



**Algorithmic Trading**

**Session 6**

**Trade Signal Generation IV**

**Momentum Strategies**

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# Outline

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- **Introduction**
- **What is Momentum?**
- **Tests to Discover Momentum**
- **Interday Momentum Strategies**
- **Intraday Momentum Strategies**
- **Summary and Questions**
- **Sources**

# Introduction

## Where Do We Stand in the Algo Prop Trading Framework?



- ❑ As we have seen, algorithmic proprietary trading strategies can be broken down into three subsequent steps: Signal Generation, Trade Implementation and Performance Analysis
- ❑ The first step, **Signal Generation**, defines when and how to trade. For example, in a moving average strategy, the crossing of the shorter running moving average over the longer running moving average triggers when to trade. Next to long and short, the signal can also be neutral (do nothing). Using moving averages to generate long/short trading signals is an example choice of how to trade
- ❑ Sessions 3 – 6 deal with the question of deciding when and how to trade
  - **Session 3**: Finding Suitable Trading Strategies and Avoiding Common Pitfalls
  - **Session 4**: Backtesting
  - **Session 5**: Mean Reversion Strategies
  - **Today's Session 6**: Momentum Strategies

# Introduction

## Mean Reversion vs. Momentum

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- ❑ Trading strategies can be profitable **only if securities prices are either mean-reverting or trending**. Otherwise, they are random walking, and trading will be futile. If you believe that prices are mean reverting and that they are currently low relative to some reference price, you should buy now and plan to sell higher later. However, if you believe the prices are trending and that they are currently low, you should (short) sell now and plan to buy at an even lower price later. The opposite is true if you believe prices are high
- ❑ Academic research has indicated that **stock prices are on average very close to random walking**. However, this does not mean that under certain special conditions, they cannot exhibit some degree of mean reversion or trending behaviour. Furthermore, at any given time, stock prices can be both mean reverting and trending depending on the time horizon you are interested in. Constructing a trading strategy is essentially a matter of determining if the prices under certain conditions and for a certain time horizon will be mean reverting or trending, and what the initial reference price should be at any given time

# Momentum

## What is Momentum?

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- ▣ We will separate between interday and intraday momentum strategies
- ▣ There are four main causes of momentum:
  - ▣ For futures, the persistence of roll returns, especially of their signs
  - ▣ The slow diffusion, analysis and acceptance of new information
  - ▣ The forced sales or purchases of assets of various fund types
  - ▣ Market manipulation by high frequency traders
- ▣ Academics sometimes classify momentum in asset prices into two types: **time series momentum** and **cross-sectional momentum**. Time series momentum is very simple and intuitive: past returns of a price series are positively correlated with future returns. Cross-sectional momentum refers to the relative performance of a price series in relation to other price series: a price series with returns that outperformed other price series will likely keep doing so in the future and vice versa

# Momentum Tests

## How Can We Discover Momentum?

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- ❑ Time series momentum of a price series means that past returns are positively correlated with future returns. It follows that we can just calculate the correlation coefficient of the returns together with its  $p$ -value
- ❑ One feature of computing the correlation coefficient is that we have to pick a specific time lag for the returns. Sometimes, the most positive correlations are between returns of different lags. For example, 1-day returns might show negative correlations, while the correlation between past 20-day return with the future 40-day return might be very positive. We should find the optimal pair of past and future periods that gives the highest positive correlation and use that as our look-back and holding period for our momentum strategy
- ❑ Alternatively, we can also test for the correlations between the signs of past and future returns. This is appropriate when all we want to know is that an up move will be followed by another up move, and we don't care whether the magnitudes of the moves are similar
- ❑ If we are interested instead in finding out whether there is long-term trending behaviour in the time series without regard to specific time frames, we can calculate the Hurst exponent together with the Variance Ratio test to rule out the null hypothesis of a random walk

# Momentum Tests

## Augmented Dickey Fuller Test

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- If a price series is trending, then the current price level will tell us something about what the price's next move will be: If the price level is higher than the previous price level, the next move should also be an upward move; if the price level is lower than the previous price level, the next move should also be a downward move. The ADF test is based on just this observation. We can describe the price changes using a linear model:

$$\Delta y(t) = \lambda y(t-1) + \mu + \beta t + \alpha_1 \Delta y(t-1) + \dots + \alpha_k \Delta y(t-k) + \varepsilon$$

- The **ADF test will find out if  $\lambda = 0$** . If the hypothesis  $\lambda = 0$  can be rejected, it means that the next move of the asset is dependent on the current level and therefore not random
- The statisticians Dickey and Fuller described the distribution of this test statistic and tabulated the critical values for us, so we can look up for any value of  $\lambda/SE(\lambda)$  whether the hypothesis can be rejected at, say, the 95 percent probability level
- Since we expect momentum,  $\lambda/SE(\lambda)$  has to be positive, and it has to be more positive than the critical value for the hypothesis to be rejected. The critical values themselves depend on the sample size and whether we assume that the price series has a non-zero mean  $-\mu/\lambda$  or a steady drift  $-\beta t/\lambda$ . Most practitioners assume the drift term to be zero

# Momentum Tests

## Hurst Exponent

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- Intuitively speaking, a trending price series means that the prices diffuse from its initial value faster than a geometric random walk would. Mathematically, we can determine the nature of the price series by measuring this speed of diffusion. The speed of diffusion can be characterized by the variance

$$\text{Var}(\tau) = \langle |z(t + \tau) - z(t)|^2 \rangle$$

where  $z$  is the log prices ( $z = \log(y)$ ),  $\tau$  is an arbitrary time lag, and  $\langle |\dots| \rangle$  an average over all  $t$ . For a geometric random walk, we know that

$$\langle |z(t + \tau) - z(t)|^2 \rangle \sim \tau$$

The  $\sim$  means that this relationship turns into an equality with some proportionality constant for large  $\tau$ , but it may deviate from a straight line for small  $\tau$ . But if the (log) price series is mean reverting or trending (i.e., has positive correlations between sequential price moves), the last equation won't hold. Instead, we can write:

$$\langle |z(t + \tau) - z(t)|^2 \rangle \sim \tau^{2H}$$

- This is the definition of the Hurst exponent  $H$ . For a price series exhibiting geometric random walk,  $H = 0.5$ . But for a mean-reverting series,  $H < 0.5$ , and for a trending series,  $H > 0.5$ . As  $H$  decreases toward zero, the price series is more mean reverting, and as  $H$  increases toward 1, the price series is increasingly trending; thus,  $H$  serves also as an indicator for the degree of mean reversion or trendiness



# Momentum Tests

## Variance Ratio Test

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- Because of finite sample size, we need to know the statistical significance of an estimated value of  $H$  to be sure whether we can reject the null hypothesis that  $H$  is really 0.5. This hypothesis test is provided by the Variance Ratio test. It simply tests whether

$$\frac{\text{Var}(z(t) - z(t - \tau))}{\tau \text{Var}(z(t) - z(t - 1))}$$

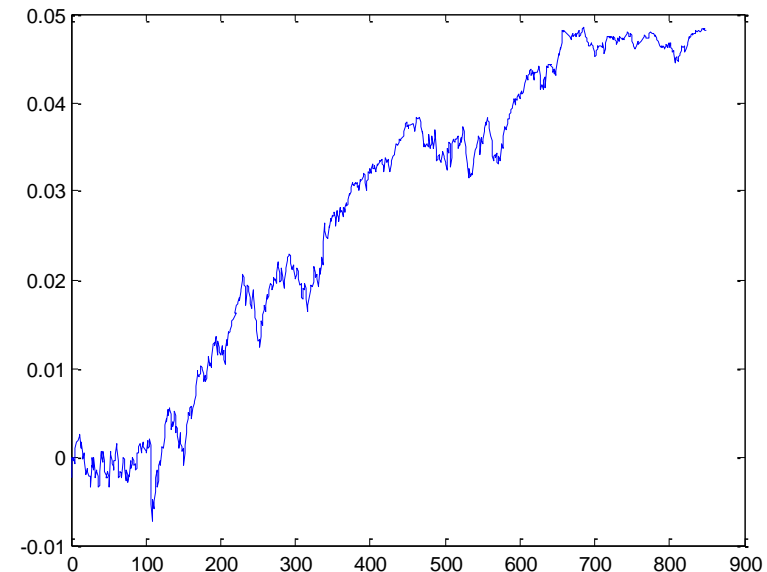
is equal to 1. The outputs of this test are **h** and **pValue**:  $h = 1$  means rejection of the random walk hypothesis at the 90 percent confidence level,  $h = 0$  means it may be a random walk. pValue gives the probability that the null hypothesis (random walk) is true

# Interday Momentum Strategies

## Time Series Strategies

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- For a certain future, if we find that the correlation coefficient between a past return of a certain look-back and a future return of a certain holding period is high, and the  $p$ -value is small, we can proceed to see if a profitable momentum strategy can be found using this set of optimal time periods
- Why do many futures returns exhibit serial correlations? And why do these serial correlations occur only at a fairly long time scale? The explanation often lies in the roll return component of the total return of futures
- Example 6.1 (file TU\_mom) results in the following return profile btw. June 1, 2004 and May 11, 2012:
  - Ann. Return: 1.7%
  - Sharpe: 1
  - Max DD: 2.5%



# Interday Momentum Strategies

## Extracting Roll Returns

- ❑ A Futures' total return is composed of spot return + roll return
- ❑ If the roll return is negative (contango future curve), buy the underlying asset and short the futures
- ❑ If the roll return is positive (backwardation future curve), short the underlying asset and buy the futures



- ❑ This will work as long as the sign of the roll return does not change quickly
- ❑ However, the logistics of buying and especially shorting the underlying asset is not simple, unless an exchange-traded fund (ETF) exists that holds the asset

# Interday Momentum Strategies

## News Sentiment as a Fundamental Factor

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- ❑ With the advent of machine-readable, or “elementized,” newsfeeds, it is now possible to programmatically capture all the news items on a company, not just those that fit neatly into one of the narrow categories such as earnings announcements or merger and acquisition activities
- ❑ Natural language processing algorithms are now advanced enough to analyse the textual information contained in these news items, and assign a “sentiment score” to each news article that is indicative of its price impact on a stock
- ❑ The success of these strategies also demonstrates very neatly that the slow diffusion of news is one cause of momentum

# Interday Momentum Strategies

## Mutual Funds Asset Fire Sale and Forced Purchases

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- ❑ Mutual funds experiencing large redemptions are likely to reduce or eliminate their existing stock positions. This is no surprise since mutual funds are typically close to fully invested, with very little cash reserves
- ❑ Also, funds experiencing large capital inflows tend to increase their existing positions rather than using the additional capital to invest in other assets, perhaps because new investment ideas do not come by easily
- ❑ Assets disproportionately held by poorly performing mutual funds facing redemptions therefore experience negative returns. Furthermore, this asset “fire sale” by poorly performing mutual funds is contagious
- ❑ Hence, momentum in both directions for the commonly held assets can be exploited

# Interday Momentum Strategies

## Summary

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- ❑ Futures exhibit time series momentum mainly because of the persistence of the sign of roll returns
- ❑ If you are able to find an instrument (e.g., an ETF or another future) that cointegrates or correlates with the spot price or return of a commodity, you can extract the roll return of the commodity future by shorting that instrument during backwardation, or buying that instrument during contango
- ❑ Profitable strategies on news sentiment momentum show that the slow diffusion of news is one cause for stock price momentum
- ❑ The contagion of forced asset sales and purchases among mutual funds contributes to stock price momentum

# Intraday Momentum Strategies

## Opening Gap Strategy

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- ❑ Gap measures the difference in opening price relative to last closing price. For example a stock closing on Friday at USD 100 and reopening on Monday at USD 95 has an opening gap of -5 USD
- ❑ What's special about the overnight or weekend gap that sometimes triggers momentum? The extended period without any trading means that the opening price is often quite different from the closing price
- ❑ Hence stop orders set at different prices may get triggered all at once at the open. The execution of these stop orders often leads to momentum because a cascading effect may trigger stop orders placed further away from the open price as well
- ❑ Also, the gap could result from significant events that occurred overnight

# Intraday Momentum Strategies

## News Driven Momentum Strategy

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- ❑ As momentum is driven by the relatively slow diffusion of news, one can benefit from the first few days, hours, or even seconds after a newsworthy event. For example, ECB press conferences are aired with 15sec. delay and only subscribers of special services can see it live to profit from any significant announcements
- ❑ Earnings announcements are another example of news driven intraday momentum. It is surprising that it still persists, although the duration of the drift has shortened
- ❑ Earnings guidance, analyst ratings and recommendation changes on a stock specific level as well as macroeconomic indicators such as housing and unemployment numbers, consumer confidence or purchasing manager indices are other examples of momentum creating news



# Intraday Momentum Strategies

## Index Composition and Leveraged ETFs

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- ❑ Rebalancings of major indices results in intraday momentum due to ETF trading activity to mirror these changes in index composition. For example, if a stock joins the MSCI World index, all ETFs as well as funds benchmarked to this index have to buy this stock. This momentum usually last only for a few hours on the announcement as well as the implementation date as there are now quite some players trying to anticipate and frontrun index composition changes
- ❑ The sponsors (issuers) of leveraged ETFs experience a similar issue which can create momentum. Let's assume there is a three times leveraged ETF mirroring a basket of stocks. If a constituent stocks goes up, the ETF sponsor has to buy it to hold the leverage ratio constant

# Intraday Momentum Strategies

## Summary

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- ❑ “Breakout” momentum strategies involve a price exceeding a trading range. The opening gap strategy is a breakout strategy that works for some futures and currencies. Breakout momentum may be caused by the triggering of stop orders
- ❑ Many kinds of corporate and macroeconomic news induce short-term price momentum
- ❑ Index composition changes induce momentum in stocks that are added to or deleted from the index
- ❑ Rebalancing of leveraged ETFs near the market close causes momentum in the underlying index in the same direction as the market return from the previous close

# Summary and Questions

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- ▣ Time-series momentum refers to the positive correlation of a price series' past and future returns
- ▣ Cross-sectional momentum refers to the positive correlation of a price series' past and future relative returns, in relation to that of other price series in a portfolio
- ▣ Lagged correlation of prices or returns, the ADF test, the Hurst exponent and Variance Ratio test can be used to test for momentum
- ▣ Different strategies apply to inter and intraday techniques. More and more sophisticated traders result in a reduced time to exploit the momentum created by significant news, e.g. the speed of news diffusion is increasing
  
- ▣ Questions?

# Sources

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- ▣ Quantitative Trading: How to Build Your Own Algorithmic Trading Business by Ernest Chan
- ▣ Algorithmic Trading: Winning Strategies and Their Rationale by Ernest Chan
- ▣ The Mathematics of Money Management: Risk Analysis Techniques for Traders by Ralph Vince