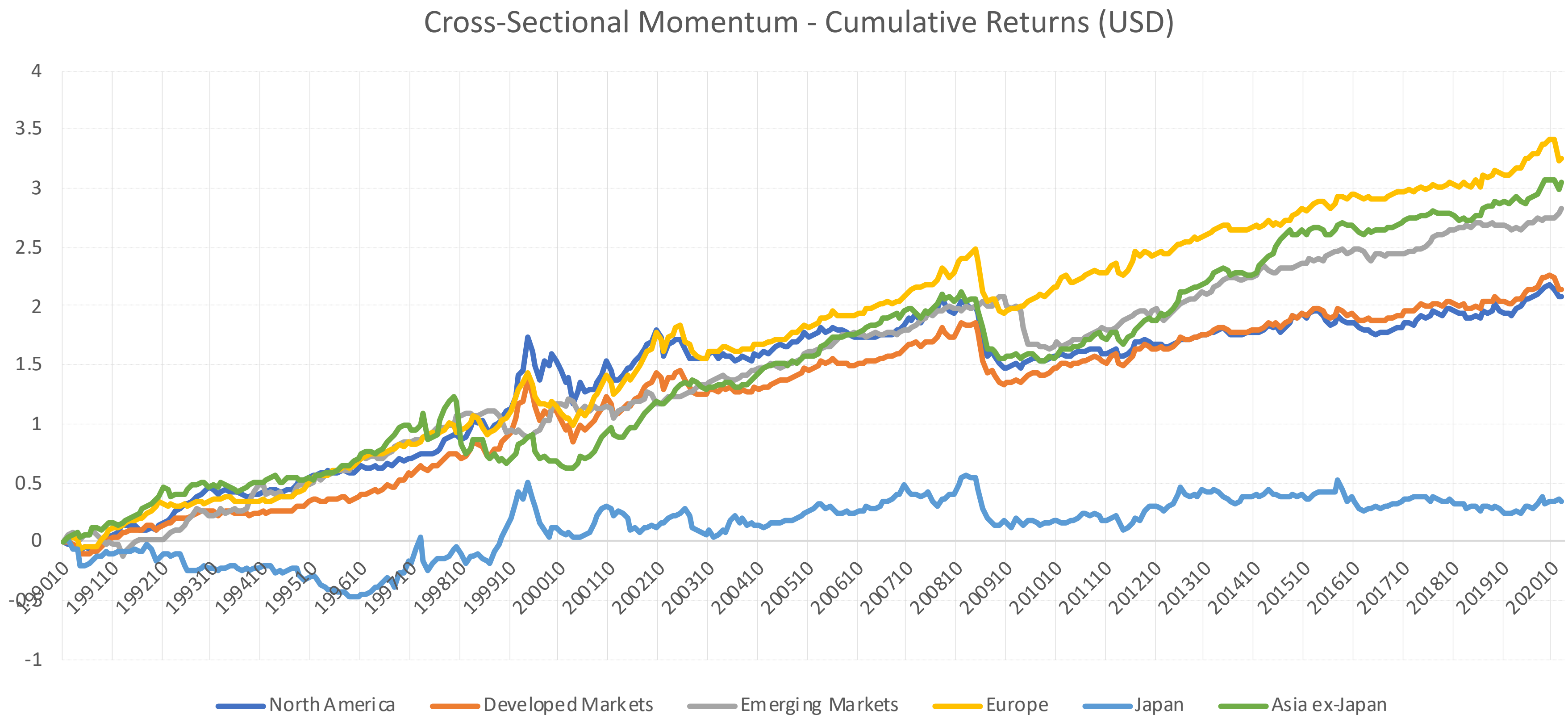
- Momentum has been one of the most **profitable** investment strategies globally but can have **large sudden drawdowns**.

- The momentum effect exists in **various asset classes**, not just equities.

** To measure momentum, the most recent month of returns is usually skipped as there is a short-term reversal effect which tends to exist for reasons related to market microstructure.*

Cross-Sectional Momentum

- Momentum generates relatively high portfolio turnover and is therefore **costly to trade**.
- The momentum effect is usually larger for smaller companies but it is difficult to exploit in that universe due to its high turnover.



Source: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

Time Series Momentum

- Time series momentum is related to, but different from, cross-sectional momentum.

- Rather than focus on the relative returns of securities in the cross-section, time series momentum **focuses purely on a security's own past return**.

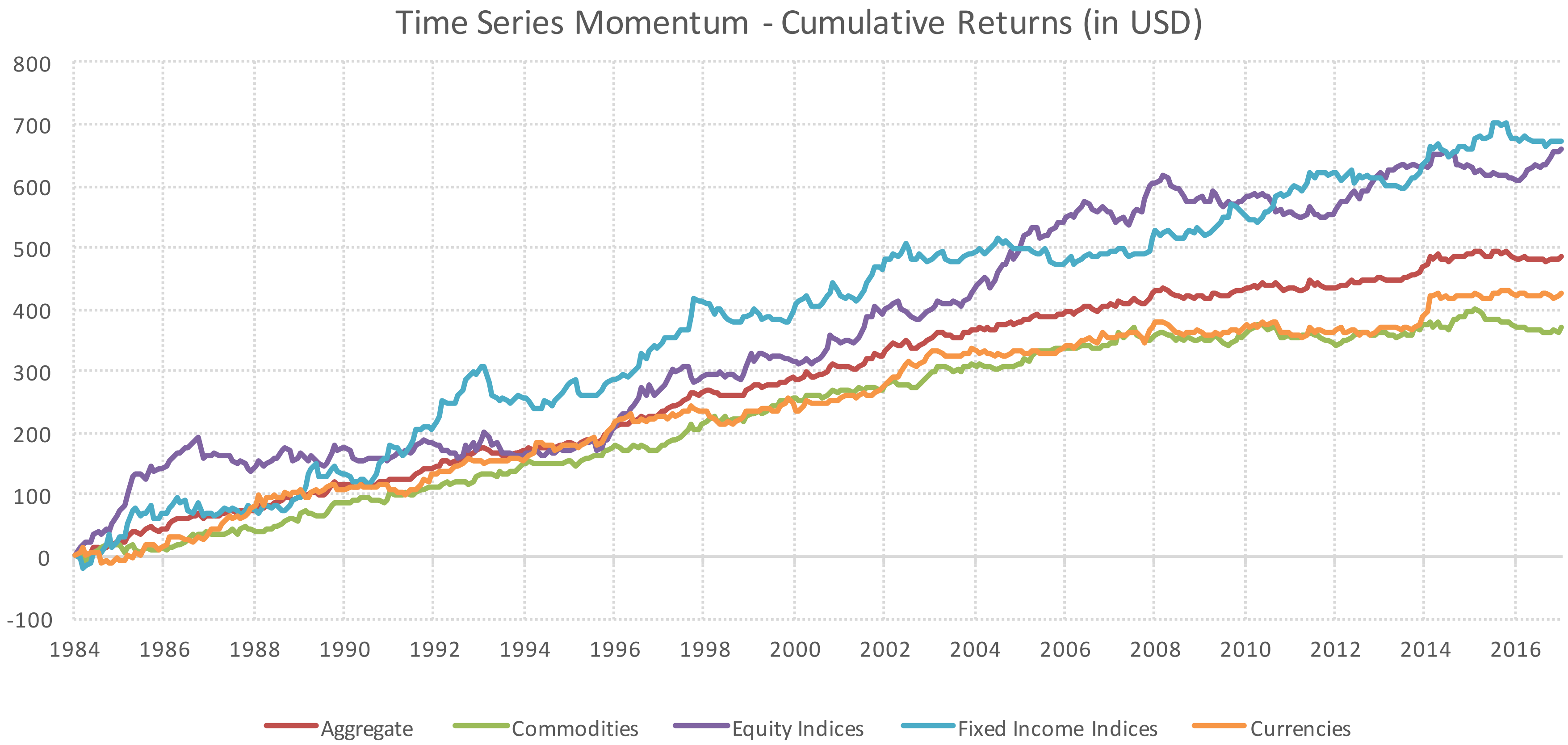
- One of the main academic papers on times series momentum is Moskowitz, Ooi and Pedersen (2012) (MOP).

- Time series momentum is often used at a more granular level, e.g. on stock indices rather than on individual stocks, bond indices rather than individual bonds, etc.

- MOP examine various lookback periods to measure momentum as well as various holding periods, both ranging rom 1 - 48 months.

- They show that lookback and holding periods ranging from 1 - 12 months generally yield positive and statistically significant return premia in each asset class.

Time Series Momentum (12-month lookback, 1-month holding period)



Source: https://www.aqr.com/library/data-sets/time-series-momentum-factors-monthly

Seasonal Momentum

- A special type of momentum factor that is **based on stock returns in past years over the same calendar month**, produces strongly positive returns that are highly statistically significant.

- Heston & Sadka (2008) find that stocks tend to have **relatively high (or low) returns every year in the same calendar month**.

- Hence, there is **positive return predictability** at lags of 12, 24, and 36 months as part of a general pattern that lasts up to 20 annual lags.

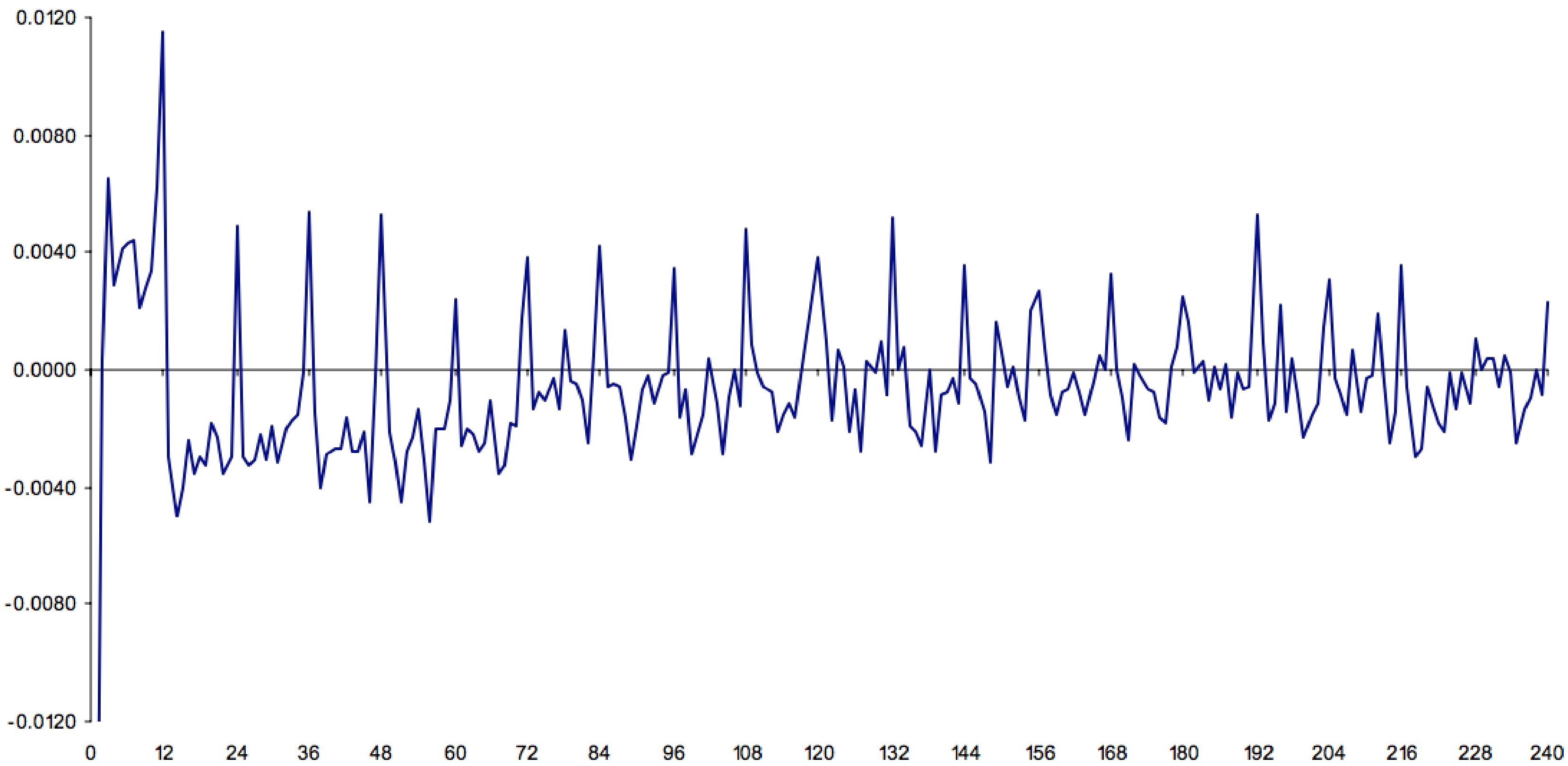
- This **effect exists for all calendar months** and it is independent of industry, size, and earnings announcements.

- So far, no convincing explanation has been found why this effect exists.

- This return effect tends to exist in all global equity markets.

Seasonal Momentum

Average monthly returns as a function of historical lags (in months)



Source: Heston & Sadka (2008).

Momentum Horizons

- A return reversal exists in most markets if last month's returns (or a shorter interval) are used to forecast future returns (the **short-term reversal effect**).

- If past returns over periods f**rom three to twelve months** (skipping the most recent month) are used to forecast future returns, then a **positive relationship** can be found.

- This relationship weakens if a return period of more than twelve months is used to forecast future returns.

- If past return periods between three and five years are used to predict future returns, there tends to be a negative relationship (the **long-term reversal effect**).

- However, **returns in past years in the same calendar month** tend to positively predict future returns for up to 20 years.

- Various **more sophisticated versions** of momentum have been explored both in academia and among practitioners.

Value

- As we have seen from the Fama-French-Carhart model and the Fama-French Five-Factor model, value is measured as the intrinsic value of a company relative to its market value.
- The intrinsic value is generally measured using accounting information, most commonly a company's **book value**.
- **More sophisticated versions of value** factors exist: they might use information that is specific to certain sectors, e.g. the value of reserves in the ground for metals and mining companies.
- Value factors tend to perform poorly during strong bull markets and better in bear markets.
- Value as a factor is used by almost all investment managers in some shape or form.
- Value is a very interesting **complement to momentum**.

Value & Momentum

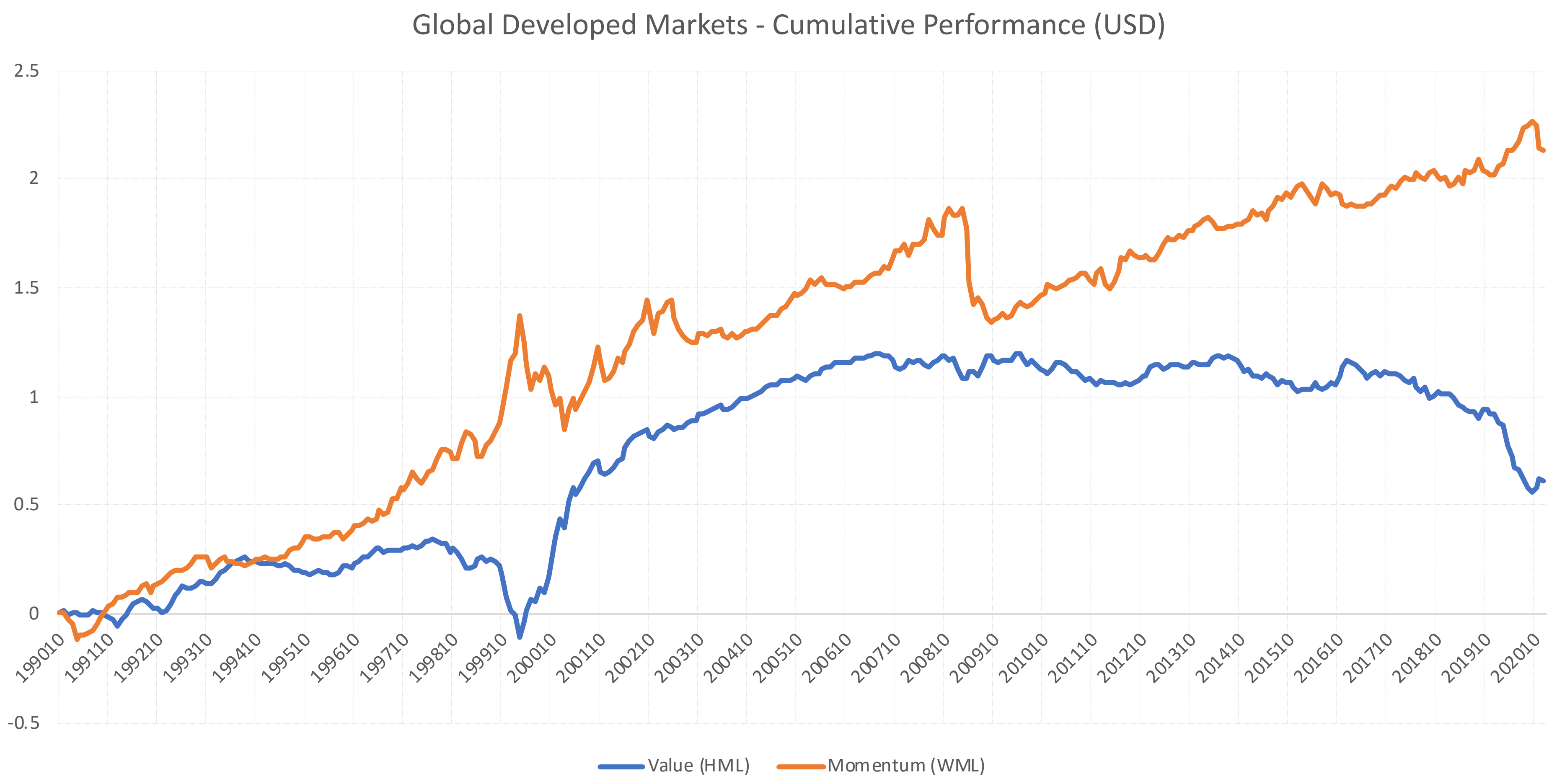
- Both value and momentum have generated positive returns on average when they are used to predict future returns.

- However, the factors are generally **strongly negatively correlated**, i.e. when value performs poorly, momentum tends to perform strongly and the reverse.

- This pattern tends to exist in all regions among equities and also in all major asset classes (see, for example, Asness, Moskowitz and Pedersen (2013)).

- **Hence, used in combination, value and momentum are highly diversifying.**

Value & Momentum



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Profitability / Quality

- Several different profitability / quality factors have been used to predict returns.
- Fama & French (2015) use **operating profitability divided by book equity**.
- Novy-Marx (2013) (NM) uses **gross profitability** measured as total revenue minus costs of goods sold divided by total assets.
- NM's profitability measure has **approximately the same power as book-to-market** predicting subsequent returns.
- Profitable firms generate significantly higher returns than unprofitable firms, despite having significantly higher valuation ratios (book-to-market).
- Also, **controlling for profitability increases the value effect** substantially.
- Difficult to explain this effect as compensation for higher risk. More profitable firms tend to have lower distress risk.

Profitability / Quality

- Other (related) factors have been used to assess the earnings quality of companies, e.g. earnings variability, cash-based vs. accruals-based earnings, etc.

- As one would expect, companies with higher earnings quality generall outperform companies with lower earnings quality (measured in various ways).

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